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Role and Use of Technologies in Relation to ICZM

Final Report

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Tecnomare

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Preface

This document is the Final Report to the Contract B4-3040/96/000599/MAR/D2, Role and Use of Techniques in Relation to Integrated Coastal Zone Management.

It is based on the examination of the State-of-the-Art of technologies for coastal application, on a number of visits to Demonstration Projects, and on the examination of the outcomes of a Questionnaire submitted to the Project Leaders of the Demonstration Projects.

A further Questionnaire has been submitted to the National Experts with the aim to investigate the possibility to adopt policies to promote the “informed” application of technologies in the context of Integrated Coastal Zone Management activities.

A technology-specific Questionnaire has been used during the visits for a few representative cases, particularly to focus on the ICZM-enabling technologies currently being applied in the context of the Demonstration Programme.

For those interested into the detailed examination of the (potential) role of technologies in ICZM, reading of Chapter 2, Chapter 3, and Chapter 4 is recommended. For those interested in the examination of the experience of the Demonstration Projects, reading of Chapter 5 is recommended. Possible Policy Options for the Promotion of the Informed Application of Technologies are listed in Chapter 6. Conclusions and recommendations about the Role of EU are given respectively in Chapter 7 and Chapter 8.

For a definition of the overall framework, reference should be made to “Towards a European Integrated Coastal Zone Management (ICZM) Strategy—A Reflection Paper” (Commission of the European Communities, 1999).

EXECUTIVE SUMMARY.

Introduction.

"Competitiveness and sustainability are the keys to the long-term future of the Union's economy: creation of wealth and jobs, enhancement of the quality of life, and preservation of the environment and the natural resource base. They depend on the capacity of citizens, enterprises, regions, nations and the Community to generate and use the knowledge, science and technology of tomorrow, in high-quality goods, processes and services, and in new and more efficient organisational forms" (Commission of the European Communities, 1998c). Competitiveness and sustainability, as well as sustainable development, can no longer be considered a matter for individual organisations or sectors alone. In the context of an increasingly interlinked and globalising economy a "systems approach" is necessary with coherent, interconnected and eco-efficient industrial and social systems, responding not only to market but also to societal needs.

The Demonstration Programme on Integrated Coastal Zone Management (ICZM) aims at investigating how to meet the challenges for specific situations like Coastal Zones (Commission of the European Communities, 1999). We consider ICZM as a mechanism to achieve competitiveness and sustainability in the Coastal Zone, where a lot of emphasis is on the "process of conflict resolution". The present document concerns the preliminary outcomes of the thematic analysis on the Role and Use of Technologies being conducted on behalf of DG XI of the Commission of the European Communities in the context of the Demonstration Programme.

Technologies are here considered according to an extensive definition: technologies may represent a support to "look" at the Coastal Zone and a support to "act" on the Coastal Zone. In practice, technologies represent a tool to support ICZM activities in all their aspects. We do not discuss here any specific technologies, rather attention is given to the ICZM framework where the technologies find application at present or could find application in the future. The assumption on the base of the present discussion is that activities undertaken in the Coastal Zone involve a sequence of problem recognition, planning, implementation, and evaluation phases. The problem tackled within the Demonstration Programme is how to make such sequence compatible with the needs of Integrated Coastal Zone Management even when triggered by Sectoral Issues.

What makes the Coastal Zone special with respect to other environments? What makes it unique the investigation of certain issues for the Coastal Zone? Generally speaking, just to mention a few distinguishing factors, we recall: (i) the fact that it is a region of interface, (ii) the fact that dynamics are most of the time faster than elsewhere, (iii) the fact that the Coastal Fringe represents a physical boundary, (iv) the fact that the Coastal Zone is submitted to the occurrence of problems generated elsewhere, (v) the risks. All such factors induce peculiarities on the on those technologies that can be applied to look at the Coastal Zone or to act on the Coastal Zone. The big issue is how to really use technologies to increase the number of available options and to enhance resilience, while decreasing vulnerability.

The Present Report.

Technology is a tool to increase the number of available options and to enlarge the freedom of action of Society to achieve certain objectives. Technological progress accompanied and sustained "the progress" in every field of human activity. In the present context "***technologies***" are considered as being either:

- those technologies that play a role in the definition of a ICZM strategy and the full implementation of the ICMZ tasks (***ICZM-enabling***), or

- those technologies which are adopted for specific sectoral needs but are compatible with ICZM strategies (or neutral with respect to them) or are such to decrease the adverse effects of coastal resource use activities (***ICZM-friendly***), or
- those technologies that are necessary to correctly implement or safeguard the implementation of ICZM plans and strategies (***ICZM-supporting***).

Implicitly we consider those technologies which are not ICZM-friendly as being counter-ICZM. As far as the issue of ICZM-friendly technologies is concerned, the question arises whether technologies used to support sectoral issues are really relevant to ICZM? The risk is to a certain extent that of having an ill-posed problem here and a discussion could be opened around such question. Certainly they are most of the time relevant to the sustainable development of the Coastal Zone and, at the extent that ICZM is a way to achieve sustainable development, they should be considered as part of the process. In other words, this also means that any ICZM plan should not underestimate the importance of the requirements and of the impacts produced by sectoral uses of the Coastal Zone and, namely, by those technologies that are there to make such uses possible. As far as the issue of ICZM-supporting technologies is concerned, it has to be noted that interventions are most of the time required to respond to the occurrence of a problem. In a more proactive approach, interventions can also be undertaken prior to the full occurrence of a problem.

The Content.

First, we briefly examine some technologies and methodologies that can most likely play a role in ***supporting ICZM activities (Chapter 2)***. Roughly speaking, we can say that the technologies and methodologies hereby introduced belong to the class of the “ICZM-enabling” technologies. ICZM-enabling technology are functional to the implementation and the success of the ICZM action.

Second, we examine in brief detail some ***sectoral issues contributing to the exploitation of Coastal Zone Space and of its Resources (Chapter 3)***. For some specific problems connected with such issue, the idea is that of presenting an example of the “technological side” of the possible solution. Roughly speaking, we can say that the technologies hereby introduced belong to the class of the “ICZM-friendly” technologies.

Third, we focus the attention on more specific, and typically more local scale, ***problems connected with or derived by sectoral uses of the Coastal Zone (Chapter 4)***. The idea, again, is that of presenting, in very crude terms, the “technological side” of the solution. We can say that the technologies hereby introduced belong to the class of the “ICZM-supporting” technologies.

We report upon the ***analysis of the Questionnaire submitted to the Project leaders of the Demonstration Projects (Chapter 5) complemented by Project visits***. What is immediately apparent is that the main technologies being considered in an explicit way by the Demonstration Projects are those related with “Information Handling”. Geographical Information Systems (GIS) play a role in the large majority of the Projects. Such outcome is certainly coherent with the fact that the large majority of the Projects focus on Planning and, following a more general trend, with information technologies that increasingly pervade all industrial and societal activities. Europe’s industrial competitiveness, its jobs, its quality of life and the sustainability of growth depend on it being at the leading edge of the development and take-up of information technologies. Also, by enabling communities in remote and rural areas to overcome isolation and to “compete in the global economy”, information technologies contribute to “cohesion” in the European Union. At the same time, the technologies underpinning the development of the information society are in rapid evolution. Advances in information processing and communications are opening up exciting new possibilities. However, large gaps still exists between scientific and technical community and the end-users community, the main problem being the different attitude toward existing uncertainty. This would ask for a complete re-orientation of current scientific approaches. Specific technologies for information gathering, information development and information use are increasingly being developed. For space limitations we do not discuss them here.

We also identify possible ***policy actions that could be adopted to promote the informed application of technologies in ICZM (Chapter 6)***. The options presented are derived, to a large extend, by a study undertaken by OECD concerning policies to promote technologies for cleaner production and products. The possibility to adopt any of such policies within the ICZM process has been investigated by a Questionnaire circulated among the National Experts representative of the Member States. The possible actions to be undertaken in the context of the possible "promotional policies" listed in Chapter 6 can suggest possible actions at EU level, at member States level, at local level, etc. It is in our opinion very well possible to make the large majority of existing policies more Coastal Zone (and particularly more ICZM) focused.

A Conclusive Discussion, as well as Specific Conclusions about the Role of the European Union, are summarised respectively in Chapter 7 and Chapter 8.

Summary Conclusions.

The Success of GIS with the Demonstration Projects

"Technical capacity" encompasses hardware, practices and human skills. The most widely used technologies in the Demonstration Projects were related to resource inventories, analysis, and monitoring. In almost every Project a database of some sort was used, and many also used a ***Geographical Information System (GIS)***. Only a few case studies reported the use of remotely sensed data, such as satellite images, for inventories and monitoring. It is important to note that skilled human resources were necessary for the utilisation of all of these technologies.

Technologies in the Demonstration Projects

In general we must say that technology is not commonly considered as being an integral component of the ICZM loop even when the coastal zone being considered is actually "full of technological solutions to sectoral problems". From a functional point of view, this appears to be a potential limit to the effectiveness and the success of the ICZM initiative. It is like planning a trip or driving in the dark and in the country without knowing if the car has functioning lights or not, without knowing whether a all-terrain car or a luxury car is available, and without knowing whether there are sufficient seats for all the passengers or not. Even worst, there is no consideration about the availability of fuel along the path and there is no consideration about the state of the road and whether or not the road will be able to "sustain" the car. Situation at moment appears to be at the level of using a map to choose the path (the data collection stage, with possible utilisation of GIS technology) and with all the possible passenger "fighting" to change the path according to their own needs. Of course, to drive it is not necessary to be an expert of mechanics, but having a driving license and not too many hands acting on the steering certainly helps a lot.

State of the Art on Technology in Relation to ICZM

A large number of technology reviews are available on the literature concerning technologies in all the possible sectors of activity. In addition technologies are largely discussed in relation with their impacts on the environment. Nevertheless, it has to be noted that there is no tradition of looking at technologies (and particularly those technologies introduced to satisfy sectoral needs) as being an integral factor in determining coastal processes and, as a consequence, an integral element in ICZM. In a ideal or mature ICZM environment, where all levels of management work properly, this situation could very well be sustained and the "quality" of the ICZM action would be guaranteed anyway. Problems arise in consideration of the fact that we are still at an exploratory stage in ICZM, where pioneers are travelling in an uncertain environment. We are not yet at a stage when it is just possible to "jump on a bus with the clear indication of where it is going and how".

The Level of Sophistication

The level of sophistication of technologies used in the coastal zone varies significantly. ***Several underlying conditions appear to be related to the level of technological sophistication employed***. Case studies in urban coastal areas always feature the use of highly sophisticated technologies, while those in rural coastal areas show no preference between high- and low-tech approaches. This suggests that where natural and human interactions are more concentrated, more advanced technical capacity is required to understand and monitor them. It may also indicate a bias toward dedicating resources to solving urban problems.

We can say that while the role of technologies as a support for problem assessment is recognised and the use is increasing fast, the role of other technologies is not explicitly recognised. However, opportunities exist for speeding up the process of utilisation of more environmentally-friendly technologies by recognising their role in relation with ICZM. The potential is there, particularly since there are alternatives for the "attribution of costs".

It appears that the level of sophistication is partially determined by available funds and human resources, and by the scale of the coastal problems being addressed. It seems that the use of more expensive, sophisticated technologies can be justified in cases where funds are available. On the other hand, it appears that much can be done using "low-tech" methods if funds are limited. Unfortunately, no information is available on the cost effectiveness of particular technologies.

The Connections

Looking at the other Thematic Analyses, we can argue that Participation and Sectoral Cooperation greatly benefit from the provision of Objective Information about the status of the Coastal Zone and about the Coastal Dynamics. Information Use and Information Development processes all start with Information Gathering which is quite often, a technological problem. The existence of "facts" constructed by integrating the available (scientific) knowledge with the available information help achieving mutual understanding and acceptance assumed that uncertainty is properly handled. The availability of an integrated knowledge, possibly implemented into specific Decision Support Systems, could be extremely beneficial also to evaluate "off-line" without actual implementation, the role of possible amendments to EU Policies and of role of possible Legislation.

The Ideal Target

The ICZM initiative itself could probably bring to the direct deployment of technologies that are functional to the planning and management actions. On the contrary, it is hard to imagine that ICZM can by itself lead to the application of sectoral specific technologies. Certainly the recognition of the role of such other technologies in determining the coastal dynamics and driving coastal changes, could lead to ICZM determining the choice of ICZM-friendly technologies, when the choice is possible, and to the more rational use of ICZM-supporting technologies, when these are justified. Three additional criteria may help in directing choices and defining priorities: (*i*) define problems at the right level; (*ii*) manage problems at the right spatial level; (*iii*) use composite instruments to achieve multiple aims. According to our classification of technologies, the ***ideal target for the informed application of technologies in relation to ICZM*** could be:

- ***Introduce*** those ICZM-Enabling Technologies which are useful for the ICZM initiative;

- ***Better Use*** of existing and/or required Sectoral Technologies and preference to ICZM-friendly technologies, when options are available;
- ***Avoid the Use or Remove*** counter-ICZM Technologies;
- ***Coordinate*** the deployment and the use of ICZM-supporting technologies.

Such classification also implicitly suggests the key to tackle the problem of the creation of the necessary technical substratum to sustain such technologies. It also implicitly suggests the key to tackle the problem of financing technologies.

Possible Specific Objectives

Concerning the possible role and use of those technologies specifically introduced to serve the needs of Coastal Zone Management, the application of tools for sustainable management requires to apply conventional management approaches in a more informed way, with a more sophisticated understanding of their limits, and within a broader framework informed by ***systems thinking***.

Concerning the possible role and use of those technologies introduced to serve the needs of sectoral uses of the Coastal Zone, it appears that the adoption of best environmental practice (BEP), best available techniques (BAT) and integrated pollution prevention and control (IPPC) to those technologies adopted to satisfy sectoral needs in the Coastal Zone represent an important factor of "Coastal Zone Protection" at least for what concerns the "pollution-related" issues and problems.

Concerning Policies, Voluntary Agreements and the possibility to adopt Eco-Labelling schemes, Environmental Impact Assessment, Environmental Audits and Environmental Reporting, and Education about Environmentally-friendly Technologies can play a major role for the promotion of the informed application of technologies with reference to ICZM.

The Role of the EU

While waiting for the definition of a European Strategy for ICZM, still there are possibilities to anticipate actions at European level that could ameliorate the "use" of technologies, such as: (i) ***"Define"*** the Framework for technologies in relation to ICZM, (ii) ***"Trigger"*** the proper consideration of the role of technologies, (iii) ***"Support"*** the adoption of enabling and supporting technologies for ICZM, (iv) ***"Suggest"*** and/or ***"Impose"*** the adoption of ICZM-Friendly Technologies, (v) ***"Adapt"*** Individual EU Sectoral Policies, (vi) ***"Promote"*** coastal zone specific EIA and SEA, (vii) ***"Raise awareness"*** about the beneficial effects of the informed application of technologies, (viii) ***"Enable"*** ICZM, (ix) ***"Develop"*** clearinghouses of information/guidelines about good or bad practices.

The Warning

Finally, in a thematic analysis that discusses the role and use of technology one might lose sight of the fact that technology by itself is not a solution to existing problems. Technologies can provide an important contribution to the sustainable development in coastal zones, but their effectiveness depends strongly on the economic, institutional, legal and socio-cultural contexts in which they are implemented. In ultimate analysis their effectiveness depends strongly on the goodness of the existing management framework (on the "humanware" and on the "orgware"). However, at the end of such analysis, with all its limits, its subjectivity, and its arbitrary character, the need to recognise that technologies are there anyway, independently on how integrative the coastal zone management initiative can be, is an important prerequisite to make the better and more sustainable use of technology.

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1. INTRODUCTION.

1.1 The Context.

The present report concerns the thematic analysis on the Role and Use of Technologies in relation to Integrated Coastal Zone Management (ICZM), conducted on behalf of the Commission of the European Communities, DG XI, in the context of the Demonstration Programme on ICZM[1].

We cannot start a discussion on the Role and Use of Technologies in relation to ICZM without looking at definitions. We adopt a broad definition for technology, identifying four aspects: facilities (hardware), knowledge (software), skills (humanware), and institutions (orgware). In the present work, we will mainly focus on the hardware and the software, touch the humanware, and mention the orgware.

Technology, and technology innovation in particular, introduces new capabilities or allows old functions to be performed with "greater efficiency". Technology can be defined as a malleable element of an organisational structure (Orlikowski, 1992), that is, a set of rules and resources that enable some actions, while constraining others, and that are in turn shaped by those actions over time. Orlikowski (1992) traces a three-way cycle of mutual influence between institutional properties, technology, and the human agents who use and build the tools within the institution. Similarly we can look at a cycle of influence between organisational, technological, and policy/planning structures, and the actions Societies perform within those structures (Fig. 1.1).

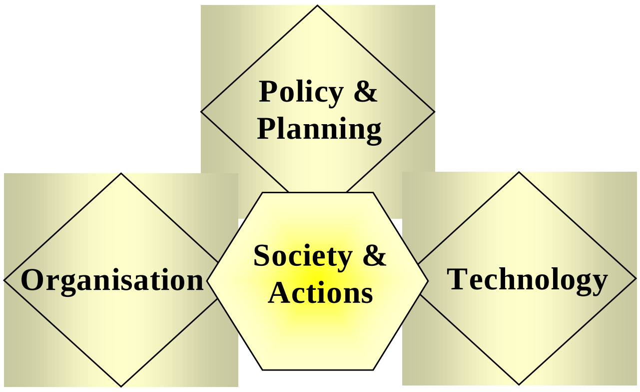

Fig. 1.1 - Mutual Influence of Technology, Organisation, and Policy/Planning on Society and Actions

Innovation on technology begins from scientific understanding, but than has to be supported by societal and market demands and has to be confronted with the growing demand for sustainable development (Herz, 1996). Technology plays a key role in the development of modern societies. It is difficult indeed to find a sector of human activity that is not being profoundly influenced by the application of technology and related innovations.

[1] *To "ensure optimal exploitation of the diversity of expertise already available with the Demonstration Projects", six thematic analyses have been undertaken: (a) Legal and Regulatory Bodies: Appropriateness to ICZM; (b) Participation in the ICZM Processes: Mechanisms and Procedures Needed, (c) The Role and Use of Technology in Relation to ICZM; (d) Planning and Management Processes: Sectoral and Territorial Co-operation; (e) Influence of EU Policies on the Evolution of Coastal Zones; (f) The Nature of the Information Required for ICZM. For more information as well as for connection with the other thematic analyses, reference can be made to http://europa.eu.int/comm/dg11/iczm/home.htm.*

The Coastal Zone is at the cross-road of a number of sectoral issues which originate a number of often competing uses (Greco, 1990; Vallega, 1992; Goldberg, 1994). To undertake such uses there is often (if not always) the need for the adoption of suitable technologies, in a more or less explicit way (Capobianco, 1998b). This means that technologies are here primarily applied to satisfy the sectoral issues for which they have been introduced. The point is thus that of evaluating the compatibility of such technologies with possible Coastal Zone Management or Integrated Coastal Zone Management objectives.

The capacity to satisfy the need of the growing population of the coastal zone depends upon technology. Only environmentally-friendly technologies can enable the production of more goods and services at less cost to the environment (NTSC, 1995). The enormous increase of production which has taken place in the industrialised world in the past century, has primarily been caused by technological progress. It has however to be mentioned that technology has become a controversial issue in the western society in the past decades, particularly in relation with the impact of technology on the environment.

An enormous need for environmental technologies is becoming apparent, however the demand is still following with some inertia. Up to now the deployment of environmental technologies in the most industrialised countries has been a product of societal intervention rather than market forces. Direct government expenditures, regulation, the threat of liability and, to a still rather limited extent, consumer choices have been examples. Greater use of environmentally friendly technologies is nowadays an on-going process in many fields of activity, however it is also apparent that there are opportunities to speed their deployment (Heaton et al., 1994). Some recommendations are here provided, of course without the presumption to give ready on the shelf solutions but with the objective to propose some ingredients that can be part of site-specific recipes.

To what extent environmentally-friendly technologies are really important in the discussion on ICZM? After all they are consequence of decisions about the activities to be undertaken in the Coastal Zone? They can be extremely important in specific situations. Look as an example at the whole discussion about the possible construction of mobile gates to protect Venice from “acqua alta” (high water) events... (Penning-Rowsell et al., 1998; CVN, 1993-1998). This unique piece of technology, if really installed, is going to affect Venice Economy, Environment, Society in a way that cannot be underestimated and that is certainly going to shape any possible ICZM initiative in the area.

Pollution, erosion, lack of space, etc. are all legacies of yesterday’s technology. They results from products, processes, systems, and activities all designed in an age when environmental concerns were largely ignored. Not only this, but also the dependency of such products, processes, systems, and activities on the environmental resources, was not recognised. Nowadays they are all at risk, not just the environment, but also the economic return and the social well-being. Legislation is largely covering all such technology-related problems and technology implementation is more and more conditioned by legislation (for the Italian situation, just to give an example, see Maglia and Santoloci, 1996), even if a coherent and organic picture is missing in many countries.

Technologies are here considered according to an extensive definition: technologies may represent a support to "look" at the Coastal Zone and a support to "act" on the Coastal Zone. We cannot list here all the technologies that can be involved in the development of a specific Coastal

Use; this is certainly a task that goes beyond the scope of our work. At same time is not necessarily relevant to the examination of the role and use of technology. We rather discuss the idea of friendliness of those technologies that are normally there for other purposes than ICZM which can be sometimes not compatible. It is our opinion that such judgement of friendliness is a basic requirement that has to be satisfied and will increasingly be satisfied by applying Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) regulations. If a choice amongst two technologies or two technical solution to a given problem is possible than the idea of friendliness call for that choice which is not incompatible with ICZM objectives.

We discuss a number of issues and a number of more specific problems. They certainly do not represent a complete list, however they cover in our opinion some important categories that either trigger or justify the adoption of specific interventions for the Coastal Zone. Purpose of the present document is to briefly introduce such issues and problems having with the aim to investigate the Role and Use of Technologies in relation to Integrated Coastal Zone Management.

1.2 Investigating the Role and Use of Technology.

While investigating the Role and Use of Technologies in relation to ICZM we immediately have to confront ourselves with the need to clearly define the terms[2]:

- ***ICZM***, "ICZM involves the comprehensive assessment, setting of objectives, planning and management of coastal systems and resources, taking into account traditional, cultural and historical perspectives and conflicting interests and uses";
- ***"in relation to"***, we give an extensive interpretation to the type of relation, distinguishing between those technologies that actually play an explicit role in the implementation of Integrated Coastal Zone Management practices and those technologies that are in a sense ICZM-"compatible" or ICZM-"friendly" or, in other words, those technologies that are in direct relation or in indirect relation;
- ***"technologies"*** are thus either those technologies that play a role in the definition of a ICZM strategy and the full implementation of the ICMZ tasks (ICZM-enabling), those technologies adopted for specific sectoral needs but are compatible with ICZM strategies or are such to decrease the adverse effects of coastal resource use activities (ICZM-friendly) and those technologies that are necessary to correctly implement or safeguard the implementation of ICZM plans and strategies (ICZM-supporting);
- ***Role***, in principle any technique could play a role either now or in the future, either in a direct/explicit way or indirect/implicit way;
- ***Use***, we refer to the actual use (and misuse) as well as to the potential use.

All those technologies which are not ICZM-friendly (either neutral or beneficial with respect to the ICZM action) are considered to be counter-ICZM. In practice this category can be considered to include all those sectoral technologies that produce impacts on the coastal zone and affect, directly or indirectly, sectors of activity different from the ones for which they where introduced.

2 We adopt here a "working definition". Coastal Zone, Coastal Zone Management, Integrated Coastal Zone Management, have a number of undetermined elements and subjective aspects in their definition which we do not enter here. Just to mention the fact that ICZM can also be considered a tool to achieve Sustainable Development objectives on the Coastal Zone, with all the indeterminacy that also characterises the definition of Sustainable Development (Capobianco, 1998c; Capobianco, 1998d).

Implicit in this classification scheme is an attribution of a "quality status" or an assessment of the possible benefits and impacts connected with the application of the technology. We necessarily keep such assessment at a quantitative stage in the present context; it would be part of a further examination of the issues, the attribution, case-by-case, of a quality status.

It would certainly be easy to restrict the attention to those technologies that actually are, or could be, applied in the practical development and implementation of ICZM tasks (the ICZM-enabling technologies and the ICZM-supporting technologies). It is however certainly worth having a wider view and consider the role and use of those technologies that are there to allow for the use of the coastal resources while giving some requirements for the ICZM-compatibility (the ICZM-friendly technologies).

The fact is that while looking at the status of technologies applied in the Coastal Zone, it is certainly relevant to consider that many technologies are there since a long time and for many reasons certainly different from ICZM. In many cases the need to maintain, or even extensively renew them, arise. On the other hand, many technologies could be considered for future implementation and their impact should be carefully assessed and mitigated.

1.3 The Problem Oriented Viewpoint.

To classify Technologies from a more practical "problem-oriented" viewpoint, we distinguish the following activities (of course they do not provide an exhaustive list, rather their aim is to serve as a starting point for discussion):

- ***problem assessment***, those activities aimed at monitoring and observing certain processes, assess and evaluate the extension of certain phenomena or events (e.g. a monitoring activity and the adoption of Geographical Information Systems);
- ***problem prevention***, those activities aimed at protecting the coastal area from the possible occurrence of certain phenomena or events and/or reduce the risk of their occurrence (e.g. the construction of breakwaters to limit erosion or water treatment plants to prevent pollution).
- ***problem mitigation***, those activities aimed at reducing the effects of certain phenomena or events once occurred or at speeding up the process of restoring baseline conditions, both during emergency response and during rehabilitation phase (e.g. clean up actions after an oil-spill or specific intervention to limit erosion following the construction of a port).

ICZM-enabling technologies primarily, but not exclusively, find their application in the context of problem recognition and planning phases; ICZM-supporting and ICZM-friendly technologies primarily, but not exclusively, find there application in the context of the intervention phase (followed by evaluation). In practice, problem assessment activities are strictly connected to the problem recognition phase and the planning phase of the ICZM loop and to the adoption of ICZM-enabling technologies. Problem prevention and problem mitigation activities are strictly connected to the intervention phase and to the adoption of ICZM-supporting and ICZM-friendly technologies

What is apparent is that an issue is something that does not necessarily represent a problem but rather is, more often, the source of problems. Issues are normally related to activities that are undertaken to exploit the Coastal Zone and its resources. Of course there could be specific sectoral problems connected to a given issue that are reinforced by their Coastal Zone location. What is also apparent is that while many issues can have local implication, the way to respond to them is very often not local, even from the point of view of the "technological response". Problems, even if of very general interest, can be tackled at a more local level and have in general a more clearly identified origin (and, as such, a more defined, and potentially simple, solution). In an ICZM framework, issues that originate from the sectoral utilisation of the Coastal Zone require the adoption of ICZM-friendly technologies or technical solutions. Problems require the adoption of ICZM-supporting technologies or technical solutions. The actual definition and implementation of the ICZM objectives require the adoption of ICZM-enabling technologies.

The peculiarity of the marine aspects, as far as technologies are concerned, has to be somehow highlighted. The marine side of the coastal zone poses a large number of practical (and technological) problems to be properly tackled.

Financial aspects are only marginally discussed in the conclusive chapter with reference to the character of technology. The relationship between sectoral activities, technologies, and job creation should also be recalled and taken into consideration while looking at the various technological options (OECD, 1996).

We do not focus directly on any specific coastal typology, even if it is clear that natural, rural, or urban coastal areas pose different requirements. These will be tackled in the following chapters in relation to the examination of specific issues.

1.4 Where Technologies can be Applied.

The management procedure generally comprises a set of related tasks, all of which must be carried out to fully achieve a desired set of objectives (Fig. 1.2). The basic steps involved in the management cycle are: problem recognition, analysis and planning, implementation of measures, and evaluation of the effectiveness of the measures in relation to the stated objectives. Technologies can be employed within each of the basic steps.

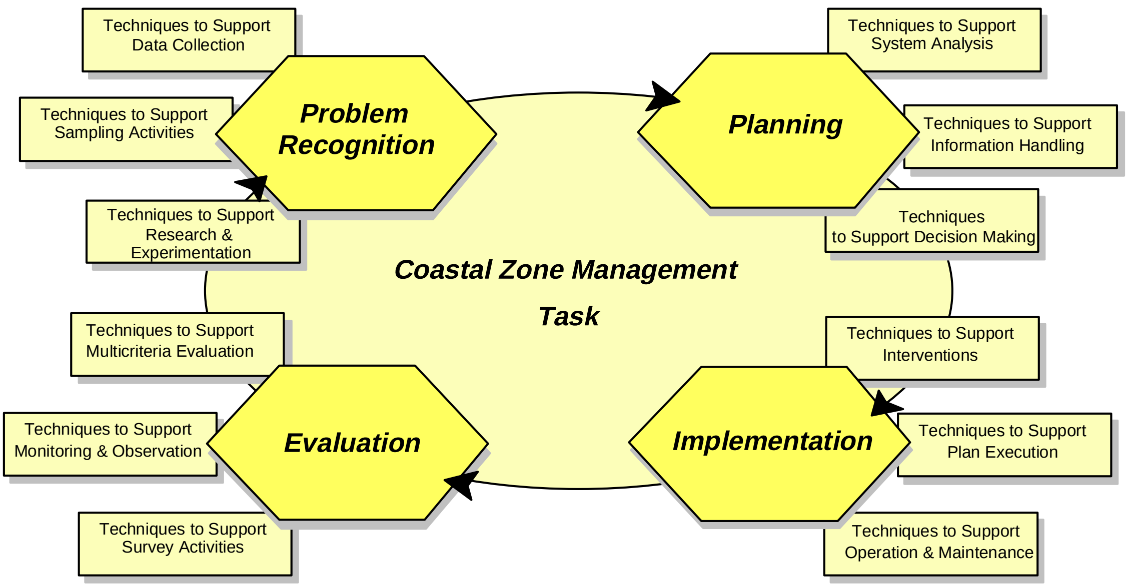

Fig. 1.2 - A Generic Coastal Zone Management Task

The cycle is the indication of a continuos process that should proceed at various levels of responsibility, not of something that is made only once, eventually with the delivery of a "plan". The plan is just the first top level step of an effort that necessarily has to proceed with a continuous feedback of action and at various scales of activity. It is in ultimate analysis the indication of a "distributed control process" on the coastal system.

Problem Recognition

Data collection and information development are essential prerequisites for coastal management, and the more relevant, detailed and accurate the data and information that are available to the coastal manager, the more targeted and effective, management strategies can be. ICZM, while seeking for an optimisation of the management actions that covers various aspects of the coastal zone functioning, necessarily has to be based on a comprehensive information about the past and the present of the coastal zone. It is only in this way that the necessary prerequisites for the rational determination of a sustainable future can be obtained. ICZM requires data and information on coastal characteristics and dynamics as well as an understanding of the potential consequences of modifications of the forcing factors. It is also essential that there is a general awareness among the public, coastal managers and decision-makers of these consequences, and of the possible need to take action.

Technology is beginning to play a more constant role for data collection and information development. Warning systems can be considered in this context: they serve the need to early detect the occurrence of an extreme event that is likely to affect the (coastal) system.

This is a fundamental principle in control system design. The better you can observe the present status of a system, and the better you can use the information about the past evolution of the same system, the better your chances to determine the future evolution according to target objectives.

Planning and Design

When the available data and information point towards a potential problem that would justify taking action, the next stage is to decide which action could best be taken, and where and when this could best be implemented. The answers to these questions depend on prevailing criteria that guide local, national or regional policy preparation, as well as on existing coastal-development and management plans that form the broader context for any adaptation initiative. Important policy criteria that could influence adaptation decisions include cost-effectiveness, sustainability, cultural compatibility and social acceptability.

The effectiveness of the planning decision is also affected by the context in which the decision is made. Traditional coastal management has been top-down by nature, but as public interest and involvement in coastal issues has grown so has resistance to top-down decision-making. The successful implementation of many coastal policies is now increasingly dependent on public acceptance. Hence, in addition to informing the public so as to raise their awareness of the issues at stake, it is also important to involve them in the planning process. Two-way interaction, achieved, for example, by means of public consultation, is a prerequisite for gaining public acceptance.

Again, according to control theory it is much better to integrate the available information and to process it adequately in order to extract the "important" dynamical characteristics, than to "react" immediately to what is observed. Also, the information derived from the data must be integrated with the available knowledge because for a complex system like the coastal zone it is very likely to be insufficient. The problem here is also to avoid the introduction of artificial "instabilities".

Implementation

Once all options for coastal management have been considered and the optimal strategy has been selected and designed, implementation is the next stage. We can distinguish here two major driving forces for changes: natural driving forces and human driving forces. An implementation strategy to deal with natural coastal changes can comprise one or more options that fall under the three broad categories protect, retreat and accommodate (Bijlsma et al., 1996). Similarly, an implementation strategy to deal with human-induced coastal changes can comprise one or more options that fall under the three broad categories protect, remove and adapt.

In both cases, up to now the main focus has been on protection, and more precisely on "reactive" protection interventions. This has been the result of two main ingenuity: (i) the lack of an adequate long term planning capacity, (ii) the general perception of the fact that technology could have been an answer for all the problems identified.

With reference to our control system analogy, it is certainly important to consider the widest possible set of implementation options, but even more important for the implementation of an optimal control strategy is the knowledge of the "dynamical character" of the implementation options themselves.

Evaluation

It is common practice in any field of policy that the performance of implemented measures is periodically or continuously evaluated against the original objectives. Such evaluation can yield new insights and information, which could give rise to adjust the strategy as appropriate (NRC, 1995). This post-implementation evaluation must be distinguished from the evaluation exercise that is done to identify the most appropriate technology. The latter can be considered pre-implementation evaluation, and is part of the planning and design phase.

Effective evaluation requires a reliable set of data or indicators (EEA, 1998), to be collected at some regular interval by means of an appropriate monitoring system. Indicators represent a tool for reporting and communicating (e.g. Turner and Adger, 1996) with decision-makers and the general public. They should fulfil a range of properties, including (*i*) a relationship to functional concepts, (*ii*) be representative and responsive to relevant changes in conditions, and (*iii*) be easily integrated within a broader evaluation framework. Evaluation will often be necessary for decades and the monitoring should be planned accordingly. There is limited experience of such long-term monitoring, so in many situations it is unclear which are the most appropriate data or indicators. For physical systems, experience can be drawn from countries where the coast has been monitored for long periods. In The Netherlands, for instance, the position of high water has been collected annually for nearly a century, and cross-shore profiles have been measured annually since 1963 (Verhagen, 1989). Observations of the "natural" evolution of the coast allow trends to be reliably estimated and hence the impact of human interventions on the coast (breakwaters, nourishment, *etc.*) to be evaluated.

In general, the technologies to be used for evaluation are the same as those used for initial description of the coastal system; the character as well as the interpretation of the data can be somehow different. While for problem assessment the consideration of the role f the implementation measures can be considered somehow optional, here it is not.

From a control system theory viewpoint, evaluation is somehow equivalent to the verification of the actual implementation measures “on the field”. Again, this is an essential prerequisite for the conduction of an “optimal control” strategy.

2. SUPPORTING THE INFORMATION CHAIN.

We hereby examine in brief detail some technologies and methodologies that can play an important role in supporting ICZM activities. Roughly speaking, we can say that the technologies and methodologies hereby introduced belong to the class of the "ICZM-enabling" technologies.

2.1 The Information Chain.

The optimum management and the correct and safe use of the coastal and marine resources require the development of effective monitoring tools and the growth of the knowledge of the environmental processes, either natural or man-induced. Together with the parallel development of analysis tools and descriptive and forecasting models, they must constitute the scientific and technological basis for every decisional procedure. At same time it is required to enhance the capabilities to operate at sea also under possibly extreme conditions.

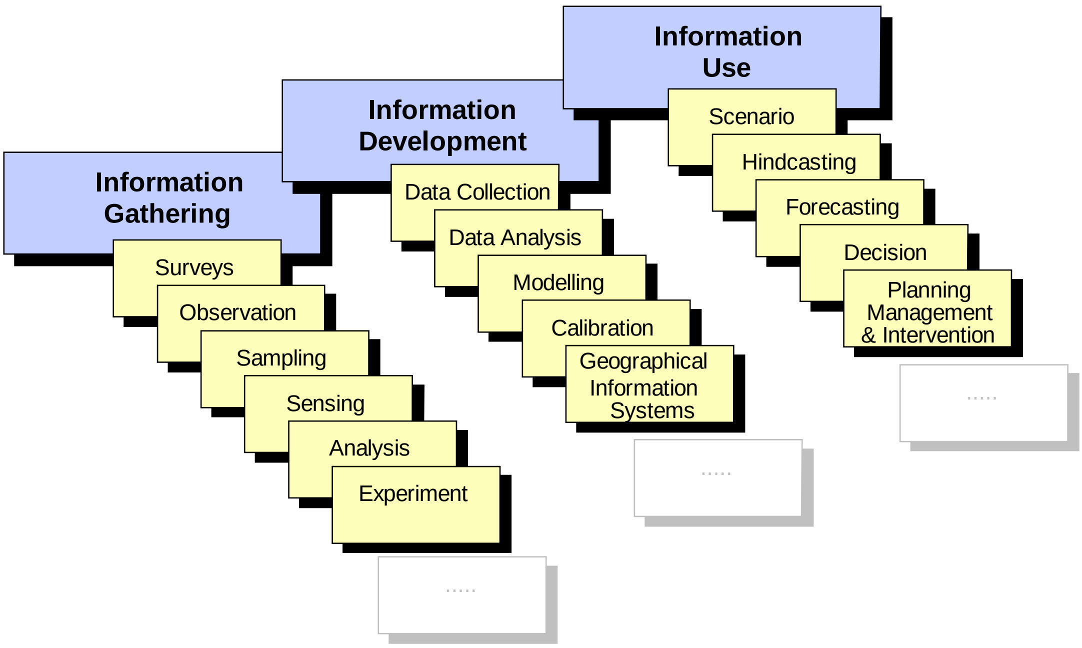

Fig. 2.1 - The "Information Chain"

Much of the information is often in the possession of individuals in various government agencies, research institutes and universities. Further, the data are often collected on the basis of very specific (and often narrow) objectives and in a wide variety of formats-including written records, digital and hardcopy maps, satellite imagery, aerial photography, real-time buoy, seismic profiles, and a range of electronic media. In practice an effort should be made to rationalise the various phases of information gathering, information development and information use (Fig. 2.1). In all the aspects of such "information chain", technologies play a fundamental role. In practice all such activities require a form of technology, in all the four aspects of §1.1: hardware, software, humanware, and orgware. Even more, being more close to the natural "field", the information chain is a perfect example of situation where all aspects of technology are more closely interlinked and cannot be separated without loosing "capacity".

Specific technologies for local scale data collection are now rather well established and potentially available for application. Recent , extensive review of the possibilities are available in the literature (Gorman et al., 1998; Larson et al., 1997; Morang et al., 1997a-1997b; UNESCO, 1996). The offer of technologies there is thus already quite extensive. The request is somehow less clear, even if various recent attempts have been made to determine the user requirements (e.g. ACRI et al., 1995)

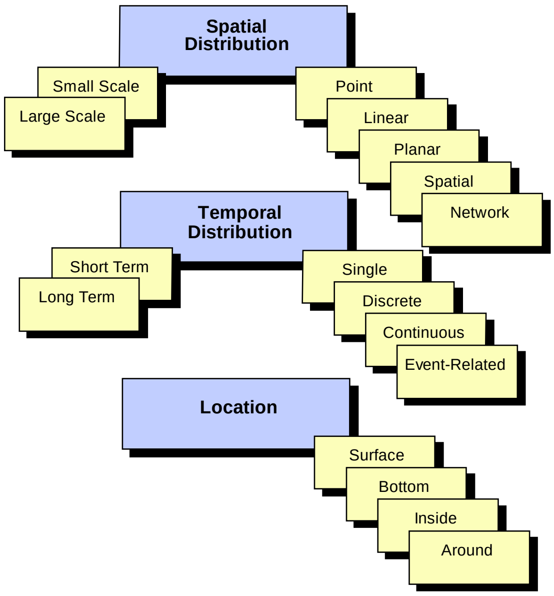

Fig. 2.2 - The Distribution of Measurements

The matter of scale is of fundamental importance, not only to properly focus on the processes but also to identify who is operating for a management task (and what type of technologies should then be used). In practice it is useful to distinguish various classes of measurements according to their distribution (Fig. 2.2). We will briefly recall the possible technologies in the following discussion.

2.2 The Fundamental Role of In Situ Investigation and the Problem of Scales.

2.2.1 In Situ Investigation

The distinction of in situ investigations from other kinds of data collection methods is more apparent in coastal and marine science because the ***in situ rises some technological challenges***. The sea is remote, hostile, highly corrosive to delicate instruments, highly variable in temperature and pressure. The first problem to be solved is in fact to gain "the possibility to be there" in exactly the right place and for the required period of time.

The distinction between surface-based and in situ research in the sea is partly a matter of technical tools that are available to perform the work and partly a matter of philosophical approach to the collection of information. Since technical distinctions can change as technology advances, it is probably better to define in situ research from a conceptual point of view. From the point of view of the marine scientist it has three important characteristics:

- ***it is direct***, in the sense that it is possible to see what scientists are doing while they are doing it;
- ***it operates on a small scale***, allowing scientists to study places, objects, situations and events that are not resolved by other means;
- ***it is directly within the environment*** and permits scientists to observe things that do not exist outside it.

The first point of view actually requires some conceptual distinction in relation to the growing possibility and to the necessity to have "real time operating scientists" substituted by a "real time autonomous systems". This is particularly true when moving from point to large scale investigations and from short term to long term. The second point actually puts a limit on the physical area that can be interested by real in-situ investigation; the quantitative definition depending on the scale of the specific process being considered. The third point aims to exclude remote-sensing or indirect techniques which do not directly focus the attention on the relevant process or on others strictly related but to quite indirect ones and also to exclude destructive approaches that could alter the characteristics of the observed objects.

In an ideal situation in situ work should be guided by real-time information on where the investigation is being performed and what is happening around. By having a direct connection with the surroundings it is possible to decide from moment to moment how to interact with them to accomplish the specific goals. In contrast, the conventional use of dredges, grabs and nets is a blind groping for things that might be there but not necessarily are. Field oceanographers are increasingly able to direct these sampling devices with information on temperature, chlorophyll, acoustic scattering or bottom topography, but these are mostly indirect guides, separated by lags of time and interpretation from the sampling of what is really wanted. By being there directly, scientists can ***add human vision to the electronic data collection***. Vision is the fastest and most accurate mechanism for the recognition and interpretation of patterns. This is especially important in biology and geology, which depend on the comprehension of the relationships among objects and events that are qualitatively diverse, heterogeneously distributed and, in the sea, sometimes completely unpredictable.

Ship-based operations are expensive and need huge amounts of personnel time. Even so, there are severe limitations to the spatial coverage, which can be achieved with ship surveys. Buoy-based measurements provide an alternative in terms of reduction in personnel time, but the costs of their operation remains high and they produce time series at points rather than sections along a track. Mounting of sensors for certain atmospheric and oceanic variables on navigational buoys in inshore waters may reduce such costs. This may also help to reduce losses due to sabotage since most people are aware of the importance of the navigational buoys to their safety.

2.2.2 The Problem of Scales

The sea is a complex system, made up of lots of randomly distributed little places with their peculiar character. Depending on where we look, the properties we observe, the resolution of investigation methods, and the time and space scales on which such methods work, we may find the marine environment to be widely uniform or be wilderingly diverse.

Each of the available investigative techniques works best on only one scale (Fig. 2.3). The use of inappropriate methods, or generalisation from one scale to another, has frequently led to misunderstanding and disagreement. Processes on one scale may have effects on another and each one may be invisible to methods that detect the other. This is a typical problem in natural science. Oceanographers have long been frustrated by the gap between the scale on which major physical, geological and biological processes occur in the ocean and the scale on which we can collect information about them.

Historically, investigations have been done at the mesoscale, constrained by human endurance and the range of ships and gear to distances measured in kilometres and duration in days or weeks. On this scale fall most of the data on productivity, population dynamics, grazing effects, biogeochemical cycling and fluxes that compose biological oceanography today, as well as the grab and dredge samples, sonar and magnetometer surveys of geology and geophysics. Even on this scale, usually it is not possible to collect information synoptically and simultaneously, and this creates uncertainty in extrapolating up or down from one time or space scale to another.

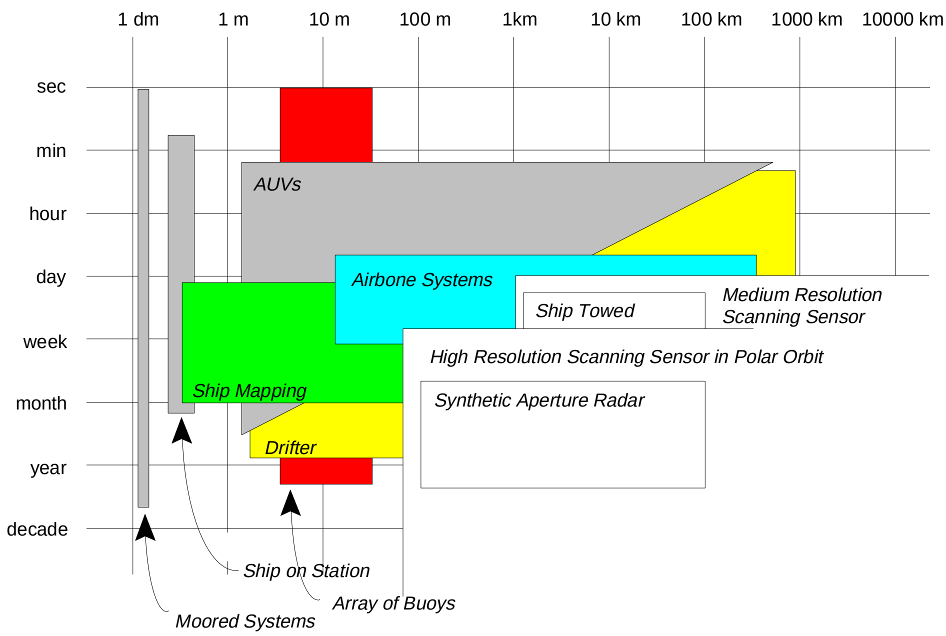

Fig. 2.3 - Available Technologies for Monitoring and Observation

Longer scales of observation have been growing in the recent past, as far as technological advances have enabled scientists to place instruments that may work for longer periods without the need of human assistance. Developments along this line are in progress and new ideas are required also for deep sea bottom investigations.

Larger scales of observation have only been made accessible recently, as satellites for observation or telemetry have enabled scientists to scan large areas of the ocean from a preferred point never before attainable. For those manifestations of meteorology, physical oceanography and biology that are visible to electromagnetic remote sensors, satellites can make observations on the long-sought global scales.

2.3 From Aerial Photography to Remote Sensing.

Coastal Management needs spatial information. Aerial photography is the most widely used form of remote sensing and is a well-established source of information within coastal studies. Photographic products (including black and white, colour and infra red imagery) have been used extensively for applications such as morphological and vegetation studies, prediction of storm surge penetration, and monitoring of land use change and environmental quality.

Although aerial photography has been used in a wide range of coastal applications, its most extensive use has been for determining rates of shoreline change. The information derived from such analyses is necessary for optimal planning of shore protection programs (e.g., beach renourishment projects) and provides a basis for delineating Coastal Hazard Zones.

The efficient management of marine resources and effective management of activities within the coastal zone is, to a large extent, dependant on the ability to identify, measure and analyse a number of processes that operate or react together in the highly dynamic coastal/marine environments. In this regard, measurements are required of various physical, chemical, and biological features of both the coastal and open sea.

Since the advent of high resolution, large-scale aerial photography in the 1930s, coastal scientists have made extensive use of data captured using remote sensing devices. Intrinsically, remotely sensed information offers numerous benefits which have been utilised in a wide variety of coastal and oceanographic applications. These benefits may be broadly classified as follows:

- ***Spatial scale.*** Remotely sensed products are available at a wide range of spatial scales. This enables analyses to be undertaken at both macro and micro scales, which is often a requisite of coastal research,
- ***Unbiased content.*** Remotely sensed data are collected objectively, unlike some conventional methods (e.g., visual estimation of wave height),
- ***Repetitive coverage.*** An historic investment in aerial photography means that much of the world's coastal margin has been photographed several times since 1945. More recently, the development of artificial satellites has provided the capacity for continuous coverage of the earth at a variety of spatial (and spectral) resolutions,
- ***Economy and efficiency.*** Remote sensing produces spatially continuous snapshots which simultaneously record the conditions within a given study area. Such a facility is often unobtainable using conventional sampling method (e.g., land-based surveying).
- ***Reduced data acquisition costs.*** Newly acquired "high resolution" (1m ground resolution) optical imagery of any region of the world will be sold on a per unit area basis. Although prices are indicative at present, the policy of each vendor is to price their products at the same rate or lower than aerial photography products of equivalent quality. Increasing competition among space imagery suppliers will also ensure that space imagery remains cost competitive;
- ***Improved cloud penetration***. radar imagery can be used for some civil engineering tasks in regions where cloud prevents aerial photography and high resolution optical imagery from being used;
- ***Non-intrusive data collection.*** Imagery can be obtained of many areas of the Earth where access to aircraft is restricted (eg close to airports, sensitive areas and sites controlled by non-cooperative parties);
- ***Reduced processing and integration costs***. information from satellites can be processed to order (eg to a specified ground reference system) and delivered in user-specified hardcopy or digital formats;
- ***Reduced delivery time.*** Particularly for imagery from locations where access is restricted: information from satellites can be delivered to the user in a matter of days.

Different remote sensing capabilities exist for the provision of the required information involving one or a combination of measurement techniques (in connection with the requirements of civil engineering, see for instance Smith Engineering, 1997). The type of sensor that is utilised is dependent on the spatial, spectral and temporal requirements of a given investigation-with the most common types of sensor used being high precision aerial mapping cameras and a variety of earth-orbiting satellites. Satellites which observe and provide images of the Earth can be a cost-effective source of such information for many coastal management tasks. At present, existing map data is usually supplemented by aerial photography. However, new sources of information from Earth observation (EO) satellites are becoming available, which offer distinct advantages and benefits over aerial photography (ESA, 1995).

For remotely sensed data, the advantages of end to-end digital processing are enormous, but are only just starting to be realised. Aerial photograph is not yet obsolete, but a stronger challenge will emerge from the combination of digital aerial survey with Digital Photogrammetric Workstations (DPWS). The use of airborne scanners is particularly advantageous as it effectively eliminates some of the geometric distortions in the raw imagery and provides digital input direct to DPWS for final rectification and on-screen mapping. The next few years will see an increasingly widespread adoption of the fully digital approach through the convergence of the software and data, and the gradual replacement of obsolete technology.

Perhaps the most important reason behind the increasing use of satellite imagery lies in their ability to record wavelengths beyond the spectral range of photographic film using a variety of sophisticated onboard sensors. For example the NIMBUS 7 satellite (operational from 1978-1987) carried a Scanning Multi-channel Microwave Radiometer (SMMR) and the Coastal Zone Colour Scanner (CZCS). The CZCS was an optical and infrared multi-spectral scanner which proved to be extremely important for the study of both meso and regional-scale oceanographic processes such as ocean fronts, eddies, coastal currents and phytoplankton blooms. New remote sensing systems are advancing rapidly and producing new data with increasing spatial and spectral resolution. For instance the infrared and microwave sensors on the European Remote Sensing Satellites (ERS-l and ERS-2) can measure sea-surface temperature to within 0.5°C and water elevation to within 50cm. ENVISAT will even ameliorate such performances. As another example, coastal currents can be detected from satellites at regional scale (Crout, 1997) providing important information for the determination of propagation of a pollutant.

Primary Measurement	**Measurable Quantities**	**Phenomena Detected**
Ocean Color (Visible Wavelenght Radiance)	Chlorophyll Concentration Suspended Sediment Yellow Substance Optical Attenuation Coefficient	Phytoplankton Blooms Sediment Plumes Dispersion of Land Runoff Sewage Discharge Plumes Fronts, Eddy Structures Shallow Bathymetry
Infra-red Radiance (Brightness Temperature)	Sea Surface Temperature	Thermal Effluent Plumes Dispersal of Rivers Discharge into the Sea Fronts, Eddies Oil Spills and Slicks
Radar Backscatter Image Synthetic Aperture Radar	Radar Cross-section	Swell Waves Internal Waves Surface Slicks Ship Wakes Bathymetric Features

Tab. 2.1 - Type of Measurements and Observed Phenomena.

2.4 Applications of Satellite Remote Sensing for Coastal Management.

In order to obtain the maximum potential result from remote sensing data it is important to identify the unique contributions and advantages with respect to other measurement techniques. However, theoretical advantages often result in practical difficulties, first of all because only a limited set of variables and then of processes can be observed directly. Today there continues to be a lack of application by the wider marine science and technology community of the significant advances made in recent years by satellite oceanographers and remote sensing technologists.

Due to the aforementioned reasons satellite remote sensing has been used for a diverse range of qualitative and (more increasingly) quantitative applications. These applications can be broadly classified into those that measure geophysical features and processes, and those requiring the collection of water quality parameters.

Although valuable information can be obtained using satellite remote sensing technology, there are substantial difficulties to be overcome and challenges that have yet to be met. For instance the high concentrations of particulate and dissolved organic matter within estuarine and coastal waters tend to make estimates of chlorophyll concentration within these environments rather unreliable. Additionally, microscale features are often difficult to resolve using satellite imagery due to the typically low spatial resolutions of current sensors.

Concerning the future development of remote sensing technology, it has been recommended that tuneable sensors be developed which will enable the data-acquisition parameters (such as radiometric and spatial resolution and the number, width and location of spectral bands) to be customised to suit the specific requirements of each application (e.g RADARSAT, Staples et al., 1997). In this respect the development and deployment of high-resolution imaging spectrometers and airborne LIDAR systems are regarded as particularly valuable for future coastal research.

One of the problems, apparently very simple to be solved from a technical point of view, is represented by the difficulties in accessing remote sensing data in a format directly applicable to the marine environmental problems they are supposed to solve. A number of organisations and laboratories are now developing basic routines for satellite data processing however, because of the required effort with processing the data from just one sensor to a level where it is useful to a wider user community, there tends to be fragmentation of activity. One laboratory specialises in one sensor and data from a different type are processed in another laboratory. Thus the step of combining the observations of different sensors type into a single application are still quite far from being possible. However this is a main

Earth Observation and Coastal Management

Application of EO data in this area is largely speculative as many applications require a high frequency of repeat acquisition and can be linear in nature putting severe constraints on spatial resolution. EO data have been used in harbour construction work, in the identification of areas suffering high sediment load, in the mapping of sediment transport in estuarine environments and to derive relationships between sediment transport and tidal flows. Most of these applications, however, require a regular and frequent acquisition of new imagery and this is often not possible due to orbital constraints and cloud cover (the spectral and spatial resolution of radar data is usually inappropriate)

Sand dunes are important for sea defence purposes and monitoring them for changes in morphology and position can be critical. Dune heights and sand movements can be monitored using DEMs, though the resolution and accuracy required is generally beyond the capability of EO sensors. Some recent dune monitoring programmes have involved using other remote sensing techniques such as laser altimeters which are currently operated from airborne platforms and provide elevation information to accuracies of several centimetres. Experimental studies using this technique have achieved accuracies of 10-20cm in height. However, there are currently no plans for launching spaceborne platforms incorporating these instruments. Very recently, the mapping of sand movement has been demonstrated using radar interferometry, though more work is needed to allow any quantification of results.

requirement for next developments: the synergetic use of data from several sensors in order to derive measurements of ocean parameters which are otherwise unavailable, could make a tremendous difference to the utility of remote sensing data.

2.5 Global Positioning System (GPS).

In conjunction with aerial photography, periodic beach surveys provide a crucial source of information which is used to assess beach stability and predict future shoreline positions. In order to effectively monitor and predict these changes accurate measurements of beach morphology incorporating both shore-parallel and shore-normal transects are required. Although it is possible to monitor beach dynamics using conventional landbased surveying methods, it is generally not practical to collect data of sufficient density and resolution to construct a three-dimensional beach change model over long sections of coastline. Increasingly, coastal scientists are responding to this challenge by employing Global Positioning System (GPS) technology (Leick, 1995).

For applications where high-order accuracy is critical, a differential mode may be used to achieve vertical accuracy in the order of 1 cm. Differential GPS is a data collection and processing technique which utilises two or more receivers to track the same satellites simultaneously. One receiver remains stationary at a known location and the position of an unknown point *(e.g.,* a survey mark) is determined relative to the reference point. DGPS removes common-mode errors, those errors common to both the reference and remote receivers (not multipath or receiver noise). Errors are more often common when receivers are close together (less than 100 km). Differential position accuracies of 1-10 meters are well possible with DGPS

The utility of GPS surveying techniques has been illustrated in several coastal applications (Lyllicrop and Estep, 1995). For instance, it is possible to use differential GPS to establish ground control for aerial reconnaissance. Also “kinematic” GPS surveying techniques, whereby the GPS antenna can be attached to a roof-mounted bracket on an off-road vehicle, are nowadays possible and are in-fact extensively applied to survey the coastline at Duck, North Carolina.

The GPS techniques enables continuous, centimetre level measurements to be collected over a few kilometers in only 1 hour. Such efficiency cannot be matched by conventional surveying techniques which collect data as discrete, static records. As a result of the continuous sampling and increased resolution, alongshore changes in beach morphology can be revealed that remains normally undetected using conventional shore-normal profiling techniques. Additionally, GPS-based surveying methods allow absolute geographic coordinates and elevations to be determined simultaneously without the need for fixed surveying points. This feature is particularly important for post-storm surveys and monitoring of rapidly eroding areas. Finally, the inherently digital format of the data enables it to be directly downloaded to a computer for processing and inclusion into a Geographic Information System for subsequent analysis.

2.6 Telecommunication and Networking Technologies.

The discussion thus far has focussed on technologies which have had a spatial component and are being increasingly used to capture, analyse, and display the information needed for integrated coastal research and management. In many instances the products derived from applied GIS research are enhancing the ability to manage coastal resources within each specific study area. While such an outcome is important the value of these individual research initiatives is limited unless the knowledge they produce is disseminated to the wider coastal community. As the scope and magnitude of coastal management problems continues to grow, it is becoming increasingly apparent that the key to solving these problems is communication and a constantly open flow of ideas and scientific data between scientists, citizens, schools and nations. The following section describes an effective means of disseminating both information and knowledge derived from scientific endeavour, using the Internet.

We should recall here the fact that information technology is attracting formidable investments and will continue to undergo fast developments in the years to come (OECD, 1997a).

2.6.1 The Internet

The Internet is a "wide area network" system which was initially developed by the US Department of Defence to provide real-time access to remote resources (including supercomputers, radio telescopes, weather analysis programs, and scientific databases). Over the last decade, the Internet has experienced a profile rate of growth as a multitude of academic, governmental and commercial agencies have become incorporated into the network. The number of computers joining the network is reported to have doubled every year since 1990. As a result of this exponential growth the Internet has become an exceptionally useful medium for the rapid exchange of current ideas and information.

Electronic mail (e-mail) is the mainstay of the Internet. Using conventional methods, it can take several days to transfer a document from one building to a nearby site and up to a week to exchange mail internationally. Conversely, information (in the form of alphanumerical text, graphics or sound) can be converted to digital form, compressed and packaged, and conveyed over the network to its recipient. Electronic mail provides access to wide audiences of people through the forum of mailing lists. Mailing lists, are e-mail services set up to send messages to a group of subscribers automatically. Several mailing lists have recently been established which cover generic aspects of coastal management and research, as well as more specialised areas such as coastal-GIS and coastal engineering. In addition to e-mail and mailing lists, the online news groups provide another method of fostering communication and discussion among members of the global coastal community. Within such forums users gather electronically to contribute information and ideas which are debated and consequently refined. Of course there is still a significant difference between diffusion in academic and private context and diffusion in public institutions. The gaps is however likely to be covered in the next few years.

> ***The Internet in the Demonstration Programme***
> Within the Demonstration Programme the use of the Internet for communication and dissemination purposes is largely diffused but it is not yet "the rule". A marked difference also exist between the various Countries. The Demonstration Programme itself is serving as a stimulus to accelerate the process of networking.

Given its phenomenal rate of growth, the Internet has greatly enhanced the ability for coastal scientists and managers around the world to communicate effectively on a wide range of topical issues. While the various electronic mail procedures are important, the real utility of the Internet lies in the facility for remote login and file transfer capabilities. By enabling members of government agencies, universities, research and commercial institutions to freely access and exchange information, the Internet has effectively revolutionised the research process.

Possibilities to transfer and exchange information become incredibly user-friendly and increased dramatically since the introduction of the World Wide Web by the CERN laboratories in Geneva. Although the Internet provides access to a plethora of remote resources (both hardware and databases), trying to locate relevant data in this sea of information can be a considerable task. In response to this situation a variety of "navigational" software tools have recently been developed. For instance, the "World Wide Web" enables a user to navigate, in an orderly fashion, through the millions of available files using a series of intuitive menus. In addition to streamlining the data location process the development of such interfaces has also broadened the range of Internet users-enabling non-sophisticated computer users to enjoy the benefits of this modern research medium. In many field the problem is now becoming that of "selecting information" instead of that of "information hunting". We are approaching the stage when it is the user to decide which information to access rather than the provider setting the type of information in advance.

2.6.2 Networking in the Coastal Community.

By joining European facilities and equipment, research programmes become possible at a scale which cannot be realised at the national level. This is essential to make the step from isolated process studies to integrated programmes which address long term prediction of the coastal system. High priority should be given to the building of an adequate infrastructure for coastal research at the European level. Networking by itself uses information technology and communication. There is a need for more movement of people and there is a need to network data.

Special laboratory facilities exist across Europe and it makes sense to share those that are not fully occupied, to prevent undue duplication of capital spends. Coastal scientists should be encouraged to use mechanisms that exist to facilitate such sharing. Sharing of specialised marine equipment is often prevented by the risk of loss, thus some scheme which insures the lender is worth promoting. *An* informal network of research ship operators is in place, and could be expanded to keep an inventory of major sea-going equipment available for loan.

National research programmes in coastal marine sciences added together far exceed the support provided through EC funding. The role that EC funding could play is to solicitate integration, allows for cooperation, stimulate large scale and multidisciplinary activities.

Coastal scientists are using contemporary technologies to ask increasingly complex questions about the coastal environment and its relationship with global weather systems. As a result of this applied research the range and volume of digital information available is growing at a phenomenal rate. In order to efficiently manage and distribute this information, a number of large-scale data repositories have been established in several countries. For instance the NOAA Ocean Data Centre serves as an archive for an extensive array of satellite imagery and derived image products and *in situ* environmental data. Using the Internet, these files may be accessed, downloaded, and displayed using a variety of standard software packages.

It is imperative that such initiatives become more widespread in future for several reasons. First, they provide remote access to both historical and current data, which are often unobtainable from other sources. Second, by maintaining an up-to-date, online database, duplication of effort and expenditure (associated with data capture) are significantly reduced. Finally, the use of these online services tends to promote networking between different institutions and machines.

Building the organisations and institutions that permit people to get together to share data requires great effort. Thankfully, there are many cases where data are shared to the benefit of all. Tools that permit to overcome the technical details of sharing data are continuously being developed. Likewise, there is a need to overcome the human and institutional details of data sharing.

2.7 Geographic Information Systems (GIS).

2.7.1 Possible Uses

Geographic Information (GI) is "information which can be related to a location on the Earth, particularly information on natural phenomena, cultural and human resources". The relation can be a specific set of co-ordinates, or can cover less precise locations or areas, such as addresses, postal codes or administrative boundaries, regions or even whole countries. Most geographic information also includes a time dimension, since the world is not a static place.

Geographic information is a complex, rapidly growing and important part of the information society. New geographic information technologies are developing rapidly (GI2000, 1996):

- GI is used by government offices from local councils to the European Commission - in areas including housing, public services, transport, agriculture and environmental protection - to monitor present conditions and for planning and forecasting;
- In the public and private sector, GI is now integral to planning use of resources for civil and national defense, crisis management and emergency procedures;
- GI is widely used by public and private suppliers of utilities such as electricity, gas, water, sewerage and telecommunications;
- In travel and transport, GI contributes materially to functions such as route-planning and onboard navigation, freight and fleet management;
- Many business sectors also use GI (geo-demographics) with other tools for marketing and planning - for example, to find the best available site for a new industrial park or shopping center;
- Academic uses of GI range from teaching in physical and social sciences to research in disciplines including environmental science and public health.

The study of coastal phenomena generally requires large amounts of spatial data analysis. The data sets involved are typically heterogeneous and are often comprised of data sources with differing scales (both spatial and temporal), coordinate systems, and levels of accuracy. Further, the data originate from source material in multiple formats including text, maps, charts, and remotely sensed imagery (O'Reagan, 1996). Geographical information systems (GIS) are an important technology for spatial planning (Burrough, 1989). It provides a powerful means of not only managing but also combining and analysing spatially-referenced information describing the coastal system (Fig. 2.4). Once created, a GIS database will have further utility in other aspects of coastal planning. It is important to realise that the quality of any planning exercise heavily relies on the availability and quality of the data, models and scenarios that are used. Sophisticated planning and design tools as applied in places may therefore not be directly transferable to other places.

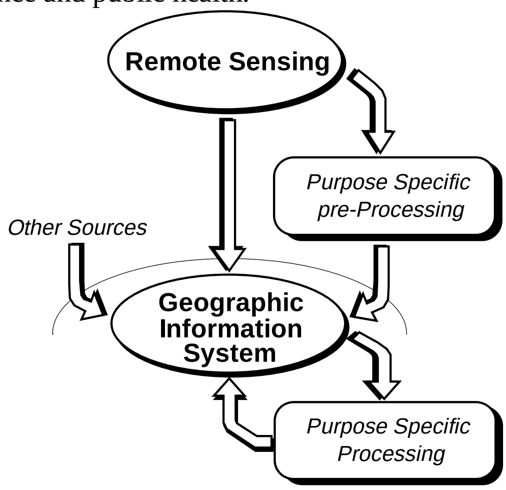

Fig. 2.4 - Processing Remote Sensing Data

A "typical" coastal zone management database may contain a combination of the following items:

- ***Topography, terrain, and bathymetry***: periodic beach surveys, aerial and ortho-photographs, bathymetric charts, soil maps, watershed/catchment information;
- ***Morphological data****:* side-scan sonar graphs, sediment samples, geological bore log data;
- ***Major infrastructure****:* inventory of shore protection structures (e.g., seawalls), roads, marinas etc.;
- ***Forestry and conservation****:* forest reserves, forest types, natural vegetative species, conservation areas, marine reserves;
- ***Coastal fisheries****:* licensing zones, pelagic and demersal fish distribution, commercial aquaculture;
- ***Oceanography****:* variety of physical, chemical and biological oceanographic data, (e.g., historical storm parameters);
- ***Environment***: point pollution sources, water quality data, industrial site locations, sensitivity analyses;
- ***Socio-economic data****:* housing location, valuation data, demographic structure, census information; and
- ***Planning***: cadastral data, past and present land use information, administrative boundaries, Coastal Hazard Zones, development pressure (industrial, urban, aquaculture, tourism and recreation, sand mining), land use capability, environmental constraints.

Important type of processing can be

- ***Long-term change detection*** information (temporal change, spatial variability)
- ***Catastrophic change detection*** information
- ***Risk assessment*** (e.g. Brimicombe, 1992, for flood risk assessment)

The formulation of an integrated coastal zone management plan requires an integrated approach to analysing the complex inter-relationships between the various data sets listed above.

One aspect of these inter-relationships is the spatial linkages among various parts of the coastal zone, and also between the coastal zone and its hinterland through river systems.

Traditionally, the management and analysis of spatial data has taken place in a hard copy environment. However, the use of paper-based Products for complex analytical procedures often proves to be tedious and cumbersome-thereby inhibiting the efficient achievement of goals. In response to this situation, computerised geographic information systems (GIS) are

Bathymetry information

Accurate information about water depth and sea floor morphology is critical for a number of tasks including planning new harbour locations, dredging operations and laying sea-floor pipelines and cables. However, usually constructed from sparsely scattered depth measurements made using sonar or even simple lead-line techniques (Gorman et al., 1998), the general availability of bathymetric maps is poor.

In shallow water down to around 20m depth, both Landsat and SPOT can effectively map water depth, though conditions need to be optimal (eg clear water, lack of suspended sediments and reflective sea floor). Where the use of EO data is possible, results are improved with regular sample spacing proportional to the original satellite data resolution

Demonstration systems exist using radar data in conjunction with echo sounders to assist in the laying of offshore gas pipes where accuracy of 30cm in 30m depths have been demonstrated.

emerging as the spatial data handling tools of choice for solving complex geographical problems. A GIS can be broadly defined as comprising a system of computer software, hardware and procedures designed to allow users to collect, manage, analyse and display large volumes of spatially referenced data and associated attributes.

Metadata are becoming an increasingly important part of data and service provider activities. As the number of available datasets and services grows, it is increasingly important that they are described in a consistent manner to allow potential users to easily identify resources of interest and to assess their suitability with respect to their particular needs (CEO, 1999).

2.7.2 The Utility of GIS Technology

Spatial data sets are unique in providing the geographic locations of features, related to known coordinate systems; in specifying attributes of features that may be independent of location, such as area, cost, and grain-size; and in describing the spatial and topological relations among the elements in the data set. Because GIS are specifically designed to manage and analyse spatial data sets, analysts are able to process and interrelate many more kinds of data than were previously feasible. As a result GIS users have the potential to greatly improve traditional missions such as data collection, research, assessment, and information delivery.

Within the framework of the GIS a variety of analytical, statistical and modelling tools may be used to transform data into information suitable for a given application (EPA, 1999a). The following as benefits which arise from using GIS technology for coastal management can be defined:

- providing a receptacle for scattered data from diverse sources;
- improving the visualisation of such data for space-use management (also 3D visualisation can be made possible, increasing the capacity to examine current as well as possible situations);
- improving understanding of interactions between uses of and linkages between ocean and land-based processes in coastal areas;
- supporting statistical, modelling and impact analyses;
- making better use of remotely sensed data;
- high quality graphical output for dissemination of information; and
- development of efficient data and information management infrastructures.

Numerous authors have suggested that the success of GIS lie "in their ability to transform representative quantities into sensory stimuli which increase ones ability to visualise and perceive localised phenomena". While this quality is not unique to GIS, it is particularly important given that the volume of data collected by existing technologies is increasing at a phenomenal rate.

2.7.3 Applications of GIS Technology within the Coastal Zone

Given its significant advantages over traditional (hardcopy) analytical techniques, GIS technology is rapidly becoming an integral part of coastal management efforts world-wide (Jones, 1995). To date, coastal-zone applications have concentrated on three types of spatial analysis:

- characterisation and measurement of linear and areal features,
- intersection (or overlaying) of spatially referenced data, and
- proximity analyses.

Many administrations have developed or are developing some form of coastal GIS. In the United States numerous regional GIS databases have been developed and maintained using

> ***Risk information***
> SPOT and Landsat TM are often analysed to map the morphology, scale and distribution of landslides at a regional level, allowing the targeting of areas for more detailed airphoto and field study. These data are then combined and integrated (often using GIS) to help determine dominant causes and help map other locations at risk. Such techniques using EO data have been applied to areas in northern Italy where large-scale landslides periodically cause significant damage. The higher resolution (~1m) of new VHR sensors will significantly improve the capability to map such events and assess associated risks, making the use of EO more widespread in this application. Where conditions are suitable, radar differential interferometry has been shown to be capable of mapping the displacements involved in landslip events.
> DEMs derived from EO data, together with other information such as land cover type (derived from multispectral satellite imagery) can be incorporated within hydrological models and used for flood risk mapping. Accurate flood risk assessment requires a dense survey of accurate elevations.

Federal government funding. Topographic maps, land-use/landcover maps, and digital elevation models (DEMs) are increasingly being included into some forms of GIS. High geometry accuracy and functionality of the resulting data model can greatly enhance resource management within the study area. The CoastWatch Change Analysis Project (C-CAP) integrates satellite imagery with GIS technology to monitor land-cover/ land-use changes in U.S. coastal wetland habitats and adjacent uplands (NOAA, 1999). The data are systematically captured every 5 years, and annual coverage is applied to those areas identified as experiencing rapid development or environmental crises (such as oil spills). Image products derived from this initiative constitute an important source of real-time information for coastal planners and resource managers throughout the United States.

In the United Kingdom, GIS technology has been used to address a wide range of coastal management issues, including offshore sand and gravel mining, coastal erosion management and marine species assessments. GIS techniques have also been used to enhance the site selection process for coastal aquaculture by highlighting those locations which meet a predefined set of criteria.

Within New Zealand, the majority of local government authorities have recently purchased GIS hardware and software and are currently capturing and inputting data for future analysis. Although coastal managers within these agencies have shown a growing interest toward GIS, the application of the technology has been extremely limited to date.

The WATER (Watershed Analysis Tool for Environmental Review) Project, at California Coastal Commission, attempts to overcome some of the data access problems by testing the application of information sharing techniques that combine previously incompatible Geographic Information System (GIS) data layers, satellite images, aerial photographs and database information from various sources, and making this data available over the Internet using public-domain software. By combining the information resources of a number of agencies in the region into a single, geographically rectified source, this project will greatly enhance the ability of agencies in the region to develop coordinated multi-agency watershed-based management solutions to nonpoint source pollution problems. For some agencies, the project will provide their first in-house access to a wealth of information that was previously inaccessible because they lacked the resources to purchase, operate, and maintain their own GIS. For agencies already possessing GIS capabilities, the project will provide access to new data sets that they will be able to use to more effectively manage nonpoint source pollution.

2.7.4 Mapping and surveys

One of the prime requirements in any field or engineering operation is to have up-to-date and accurate maps of the area under consideration. Such maps are used for tasks which include logistics planning, road construction planning and environmental impact analysis. Topographic maps are also required by the industry and are used for tasks such as dam planning and routing studies and as essential input to other tasks such as earthquake analysis, landslide detection and line-of-sight analysis.

Digital elevation models (DEMs) manipulated by computer are becoming widely accepted as the norm for topographic study and are normally created by digitising the contours of existing topographic maps. Advances in processing power mean that DEMs are increasingly being created using stereo image pairs. DEMs derived from the new generation of higher resolution satellites should allow vertical accuracy of between 2m and 3m at best (depending on ground cover), which is suitable for visualisation applications such as line-of-sight and impact analysis.

The satellite imagery can then be referenced to the DEM which enables geologists to extract quantified geological information (e.g. the orientation of rock formations and faults). Geological information provides a framework for producing geotechnical maps which illustrate the interfaces between materials (i.e. rock or sediment), the range of materials and other geotechnical data relevant to a specific development

2.8 Coastal Information Systems and Use of Models.

2.8.1 Coastal Zone specific Geographical Information Systems

The power of modern information technologies can be applied to the development of flexible Coastal Information Systems (CIS) as Coastal Zone specific Geographical Information Systems (GIS), to integrate data, including historical, remote and in-situ, with numerical models, with georeferential and with multimedia visualisation capabilities. These will provide the experts with diagnostic capability as well as improving the transfer of information to the wider community of coastal user and policy makers. The dominant concept here is that the transfer of available knowledge should be guaranteed also to the non-skilled decision-maker of the small municipalities.

For management of coastal resources to be optimal, it is necessary that policies be based on informed decision-making. This, in turn, requires ready access to appropriate, reliable and timely data and information in a form which is suitable for the task at hand. Unfortunately, the comprehensive range of information typically required is seldom available and rarely in the possession of those decision-makers responsible for management within the Coastal Zone particularly as far as the marine component is concerned. Practical knowledge of the mechanisms driving both the Coastal Zone system as a whole and its constituent sub-systems is a necessary prerequisite for effective ICZM. In practice such knowledge is surrounded by “uncertainty” introduced by the existence of “limits for predictability” that restrict the range of conditions that allow for the evaluation of coastal modifications. We distinguish (Capobianco, 1998a):

- ***Intrinsic limits to Predictability***, those limits given by the intrinsic behaviour of the Coastal System;
- ***Extrinsic limits to Predictability***, those limits given by the uncertainties related with the forcing factors (think for instance to the possible long term changes of the wave climate and/or the possible modifications of relative sea level);

- ***Scientific limits to Predictability***, those limits given by our present knowledge and understanding of the long-term processes and by the present level of applicability of the state-of-the-art knowledge on coastal processes;
- ***Technical limits to Predictability***, those limits mainly given by our technical ability to describe the initial and the boundary conditions and to provide suitable information to describe what are the long-term and large scale changes for a given coastal system;
- ***Organisational limits to Predictability***, those limits given by lack of co-ordination in organising the available information about the forcing factor and the boundary conditions as well as those limits given by the lack of resources to collect the basic information.

Coastal planners will always face a certain degree of uncertainty, not only because the future is by definition uncertain (Nicholls and Branson, 1998), but also because knowledge of natural and socio-economic coastal processes is and always will remain incomplete (Funtowicz and Ravetz, 1995). The information thus obtained can help to determine the optimal management strategy and timing of implementation. There are a number of decision tools available to assist in this process. Examples of these tools include cost-benefit analysis, cost-effectiveness analysis, risk-effectiveness analysis and multi-criteria analysis. The latter technique is particularly relevant when great significance is attached to values that cannot be easily expressed in monetary terms.

2.8.2 Linkage with Predictive Models

In the majority of applications to date, GIS has been used to provide an advanced database system, and an effective means of displaying information. While these databases often contain historical data, they are purely static in terms of their ability to extrapolate trends and model alternate scenarios. The integration of GIS with predictive models holds enormous promise for coastal zone management. The next advance in coastal management techniques will come when a GIS is coupled to simulation tools and to on-line data assimilation capabilities. This will enable true cross-disciplinary planning within a regional management strategy. The greatest challenges for the development e such systems are posed by the array of data structures used by current GISs, and more importantly, by the range of reliability and sources of data.

Mathematical modelling plays an important role in coastal research and is essential for the prediction of the long term impacts of natural or human forcing. In practice, with the increasing tendency and need to look at long-term and large scale impacts of projects and interventions in the coastal zone, the use of technological solutions necessarily has to be complemented by modelling.

Most coastal research institutes have available mathematical models of estuarine and coastal waters, describing the dynamics of relevant physical, chemical and biological phenomena. Many research projects contribute at the improvement of these models, by producing better mathematical treatments, more insight in dynamical processes or more reliable boundary conditions. Few projects produce user-friendly software. Mathematical models generally are shared only by small groups of specialists. Attempts are increasingly being made to enlarge the community of users (e.g. EPA, 1999b; USACE, 1999), with all the risks connected with such an operation.

Advanced mathematical methods are being developed which enable a more efficient use of experimental data, by incorporating established theoretical relations (data assimilation). ***Monitoring and modelling necessarily have to go together for the benefit of both*** (for calibration and for the decision of where, when, and how to monitor, using limited resources).

There is a strong demand for the further development of techniques to derive input conditions from observed concentration distributions (inverse modelling). See for instance Shen and Kuo (1998) for an application to eutrophication modelling. Another development aims at optimising the use of available computing infrastructure. Techniques, such as "parallel computing" may render large computer tasks feasible by distributing them efficiently over many small systems. Application of such computer techniques can have a great practical importance to Coastal Zone studies. Most existing data processing techniques are suited only for "off-line" use. In some cases, however, real time information is required: for certain executive tasks in the Coastal Zone or for the operation of certain field programmes. Remote sensing and GIS techniques can be used to develop, manipulate, and synthesise model input including land cover, digital elevation data, and site characteristic data.

Without going into any detail, example of the type of models that can be relevant for coastal zone management tasks are:

- Hydrodynamic models
- Water Quality models
- Sediment transport models
- Morphological evolution models
- Ecological models
- Landscape models
- Coastal land cover and use change models

The integration of different models is still an important hot issue not only within the engineering community, but also at research level (e.g. Atkinson et al., 1998, for what concerns the link between hydrodynamic and water quality models; Capobianco et al., 1999, for what concerns models of long-term morphodynamics; Costanza et al., 1993, for ecological and economic system; Turner et al., 1998, for coastal ecosystems; Odum, 1983, for a generic ecological system).

Spatial landscape models and land use and cover change models can be particularly relevant to ICZM (Costanza and Ruth, 1997). Spatial modelling of land use change has been approached differently by various researchers in the past. Costanza et al., (1990), taking the ecological approach, developed a coastal ecological landscape spatial simulation (CELSS) model which predicted habitat succession in Louisiana based on natural and anthropogenic induced changes to water and nutrient levels. This model uses a grid of cells with state equations describing the interaction of water and nutrient fluxes between adjacent cells. Plant succession is modelled using a set of temporal rules where the state of the plant community changes if environmental conditions (e.g. salt concentration) are altered. Turner (1991), using the statistical approach, developed a simulation model of land use change. She combined first-order Markov land use transition probabilities and the influence of a cell's nearest eight neighbour on a cell's probability of changing land use states. Probabilities were derived empirically using a land use change analysis. She found that this model performed better than land use change models that only used Markov transition probabilities. Engelen et al. (1995) employing the mathematical approach, used cellular automaton to model land use changes in Caribbean Islands. Such approach originated the popular RamCo model (Uljee et al., 1996) and the SimCoast model in its fuzzy logic extension. They developed a series of historical land use change maps used to parameterise a set of automaton growth rate rules. Summarising, these rules can be summarised into four classes: spontaneous, diffusive, organic and facility influenced growth. Spontaneous growth models the nearest neighbour's influence on adjacent cells; diffusive growth occurs in areas that are *suitable* enough to allow for development; organic growth allows current use locations to expand outward; and, facility influenced growth is based on the general influence of existing facilities on development of the area. In practice the description of the behaviour can be further summarised by rules describing the positive effects and by rules describing negative effects. Capobianco and Otter (1996) applied simulation modelling to evaluate the possible response of NorthWestern Mediterranean Deltas to changing sea levels. In this latter case the concepts of physiographic units has been used, as an approach to deal with the complexity of the coastal zone on a regional scale.

2.9 Emerging Technologies for Monitoring the Marine and Coastal Environment.

Information gathering, especially for what concerns the maritime part, can greatly benefit from the adoption of suitable sampling strategies and the standardisation of quality control procedures (CEC-DGXII, 1993). Whilst it will not be possible to provide data on all time and space scales, both for resource and for technological limitations, it is necessary to apply a coherent sampling strategy to provide more and/or better observations and to be able to measure or to gain information about new variables. Thus synoptic coverage of a limited set of variables can come from satellite and airborne remote sensing, and more recently from land based radars, whilst moored stations provide time series at a limited number of sites or about a different set of variables. Ships and buoys provide mobile platforms for the "lagrangian view".

There is a trend towards increased autonomy, both of platforms with sensors (say "carriers" of instruments) and for benthic laboratories undertaking high level and high complexity in-situ experiments (Atturio, 1997). Research ships will most probably continue for a long time to provide sample collection and analysis facilities which cannot be undertaken in any other way. Developments in all these technologies need to be selected for the aspects having major coastal relevance. There continues to be a place for cheap, sometimes expendable, instruments that can be used in large quantities.

Development of chemical sensors for moored and drifting data buoys - The development of data buoys to overcome time-consuming ship-based observations for certain chemical variables like nutrients, petroleum hydrocarbons and trace metals has been receiving the attention of technologists in recent years (Atturio, 1997). A few prototypes are already available in the market, and they are being tested for their accuracy and reliability. Most of the chemical sensors developed to date measure concentrations at the level of parts per million. More research is necessary to achieve increased accuracy and sensitivity, say to levels of parts per billion, as required to detect certain contaminants.

The dynamical Coastal Zone is a fascinating but hostile environment for instrumentation, and this presents a considerable challenge to the idea to build simple systems for robustness and protection. It is in many respects more hostile than space or the deep ocean, but it is on the other hand more easily and in principle more cheaply accessible. Some small scale processes can be studied in laboratory facilities such as wave tanks, flumes, rotating tables and aquarium, whilst others can take place in "protected waters" such as mesocosms. On the large scale, the extension to three dimension of systems for underwater acoustic tomography (transferring technologies from military applications) will guarantee the possibility to better study nearshore currents (Voronovich and Goncharov, 1993). In the following, we illustrate in some more detail a few examples.

Video Observation Techniques

Video Observation techniques represent an interesting case study of development and diffusion of technology, especially as a support to coastal engineering (Aarninkhof and Holman, 1999; Plant and Holman, 1997). Even if potentially available since many decades now, video observation techniques experienced a significant development in the last years for four basic reasons: (i) abatement of the cost of hardware, (ii) availability, at low cost, of better image processing techniques, (iii) the Internet which allows for a simple (almost in-house) remote control, and (iv) for the most advanced application, the possibility to assimilate images within hydrodynamic models or coastal morphological models.

Nowadays they hold a good promise of ready transfer to many coastal management applications where the "management of morphology" is particularly significant: (i) they operate at relatively low cost; (ii) the principle of functioning can be easily understood (even if the functioning itself can be extremely complex).

The Application

The application of video observation techniques is expanding rapidly. Numerous examples are available all over the World (http://cil-www.oce.orst.edu:8080/).

In The Netherlands, still maintaining a strong research character, they are however becoming common practice in shoreline monitoring.

Regione Abruzzo is considering their application for the most critical situations.

LIDAR

Aircraft-mounted scanners, including thermal sensors and radar and microwave systems, may also have applications in coastal studies. LIDAR (light detection and ranging), SLAR (Side-Looking Airborne Radar), SAR (Synthetic Aperture Radar), SIR (shuttle imaging radar), and passive microwave systems have applications including mapping of bottom contours of coastal waters. A LIDAR system (Parson et al., 1996), known as SHOALS (Scanning Hydro-graphic Operational Airborne Lidar System), is extensively being used by the U.S. Army Corps of Engineers (USACE, 1999) to profile coastal areas and inlets (Lillycrop et al., 1996). The system is based on the transmission and reflection of a pulsed coherent laser light from a helicopter equipped with the SHOALS instrument pod and with data processing and navigation equipment. In operation, the SHOALS laser scans an arc across the helicopter's flight path, producing a survey swath equal to about half of the aircraft altitude. A strongly reflected return is recorded from the water surface, followed closely by a weaker return from the seafloor. The difference in time of the returns is converted to water depth.

LIDAR may revolutionise hydrographic surveying in shallow water for several reasons. The most important advantage is that the system can survey up to 8 square km per hour, thereby covering large stretches of the coast in a few days. This enables almost instantaneous data collection along shores subject to rapid changes. The system can be mobilised quickly, allowing large-scale post-storm surveys or surveys of unexpected situations such as breaches across barriers. Finally, minimum survey water depth is only 1 m; this allows efficient coverage of shoals, channels, or breaches that would normally be impossible or very difficult to survey using traditional methods, especially in winter. Maximum survey depth is proving to be about 10 m, depending on water clarity.

Shallow-water Bathymetry

Bathymetry in the next future will not require expensive and long ship surveys anymore. It is generally accepted that the reason why the sea bottom topography is visible in SAR images is due to a train of effects. Features on the sea bottom modulate the (tidal) flow, which generates variations in the sea surface roughness. These surface roughness variations cause variations in the radar backscatter, which show up in the SAR image. Consequently, the imaging model suite consists of three sub-models: a flow, a wave, and a radar backscatter model. The model suite computes the expected radar backscatter for a given sea bottom topography. To extract sea bottom topography information from a SAR image, this model suite has to be inverted (Greidanus et al., 1997; Wensink and Campbell, 1997). Meteorological and tidal information acquired simultaneously with the satellite data is therefore required which renders this technique unsuitable for areas where detailed knowledge of meteorological and tidal data is unavailable or unreliable. The use of radar might be considered in some circumstances as the signal can penetrate suspended sediments and cloud which may persistently cover some regions preventing the use of the optical Landsat or SPOT data.

The Application

The technique has been widely applied at experimental level for rapid survey of bathymetry of tidal inlets in the Dutch Wadden Sea. Costs are reduced at about 10-20% of costs using traditional ship surveys, without considering the advantage of the synoptic measurement. However accurate results using radar data can only be obtained if precise conditions exist involving the wind and the tide.

Mapping Surface Currents in the Coastal Zone

An HF radar system that maps surface currents was developed by NOAA 20 years ago. It was known as CODAR (Coastal Ocean Dynamics Applications Radar). Descendants of that system are now on the market that have been tested in many different coastal settings (Georges et al., 1998). Although reliable current maps can be produced under certain conditions, tests have shown that these radars' performance can be degraded by obstacles in their field of view and in the vicinity of the radar antennas. The operation is based on the installation of two shore-based radars, spaced about 20 km apart, that illuminate a common sea surface area using line-of-sight and groundwave propagation. Typical frequencies used are 12 and 25 MHz. Each radar measures the Doppler shift of echoes. Surface currents that transport the waves impose an extra Doppler shift that is proportional to the radial current component. By combining the information from two radars, current vectors can be mapped with nominal 1-km resolution over coastal areas of a thousand square kilometers or more. Higher resolution can be obtained using synthetic aperture arrays of emitters working at higher frequencies (Georges and Harlan, 1994).

Remotely Operated Vehicles (ROVs) & Autonomous Underwater Vehicles

Research and development efforts are being made to develop unmanned remotely operated vehicles equipped with sensors for measuring physical, chemical and biological parameters. A few prototypes have been developed. Such a technology will be very useful for coverage of large areas in a short period of time. It avoids the use of several sampling devices and should reduce the excessive requirement for research ships. This new technology may become commercially available within a few years.

Conventional sampling strategies rely heavily on the use of CTD sensor packages and water samplers deployed from a ship. This provides a vertical picture of ocean

The State of Application in Europe

At moment main users are large industries, particularly for offshore activities.

In general we are here still at level of technologies that require a significant organisation that cannot be guaranteed by local coastal managers. Developments are occurring at European level.

However, it is likely to foresee a wider application of such technologies at least at level of single Countries as soon as technology becomes more reliable, skills develop further, costs are reduced.

structure. The horizontal structure in the ocean is largely underobserved because of the time and costs associated with horizontal sampling. Autonomous Underwater Vehicles (AUVs) may provide a viable, cost-effective way to increase information on horizontal variability. AUVs could effectively map volumes of ocean and even resolve temporal patterns by repeated coverage of the grid, or by coordination of multiple AUVs. Most sensors that have been developed for tow-yos and for moorings can easily be mounted on a simple AUV, providing many of the critical measurements for interpreting the 3-D circulation structure. Range requirements would be dictated by the scale of the spatial question and by the duration of the sampling requirement.

Benthic Stations and "Tripods"

Long-term monitoring systems such as long term mooring systems and remotely controlled in-situ benthic stations. In order to evaluate fluxes and to quantify processes which determine the responses of coastal ecoystems to environmental changes, it is imperative to establish a data base covering seasonal cycles and interannual variability as well as fluxes of material at some selected boundaries (estuaries, shelf break, shore line, etc.). This data base can be best obtained from long-term moorings, measuring basic physical and chemical parameters, and equipped with instruments as current meters, wave and tide recorders, salinity and temperature probes, fluori- and transmissometers and chemical probes if they become available. Site selection and measurement strategy should be defined to provide essential support for process studies and to validate process models, in particular those related to the carbon cycles. Site selection should also take into consideration the results of previous research programs. Sampling frequency at boundaries should be adapted in order to cover intermittent episodes, such as flood, storm and bloom events.

Because of the importance of benthic processes in coastal systems, it is important to develop remotely controlled in-situ benthic stations, that are capable of biological, chemical and physical experiments over periods relevant to the processes involved (Von Alt et al., 1997). Remotely controlled in-situ benthic stations are promising complementary tools to the expensive use of manned submersibles. Accurate quantification of fluxes of climatically active trace gases to the atmosphere requires the development and installation of equipment that allow measurements with a temporal resolution sufficient to record pulse emissions when required.

The State of Application in Europe

At moment main users are scientific organisation in the context of basic research on benthic processes.

The potential of the technology still has to be fully recognised, especially in relation with the information that can be provided.

However, it is likely to foresee a wider application of such technologies even at regional and local level. Fundamental requirements are again a more reliable technology, further development of skill, reduction of costs, and, more importantly, a suitable organisation for the provision of services.

Benthic station, intended as a collection of instruments, could be upgraded up to the level of benthic laboratory. There is a clear trend toward the transfer of well proven method for chemical determination, that are typically laboratory based, to in situ application through extensive use of automation. This will eventually give "microlaboratories" which allow a series of automated manipulations, necessary for the determination of dissolved chemicals, to be performed with almost no intervention from the operator. Benthic stations could also become components of a network of underwater investigation systems, which will eventually maintain a real time observation and sensing capability at sea bottom.

2.10 Observational Synergies between Measuring Technologies.

2.10.1 Need for Synergies

Thanks to the progresses in scientific knowledge and to advances in information technology, models of coastal processes are now widely implemented and available. Furthermore they appear to have generally surpassed the availability of observational and experimental data with which to initialise, force and evaluate their behaviour and performance. The lack of data actually represents a limit for improvements in process understanding, especially on large scales, and inhibits the further development of models, both descriptive and predictive.

Simultaneous cover by remote sensing and in-situ sensors enhance the value of both, giving spatial but infrequent details at the surface on one hand, whilst continuity at limited positions and depth structure comes from the other (Pfeiffer et al., 1998). Also, possibilities for event-driven sampling are an essential aspect of the design, in view of the importance of episodic events. Different technologies may complement the data and information they can originate (Fig. 2.5).

	Information Gathering			**Information Develop.**	**Information Use**	**Intervention**	
	Campaign	Remote Sensing	In-situ sens.	Integrated Modelling	Planning and Regulation	A Priori Intervention	A Posteriori Intervention
Protection from Sea-level rise		■■■	■	■■■	■■■	■	
Protection from Erosion	■	■■		■■■	■■■	■■	■■
Short-term Events		■■	■	■■■	■■■	■■	■■
Oil Spill		■■	■	■■	■■	■	■■■
Emergency in Waste Disposal	■		■■	■	■	■■	■
Emergency in Algal Bloom	■■	■■	■	■	■		■■
People Rescue		■■		■	■■	■	■■
Object Rescue	■	■■	■	■	■	■	■■
Ship Recovery	■	■■	■	■	■	■	■■
Near-shore Traffic Control		■■	■	■■	■■	■■	
Off-shore Traffic Control		■		■■	■■■	■	

Tab. 2.2 - The Information Chain for a Number of Uses

We expect that the proper "sensor fusion", drived and managed by adequate modelling approaches will be the necessary step to allow for a better utilisation of the available measurement technologies. The understanding of the measurement processes will represent the necessary prerequisite. In this respect the Coastal Zone will be a very difficult test bed as far as an high number of processes will act together in the formation of the measurement.

Tab. 2.2, gives an expansion of the information chain for a number of possible uses. It is based on an investigation of the requirements for Marine Technologies (Garbuglia et al., 1994). An expansion of long-term (surveillance) and short-term (operational) information needs for different types of coastal activities are indicated in *Appendix A.*

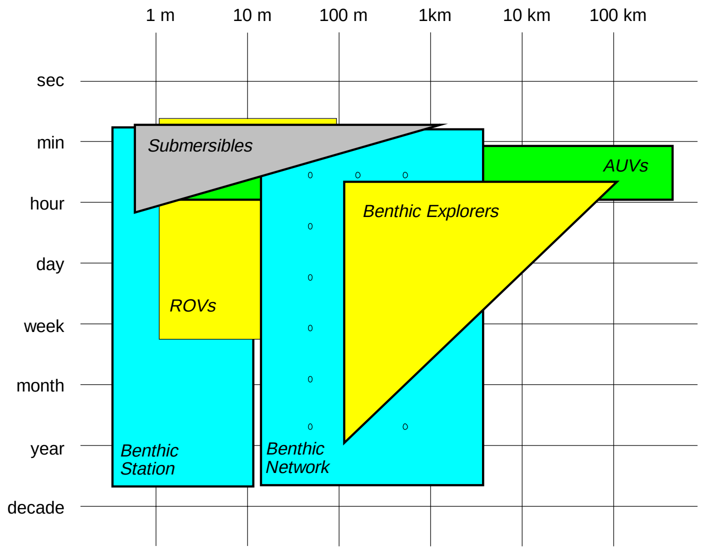

Fig. 2.5 - Observational Synergies

2.10.2 Coastal GOOS

Coastal scientists are using contemporary technologies to ask increasingly complex questions about the coastal environment. As a result of this applied research the range and volume of digital information available is growing at a phenomenal rate. In order to efficiently manage and distribute this information, a number of largescale data repositories have been established in several countries. For instance the NOAA Ocean Data Centre serves as an archive for an extensive array of satellite imagery and derived image products and *in situ* environmental data. Using the Internet, these files may be accessed, downloaded, and displayed using a variety of standard software packages.

It is imperative that such initiatives become more widespread in future for several reasons. First, they provide remote access to both historical and "living" (current) data, which are often unobtainable from other sources. Second, by maintaining an up-to-date, online database, duplication of effort and expenditure (associated with data capture) are significantly reduced. Finally, the use of these online services tends to promote networking between different institutions and machines.

With tight budgets and research projects that beg for increasingly large quantities of data, there are growing needs and desires to share data within the scientific community. Building the organisations and institutions that permit people to get together to share data requires great effort. Thankfully, there are many cases where data are shared to the benefit of all. Tools that permit to overcome the technical details of sharing data are continuously being developed (the HyperText Markup Language at low level, and the use of Metadata at high level, represent two

Operational Wave Forecasting

Organisations involved in planning operations at sea or designing structures such as oil rigs or coastal defences ideally need wave climate information (ie average and extreme wave conditions for different times of year).

Significant wave height data is currently gathered from gauges fixed to buoys or offshore structures. Often data from these sources is often inconsistent, unavailable or of limited quality.

Radar altimetry can be used to measure the significant wave height of oceans to an accuracy of the order of 10cm. Global archives of wave altimeter data now exist and have been compiled to show average, maximum, minimum and potential extreme ranges. Historic information about sea state is sold commercially and can also be combined with optical meteorological satellite data to provide a near real-time service for vessel, rig and plant mobilisation and navigation and other offshore engineering operations.

formidable examples). Likewise, we need to overcome the human and institutional details of data sharing. Every Institutions should do is part to maintain environments to create and share data in the future.

CEO, the Center for Earth Observation is largely based on the Internet with the objective to contribute to a European system for Earth observation by stimulating user-oriented services. These will take advantage of established institutions, existing or planned networks and projects. For what concerns the coastal zone application, an extensive investigation of the requirements of the possible user communities has been recently conducted (ACRI et al., 1995). CEO is also promoting the development of a Coastal Information System, able to integrate available data and models in a Geographical Environment (the DESIMA project).

A monitoring strategy should be developed for the detection of trends in the condition of coastal systems, for the assessment of sustainable development and for the estimation of risks . Such a monitoring strategy not only provides an important instrument for Coastal Zone management, but also greatly contributes to a better understanding of the dynamics of coastal systems. A set of variables has to be defined which characterises the most relevant aspects of the physical, chemical and biological condition of the Coastal Zone. Not only changes of a regional and temporal character, but also changes of a global and permanent character have to be monitored. As a first step towards an integrated coastal monitoring strategy one might consider the implementation of the Global Ocean Observation System (GOOS) at the European level (Bosman et al., 1998; Woods et al., 1996). Priorities concerning the type of variables to be monitored have been largely examined concerning the marine part (see *Appendix B*, extracted from the EUROGOOS Marine Technology Survey, 1998).

At present there is no regional-wide monitoring strategy, though a few national networks exist mainly for local or regional impacts. The proposed introduction of the Global Ocean Observing System (GOOS) is an important opportunity to give an umbrella organisation for the introduction and coordination of long term monitoring in the Coastal Zone.

What is also particularly important for management purposes is the possibility to detect changes, either long term changes or short term changes following specific events.

3. THE ROLE OF TECHNOLOGY IN THE EXPLOITATION OF COASTAL ZONE SPACE AND OF ITS RESOURCES.

Traditionally, attention has been largely devoted on water-related issues and water management (EPA, 1996; CEC, 1998a). However the need to adopt a wide-ranging perspective, and the need to be as more proactive as possible, which are implicit into the principles of ICZM, ask to look at aspects that are not directly connected with water. Moreover, the proposed European Spatial Development Perspective (CEC, 1997), and the need to balance it with the dynamic character of the coastal zone, require the examination of the effects of those technical solution that often accompany development.

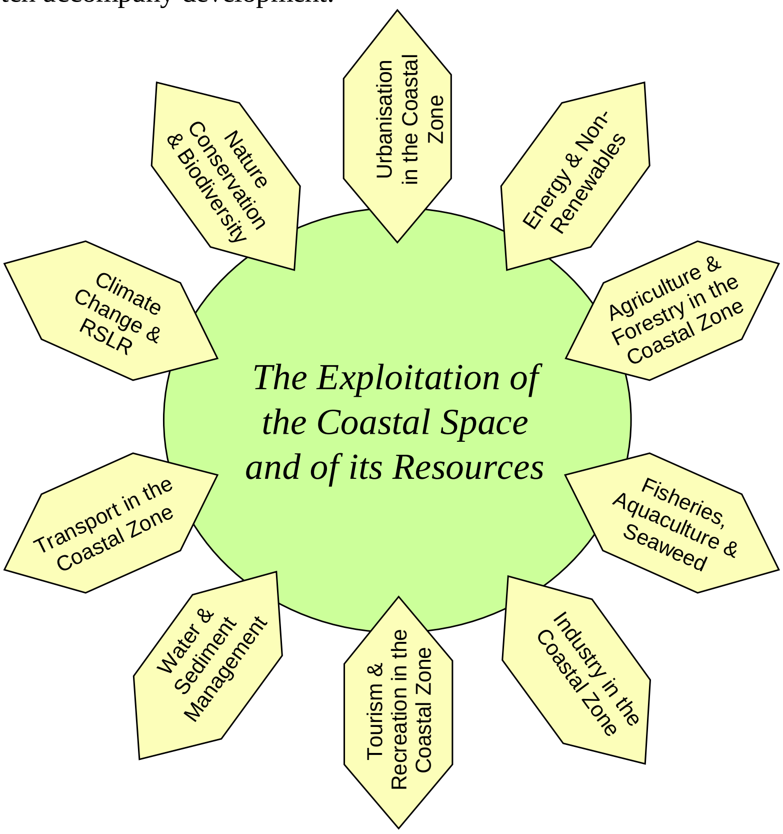

Fig. 3.1 - Some Sectoral Issues Contributing to the Exploitation of Coastal Zone Space and of its Resources

We hereby examine in brief detail some Sectoral Issues contributing to the exploitation of Coastal Zone Space and of its Resources. We include here also a few issues that are not directly due to exploitation activities but are somehow intrinsically connected and should be properly considered for the sustainable utilisation of Coastal Zone Space and of its Resources. The issues ask for the adoption of preventive measures. The issues are all present, in a more or less explicit way, in the Demonstration Projects. For some specific problems connected with such issues, the idea is that of presenting the "technological side" of the solution. Roughly speaking, we can say that ***the technologies hereby introduced belong, if properly applied, to the class of the "ICZM-friendly" technologies***. If not properly applied they can very well act as counter-ICZM technologies. This means that the context of application as well as the way they are applied is critical for the success of the application.

3.1 Pressure from Urbanisation.

Pressure on the Coastal Zone from urban development is concentrated in areas close to the major cities, but is certainly further increasing and spreading. Such development must be assessed in the context of an evaluation of the full resource value of the Coastal Zone, making a distinction between developments that require a coastal location and those that do not. Development in urban areas is crucial for the overall welfare of a region but, at the same time, cities often suffer from overcrowding and pollution, land degradation, decayed or insufficient infrastructure. Urban policy, urban planning and ecological monitoring are therefore fundamental tasks for government authorities, especially at local level. Urban development in the Coastal Zone, in addition, is characterised by specific "physical limitations" originated by the marine boundary.

A part from new urban development, for which opportunities certainly exist to undertake a suitable (and more sustainable than the past) spatial planning and spatial development, it is the existing urbanisation that is often requiring efforts to solve problems such as accessibility and lack of space. These efforts should occur on a scale that requires suitable planning and management actions supported by suitable technologies such as those used to connect areas of the cities, reclamation technologies, etc. Such kind of attention and consideration has been totally missing in the past since authorities were simply happy with those private enterprises setting-off development.

Problem - Accessibility

Achieving sustainable urban accessibility is a vital step in the overall improvement of the urban environment and maintenance of the economic viability of cities. The importance of accessibility in the way the city functions and the linked problem of traffic growth, projected to continue further, induce environmental problems, health related problems, and social problems. Meeting environmental and transport objectives requires integrated approaches combining transport, environmental and spatial planning. However, relatively few cities have fully integrated systems. Current actions towards sustainability in this field mainly seek to reduce road traffic and congestion, essentially by encouraging a modal shift from private cars to public transport and, less often, to cycling and walking. Whilst these actions are important, they do not in themselves constitute sustainability measures.

> ***Example on Accessibility***
> Examples are numerous along the European coasts. With reference to the Demonstration Projects we can mention here the example of ***Napoli*** where the entire gulf is an urban centre characterised by all the activities and problems that can exist in Coastal Zones are concentrated: congestion, industrial decline, intensive tourism, pollution, abandonment and deterioration of the natural and cultural heritage, potential in jobs and wealth. We can also mention the example of ***Barcelona*** where the Olympic games of 1992 have represented the opportunity to "re-open" the city to the sea and give the opportunity to the inhabitants (and the tourists) to actually begin using again (after almost one century) the water front. An innovative solution to "collect" the crossing traffic here has represented the key solution for the intervention.

Technological Solution - Use the Adjacent Sea Bottom

Technologies may help overcome some of the physical limitations represented by the seafront. As an example the adoption of submarine tunnels as well as submarine parking facilities may free valuable space and ameliorate living conditions by reducing traffic on the seafront. The concept of "green building" should also be promoted and expanded in order to ensure not only the resource-conscious use of all building materials but also the design of buildings for durability, adaptability, multiple use and, if possible, for future decommissioning.

Problem - Lack of Space

Coastal Cities often developed in a situation where, to the physical constraint given by the sea, other physical constraints (adjacent rivers or hills/mountains) have begun showing their effects on the landscape and on the functioning. The pressures for additional expansion and developments can be such to call for the expansion in the direction of the sea. We can mention here the frequent example of the need for new port and harbour developments or for new airport constructions.

> ***Example on Lack of Space***
> Examples in this case come mainly from East Asia. Situations where these type of pressures are present, are however widespread in Europe and connected problems are becoming an hot issue. We mention here the case of the proposed extension of ***Schipol Airport*** where one of the options being examined is that of a completely artificial island on the Dutch coast or the proposed extension of ***Rotterdam*** harbour.

Technological Solution - Land Reclamation & Artificial Islands

Possible solutions to such pressures could be reclamation projects with artificial peninsula or artificial islands. Possible solutions, as proposed extensively in Japan, could also be "floating islands". They all require careful and sound planning with emphasis on good engineering and environmental considerations. These developments require the ability to predict the environmental conditions comprising waves, currents and water levels which influence all engineering activities in the coastal and offshore regions. It is essential, therefore, to be able to predict the waves, currents and water levels at any given location in the seas of interest both in terms of extremes and sustained characteristics. This will enable proper evaluation of the interaction of environmental forces with the marine infrastructure leading to cost effective solutions for coastal development.

> ***Example on Artificial Island***
> The town of Marbella in southern Spain is considering a proposal to build an artificial island 500m off its coast. The artificial island is proposed to be built half a kilometre off Marbella on the Costa del Sol. The 150,000m^2 island should be connected to the coast by a 500m-long, 4-lane causeway. There should be 30,000m^2 open space and a developed area of 120,000m^2

Technological Solution - Integrated View

The example of the transboundary link across the Oresund, between Denmark and Sweden, can be mentioned here. Problems of accessibility and of lack of space have been tackled in a integrated way by using a bridge, a tunnel, and an artificial island in a situation of environmentally sensitive area and while attempting to implement "zero impact" solutions for the Baltic Sea. It is also an interesting study case for the application of complex and potentially impacting technologies in a transboundary environment with a different attitude toward coastal planning and management.

3.2 Energy and Exploitation of Non-renewable Resources.

Energy-related activities present specific peculiarities while undertaken in the Coastal Zone. Technologies employed within the whole energy production chain require specific actions to be undertaken to make them more ICZM-friendly. In fact most of such technologies can be considered counter-ICZM.

Looking at the present situation, we should consider here that a large majority of power plants are located in the Coastal Zone and, often, in environmentally sensitive Coastal Zones. The reason was simply the availability of cheap land, the good connection with port facilities for the supply of hydrocarbons, and the availability of cooling waters.

Due to intense regulation on the subject, future energy-related technologies will certainly be more environmentally-friendly (CEC, 1996a-1996b; ECE, 1995a). However, we must recognise that attention is very much focused on reduction of emissions and pollution and much less on the spatial implications.

Quite often the Coastal Zone also represents the site for the direct extraction of conventional energy sources, e.g. gas in shallow areas. This means that the source of "problems" is general (connected with the strategic aspects of resource exploitation) but can also very well be local.

Problem - Sudsidence

A specific sectoral issue concerning the extraction of conventional energy sources in the Coastal Zone is the resulting subsidence that, just to make the problem worst, occurs in areas which are by themselves shallow area. We should also take into account that massive production of conventional energy sources has strict requirements in terms of Coastal Space utilisation and in terms of transport of the extracted material or of the produced energy. Ground subsidence has major implications for existing and planned developments such as road and rail infrastructure, water and sewage systems and can act as an "early warning signal" for regional hazard mapping. Techniques for its measurement over small areas are well established. However, its measurement over large areas is much less straightforward.

> ***Example – Gas Extraction***
> With reference to the Demonstration Projects we can mention here the example of the ***Waddensea*** Project; the Dutch Waddensea area is recognised as being characterised by important gas reserves.
> Connected to this, we can mention the problem of landing of pipelines to the shore.

Technological Solution - Monitoring & Modelling

A possible solution here would be a Coastal Zone specific application of Environmental Impact Assessment that necessarily has to be based on detailed precision monitoring and on a suitable modelling. Measuring subsidence over large areas is currently performed using Global Positioning System (GPS) equipment in conjunction with electronic distance measurers and conventional survey techniques. Although this method can produce highly accurate results there are fundamental problems such as: the reliability of benchmarks, the interpolation that might be required between measurements and knowing where to look for subsidence in the first place. Recent developments in Earth observation have shown that ground displacement in urban areas can be measured from space down to millimetre accuracy over a few thousand square kilometres at a time. The technique, known as "radar interferometry", uses two radar images of the same place on the ground but acquired at different times

Problem - Heat Pollution

A typical problem connected with the presence of Power Plants in the Coastal Zone is the discharge of water at a temperature higher than background temperature. This can affect the ecology of the nearby environment (e.g. Çakiroğlu and Yurteri, 1998). Existing regulations as well as existing EIA legislation should already prevent the most extreme situations to occur. However there is still a large freedom in the definition of the technical solution and, what is more subtle concerning possible long-term effects, in the operational management of the discharge.

> ***Example – Coastal Lagoons***
> Examples are numerous along the European coasts, almost in every place a power plant is located. Problems arise mainly in those situations were the discharge is in low circulation areas (e.g. coastal lagoons) and with a different character in Southern Europe and Northern Europe (because of the temperature gradients).

Technological Solution - Reshape the Outfall & Integrate

The technical solution here could be that of shaping the out-fall area in such a way to use otherwise disposed thermal energy. In a integrated approach to Coastal Space utilisation this could be the way to sustain aquaculture activities in areas where it would otherwise be non-economical. In any case a suitable approach requires to limit spatially the temperature disturbance.

Problem - Switch to Alternative Energies

Environmental issues for Islands and arcipelagos could benefit from the adoption of renewable energy sources, especially when costs of local production are comparable with costs of transportation of energy. Although basic principles of converting marine renewable energies (wind energy, wave energy, ocean thermal energy, current energy) have been proven by even just a few demonstration facilities (OTA, 1995), high commercial and technical risks of this new technologies still exist. Risks are particularly large in relation to commercial scale plants for a full scale utilisation of marine energy sources in the future.

Example – Wind Energy in the Cyclades

With reference to the Demonstration Projects we can mention here the example of ***Cyclades*** in the Aegean sea. Generation of electricity from wind turbines is an option that could soon become more economically convenient, and certainly more environmentally – friendly electricity produced from local “traditional” power plants.

Technological Solution - Small Scale Plants & Offshore Wind Farms

The future exploitation of these resources requires further fundamental R&D and demonstration activities. The option could be that of small scale plants to serve the needs of small (and often isolated) communities.

Wind energy converting technology has reached a new market status on-shore. Today, it is the most developed converting technology for renewable energy sources, beside hydro-power technology. It is most actual to extend the use of this technology into offshore areas which provide huge wind energy potential (Krohn, 1999). The steady opening up of the electricity markets throughout Europe and around the world has brought with it a range of new ideas about how to support renewable energy in an increasingly competitive climate. As geographical and state monopolies are dismantled, so power companies and suppliers, large and small, are now (or soon will be) able to compete for the business of any customer they want, even across national boundaries.

3.3 Industry: Pollution and Need for Decontamination.

Industrial development in Europe occurred largely in low-lying coastal areas. The main explanation being the large availability of relatively inexpensive land. Nowadays the pressures for occupation of land are slightly different, being more connected with the availability of services than just the availability of space.

We necessarily have to keep the discussion very short here, however the tendency to relocate many industrial setting originally introduced in the coastal zone has to mentioned.

Example – The Impact of Industry

With reference to the Demonstration Projects we can mention here the example of the ***Forth Estuary*** and its catchment where the industrial component still plays a significant role. The case of ***Taranto*** is rather extreme from the point of view of the complex interconnections between natural, rural, urban environment and the industrial settings; all the socio-economy of the area is strongly affected by such interconnections.

Problem - Industrial Pollution

Pollution is the most important related problem here. Industrial settings often require water and are often located along rivers. We should also consider that a large number of industrial settings have been located in low-lying coastal areas because of the limited economic value attributed to them in the past (and the large availability of space). Their pollutants, soon or later, in a more direct or indirect form, always reach the coastal zone. Similarly to power plants, heat pollution also frequently characterises industrial settings.

Technological Solution - BEP, BAT, IPPC

From consolidated experiences with industrial production in general, it appears that the adoption of best environmental practice (BEP), best available techniques (BAT) and integrated pollution prevention and control (IPPC) will play a fundamental role here. The direct costs required for such options are certainly recovered indirectly in the long-run on many situations. Existing pollution prevention regulation, when properly applied, should guarantee the application of ICZM-friendly technologies, at least at the level of single plant or single project. While such options are certainly the preferred ones for the future, still situations inherited from the past require ad-hoc technical solutions for requalification and remediation.

Problem - Contaminated Land

The restructuring of heavy industry and utilities have left large areas of vacant and often contaminated land within cities whilst increasing the pressure for the development of urban open space and countryside. There is an urgent need to ensure the reuse of redundant, derelict or contaminated land, which is at a greater scale than during any period in industrial urban history. The recycling of previously developed land, and in some cases existing buildings, of itself can be seen to meet the sustainability objective of the reuse of a resource. In addition, land recycling also has the potential to achieve the retention of green field sites, and protection of countryside, open space and wildlife.

> ***Example – Need for Requalification***
> With reference to the Demonstration Projects we can mention here the example of ***Barcelona***. The northern area of Barcelona, where large number of abandoned industries where located, undergone an extensive intervention of decontamination and requalification.

Technological Solution - Decontamination

Decontamination of polluted soil is a major concern in many urban regeneration projects. Cleansing techniques are often expensive operations for which suitable organisation is required in addition to a continuous upgrade. Decontamination should not be seen as a separate project requiring subsidy, but rather as part of an integrative approach - this provides a financially advantageous position (eventually through the attribution to the contaminer of the costs for the decontamination technologies).

3.4 Pollution from Agriculture and Forestry.

Impact of agriculture and agriculture activities on the coastal zone can be extremely significant and can occur both locally and remotely. Discharge of nutrients and pollutants are the most significant issues, but also the modification of erosion patterns should be considered. In an Integrated Coastal Zone Management approach, Agriculture can be seen in relation with other type of utilisation of the Coastal Zone with reciprocal benefits; suitable mapping is an extremely important action to be undertaken here.

Overgrazing and reclamation, especially that extensively undertaken in the past when the “value” attributed to coastal wetland was almost negligible, represent today significant problems for certain sensitive coastal ecosystems. Agriculture and forestry can also have impacts on coastal water quality. There is in general a need for environmentally sustainable farming practices in the Coastal Zone. We should also not forget to mention that agriculture is undergoing serious processes of restructuring and the opportunity to balance such processes with needs posed by environmental requirements or with the recognition of on-going processes in the coastal zone, should not be missed (e.g. Bolsius et al., 1993).

Looking at technologies, generally speaking we should also consider the threats posed to agriculture and forestry by their Coastal Zone location; technological solutions are required to reduce such threats.

Problem - Discharge of Nutrients and Pollutants

Agriculture is considered as being a source, sometimes the main source, of Nonpoint Source Pollution and of an excessive supply to nutrients to the Coastal Zone which is cause of eutrophication. Examples of such problem are widely distributed along the European coasts. Release of nutrients and pollutants from agriculture activities are regulated by existing water quality legislations. However, the style of agriuculture as well as the irrigation practices can be such that limits are difficult to respect sometimes, without additional interventions for mitigation.

> ***Examples – Nutrients from Agriculture***
> Examples are numerous along the European coasts. With reference to the Demonstration Projects we can mention here the example of ***Brest*** where in-fact the mitigation of the "pressures" resulting from agriculture is one of the main concerns. Rivers can represent locally a problem, like in the case of the ***Coast of Finland***. More in general, examples could also come from situations like the water catchment area of the ***Lagoon of Venice*** where agriculture (and animal raising) has been recognised as the main source of nitrogen loading to the Lagoon.

Technological Solution - Introduction of Buffer Zones

The extensive literature being developed on "wetland ecology and technology", particularly following experiences in the United States (Mitsch and Reeder, 1991; Mitsch and Gosselink, 1993), as well as some European Research Projects, suggest that the adoption of suitable "buffer zones" as a "soft technology" can guarantee a suitable abatement of nutrient loading.

Problem - Persistent Organic Pollutants

Pest management is often undertaken by using pesticides and other substances which act as Persistent Organic Pollutants (POPs). POPs accumulate in the groundwater and, other than causing local pollution, reach, as Non Point Pollution (NPS), the coastal waters.

Fertilisation is also often undertaken by using excess of nutrients which accumulate in the groundwater and reach, as Non Point Pollution (NPS) the coastal waters.

> ***Example – POP Discharge***
> Examples could be numerous along the European coasts and cover a large number and various types of crop areas. The issue is extremely important in the Baltic sea due to the limited water exchange. A field is the basic unit in which a farmer works. Fields can be of varying size but the trend has been for small fields to be amalgamated to make large fields in which large capacity machinery can work effectively.

Technological Solution - Precision Farming

One major technological change which is seen in farming is "precision farming". Without precision farming a whole field is treated with fertiliser, agrochemicals, etc. even if parts of that field may not need them. Precision farming, that, we must say, is also stimulated by market opportunities represented by better quality of products, is an approach to use more carefully potentially pollutant substances, and to better limit they dispersion, and to better control their distribution.

Problem - Management of Freshwater

A specific sectoral issue for agriculture in the Coastal Zone concerns the management of freshwater supply for irrigation and the control of saltwater intrusion along supply channels and/or the drainage network in low-lying areas. This is an issue which has become of particular importance in lagoonal and estuarine environment, particularly if situated in areas of local subsidence or significant relative sea level rise. In the Mediterranean coastal zones, during the Summer freshwater management can become one of the most important issues.

Technological Solution - Control Salt Water Intrusion & Manage Irrigation

Techniques to limit and/or control the degree of salt water intrusion can result to be beneficial. They can range from the use of specific automatically operated gates along the main streams to the use of deep screens and barriers along the enbankments and dikes.

Irrigation and drainage networks should be designed to take into account the needs of agriculture, the seasonal dynamics, and the specific long term processes in the Coastal Zone. Current irrigation scheduling and delivery systems are inefficient and technologies may be able to increase the efficiency and effectiveness. Particular issues include the unpredictability of demand for irrigation water and a lack of full understanding of the complex relationship between crops and their water requirements. Technical options to reduce maintenance requirements are also an important aspect to be considered in the context of water management (e.g. Thompson and Sultana, 1996, for embankment options).

Example – Freshwater and Salinity Intrusion
The problem is reported frequently for deltaic areas. For instance along the ***Po Delta*** is being tackled by using tide gates; along the ***Sile River***, north of the Lagoon of Venice, freshwater intake in summer time is undertake by monitoring the salinity in the bottom of the river. With reference to the Demonstration Projects we can mention here the example of ***Ria de Aveiro***, where salinity intrusion is significant.

Problem – Mapping

The classical transition in land use and cover has been, and still is, from natural environment, to rural environment, and finally urban environment. The rural environment plays a very important role as a buffer zone between natural and urban environment. CORINE land cover represented a significant step toward the understanding of the "spatial relationships" between such three environments at European scale. However, to satisfy needs for local planning and management, the information available to decision makers at local level is still suffering from problems of resolution and update.

Example – Need for Mapping
In Algarve and Huelva transformations occurred more rapidly than the update of the information on the hydrological network. All the situations where changes in land use and cover are occurring, mainly as a result of socio-economic pressures, increasingly require high resolution information (possibly complemented with elevation data, in low-lying coastal area) and, even more so a synoptic update of the available information.

Technological Solution - Remote Sensing and GIS

Technologies are available here to respond to most of the planning exigencies. Remote sensing information, carefully pre-processed and included into a GIS environment can be the key for detecting changes, for the application of screening models, for risk assessment, for the assessment of the resilience of a coastal zone, etc.

3.5 Fisheries, Aquaculture & Seaweed.

Balancing the conservation of resources with the socio-economic dependency of fishing communities is one of the most difficult current issues in the Coastal Zone and requires to be addressed according to a multi-sectoral approach. Technological developments are also potentially available for those situations where fishing is threatening protected species (e.g. the use of acoustic pingers for dolphins as described by Stone et al., 1997, or large-mesh nets to reduce by-catch of juvenile fish.

Aquaculture accounts for an increasing proportion of fish production and is of growing importance as a raw material for the processing industry. Offshore aquaculture is a strategic targeted issue that will make an important contribution in the next future to the production and supply of aquatic food resources. As matter of fact the increased demand for fish production and high value's products and the consequent deficit in the national fishery sector make it imperative to increase the domestic fish production and this demand will continue to be a strong driver for the marine aquaculture market (CEC, 1998b).

In world terms, seaweed production is increasing each year. In many regions of the Community, the gathering of seaweeds has traditionally provided a source of revenue and employment. However, the position of Europe is decreasing, year after year, even though the quality of European seaweeds remains one of the highest in the world, due to the quality of our coastal waters, as compared with south-eastern Asia. To increase European competitiveness in this growing marketplace, different key actions must be carried out, concerning the resource itself, and the processing of that resource into finished products

The role of technology, while maximising production, should be here that of guarantee safety and quality of the environment that, in ultimate analysis, is the basic substratum for the production itself (Banks and James, 1998). We should also not forget that the proper utilisation of fishing technologies can be supported by modelling (Ruth and Lindholm, 1997).

Problem - Conflicts with Tourism and Nature Conservation

The potential for conflict between aquaculture and other users of the Coastal Zone is likely to increase. There are, however, positive as well as negative interactions between aquaculture, the tourism industry and nature conservation. At the hearth of many difficulties lies the choice of location for the development of aquaculture. Decisions on location require consideration of a wide range of matters and should involve all of the relevant actors, as well as a mechanism for public consultation.

Example – Nature Conservation

With reference to the Demonstration Projects we can mention here the example of the local management plans on the ***Norwegian coasts*** where the conflicts are with nature protection issues, or the example of ***Bantry Bay***, where there is a large number of conflicting issues with complex mutual interrelationships.

Possible Technological Developments

Develop management strategies and codes of practice that are compatible with environmental conservation, hand in hand with technological developments allowing aquaculture and offshore aquaculture to operate commercially without harming the environment.

- *Development of GIS systems to map and study aquaculture and environmental interactions leading to rational Coastal Zone management strategies, including studies on the effects and management of multipurpose area interests.*
- *Development of technology to prevent the spread of disease from, and within, aquaculture and offshore aquaculture installations.*
- *Development of integrated farming systems that permit recycling of wastes from other resource users while determining effluent quality criteria for these wastes and methods to comply with these criteria.*
- *Development of GIS models to forecast the effect of climatic and environmental changes on aquaculture and offshore aquaculture production systems.*
- *Development of disease and parasite treatments compatible with environmental sustainability.*
- *Development of disease monitoring systems.*
- *Development of strategies to allow the farming of introduced species in a safe and sustainable way, through controlled introductions and agreed codes of practice, involving official quarantine laboratories.*

- *Development of structures and procedures to reduce or avoid the escape of farmed fish.*

Problem - High Costs

Offshore and submerged fish enclosures have proven difficult to operate in the past, as well as costing more to operate than conventional near-shore systems - which are already being used to boost Norwegian and Chilean production. This is particularly the case for places that are exposed to waves. Possible applications are recognised however, in countries with few protected or available sites.

Example – Technologies for Offshore Aquaculture
Early attempts to adopt offshore aquaculture techniques in the ***Finnish*** Argipelago have proven to be unsuccessful because of the high costs of the technology (in a period of low market prices). In that case the main problem was the need to travel a lot from the mainland for regular and also very simple operations. The possibility to have "reduction" of the cost of the fuel come quite late.

Technological Solution - Remote Control & Remote Surveillance

The adoption of technical solutions to minimise the needs for maintenance and surveillance represents an important requirement. By adopting different type of cages able to sustain extreme wave conditions, and by adopting "remote control" and "remote surveillance" techniques it could be possible to reduce the cost of production.

3.6 Tourism & Recreation: an Opportunity and a Threat.

Tourism is now recognised as being the single largest global industry. Today the travel & tourism industry is worth over 10% of the world-wide Gross Domestic Product (GDP) and represents one in nine jobs. It is therefore one of the world's largest economic activities and a large percentage of such activities is oriented toward the Coastal Zone. There is also a marked increase in the availability of speciality holidays covering a large number of different facilities that have to be provided. Quality of bathing water is often the main concern since decades now, starting from the consideration that the health of the tourist has to be preserved (EU, 1976). However, other aspects necessarily have to be taken into account while considering that also the health of the coastal zone has to be preserved from the tourists. To some extent we could consider the problems connected with tourism related facilities as being is strict connection with those of the urban areas.

Problem - The Consequences of Seasonality

One of the peculiarities of the tourism and the recreation "industry" is that of being extremely seasonal (with shorter seasons in Northern Europe and longer seasons in Southern Europe). This is on one hand perceived as a missed opportunity for the relatively low utilisation of the coastal area. On the other hand it is the source of organisational problems: infrastructures and facilities are often under-dimensioned for the peak of the tourist season, and are over-dimensioned for the rest of the year. Furthermore the development which is promoted to try to respond to the needs of the seasonal tourism is often uncontrolled.

Example – Seasonal Tourism
Examples are numerous along the European coasts. With reference to the Demonstration Projects we can mention here the example of ***Storstrøm*** where tourism, particularly in the low season, is seen as the key to the region's future prosperity, helping to compensate for declining employment in fishing, agriculture, industry and - to some extent - shipping. Concerning problems related with seasonality we can also mention here the case of ***Strymonikos*** where the population raises from 16.860 to over 150.000 in Summer.

Technological Solution - Coastal Zone Specific EIA for Tourist-oriented Infrastructures

Paradoxically the solution to such a problem goes often in the direction of more infrastructure development in the Coastal Zone, together with nature conservation, archeological sites, cultural offer in general. This requires a careful planning and asks for the suitable application of EIA for any development eventually undertaken.

Problem - Tourism-induced Erosion and Pollution

Tourism represents often the first cause for the exacerbation (if not the origination) of problems in the Coastal Zone; think for instance to erosion or to pollution. Local erosion, as opposed to structural erosion, is often connected with facilities built to satisfy recreational needs. Local pollution, as opposed to pollution originated onshore, is often connected with behaviour of tourist and/or to poorly dimensioned infrastructures.

Example – Support Environmentally-friendly tourism

Examples are numerous along the European coasts. With reference to the Demonstration Projects we can mention here the example of the ***Waddensea*** Project which is addressing the promotion of environmentally-friendly tourism to create jobs and generate local income.

Solution - Soft Protection Technologies

The adoption of soft protection technologies based on the engineering of the "natural systems" (Capobianco and Stive, 1997) can help reconciliate here needs of nature conservation with the needs of facilities and infrastructures required by the tourism industry.

Problems Connected with Tourism, Marinas and Recreational Boating.

Marinas and recreational boating are increasingly popular uses of Coastal Zones. The growth of recreational boating, along with the growth of coastal development in general, has led to a growing awareness of the need to protect Coastal Zones. Boating and adjunct activities (e.g., marinas) are an important means of public access. When these facilities are poorly planned or managed, however, they may pose a threat to the health of aquatic systems and may pose other environmental hazards. Ensuring the best possible siting for marinas, as well as the best available design and construction practices and appropriate operation and maintenance practices, can greatly reduce nonpoint source (NPS) pollution from marinas.

Technological Solution - EIA, Monitoring, and Friendly Design

Better planning of marinas' location, better design .and a full application of EIA procedures can help avoiding a large number of adverse effects. Suitable monitoring of water quality conditions is highly recommended. Suitable hull design for boating in estuaries and lagoon areas is highly recommended.

Problem - Litter

Litter threatens marine life through entanglement, suffocation and ingestion and is widely recognised to degrade the visual amenities of marine and coastal areas with negative effects on tourism and general aesthetics. Litter is any persistent manufactured or processed solid material which is discarded, disposed of, or abandoned in the marine and coastal environment, sometimes called marine debris. Litter in the marine environment can also destroy coastal habitats and in some situations interfere with biological production in coastal areas.

Many vessels in use today were not designed with adequate capacity to store garbage. And often, tourists and recreational boaters so not bring their trash ashore. Providing facilities to recycle or dispose of wastes at marinas, wharves and beaches would reduce the plastic released into the sea. Reducing the amount of waste generated in the first place will also help. Both approaches are needed to address the problem.

Technological Solution - Collect and Receive

It could be extremely beneficial to use "boat of opportunity" that, by operating on a voluntary basis, can provide litter collection. Adequate "reception" facilities should also be provided.
A technology that could be experimented in highly crowded coastal areas could be that of "floating garbage collectors". Simple, and relatively inexpensive, technologies can play the role of stimulating good style of behaviour.

3.7 Water and Sediment Management and Safety in the Coastal Zone.

Water is a natural resource indispensable for basic functions (drinking, washing and cleaning), for industrial processes and for agriculture. Water is a renewable and a re-usable natural resource. Water is part of a cyclical process of the natural system - rainfall is stored as groundwater and in rivers, lakes and seas, then evaporates and forms clouds, which in turn result in rainfall. Water management is one of the most significant issues in the future of environmental management in Europe (CEC, 1998a).

Management of water resources in the Coastal Zone has its peculiarity in the fact that in the Coastal Zone freshwater meets sea-water and often mix in low-lying areas like estuaries and lagoons originating a number of very peculiar habitats. The need to consider also sediment as a resource to be managed is being now increasingly recognised, at least at scientific level.

More specifically, water represents the main driving factor for Coastal Zone dynamics on all scales. Sediment constitutes the fundamental ingredient for the morphological evolution of the Coastal Zone, while salinity represents one of the regulating variables for the ecological components. Basically it indicates the interface between fresh-water (river) and salt-water (sea) environment.

Problem - Manage Sediment while Managing Water

The attention has been always devoted to the management of water, to guarantee supply (and for energy production) and to protect from riverine floods and from sea storm attacks. Extensive dredging and damming activities have been undertaken for such purpose on many low-lying coastal areas. And many dikes have been built upstream to build reservoirs.

However, dredging, damming, and diking have strongly limited in the recent past the supply of sediment to coastal zones, representing the main source of the present erosion problems, especially for those areas that experienced previously a large shoreline advance.

Example

Deltaic areas and, more in general, all the areas adjacent to river mouths, experienced in the past large accretion due to increased sediment supply connected with land use practices in the watersheds (***Regione Abruzzo*** is a clear example).
However, in recent decades, the attitude toward water management has strongly limited the possibilities for such coastal areas to be physically sustained. Also, for the same reason, environments such as river deltas are getting increasingly vulnerable to natural as well as human induced subsidence problems.

Technological Solution - Conciliate Water & Sediment Management

Technologies are required to carefully design, plan and implement water and sediment management schemes that conciliate utilisation needs, with safety considerations. Once the existence of the problem is recognised, technical solutions are there for continuing managing water while reducing the disturbances to the dynamics of sediment. Even more, the adoption of practices of "controlled erosion" inland could serve the purpose of reducing coastal erosion on the long-term. It is clear, however, that other then adequate technical solutions, a suitable organisation and territorial planning is needed here.

Problem – Groundwater Depletion and Lack of Freshwater

In low-lying areas, groundwater depletion may cause salt water to infiltrate into the aquifer, degrading the water quality. This can render the supply unsuitable for many uses, both with respect to human utilisation but also with respect to agricultural and industrial practices. In certain aquifers, depletion can also irreversibly reduce the water holding capacity of the aquifer, permanently destroying its potential to function as a water reservoir (Essaid, 1990) and seriously degrading the quality of the overall environment.

Example
In many islands, availability of freshwater drops dramatically in the Summer period when, on the other hand, the demand reaches its maximum level due to the tourist season. This is the case for many Mediterranean Islands and, within the Demonstration Programme, of Cyclades.

Technological Solution – Desalination Plants

In some areas, alternative water supply sources such as desalination and recycling will probably emerge as less expensive options (e.g. experience from California, CCC, 1993). The use of desalination technologies certainly benefits a lot from the existence of integrative management practices. On the other hand, it is a good example of technology that can help ameliorate living conditions in the coastal zone, reducing conflicts originating from a scarce resource.

3.8 Transport in the Coastal Zone: Looking for Space.

The Coastal Zone is often the site of dense transport networks both onshore (because of coastal plains) and offshore (because of shipping). On the other hand, transport networks have been always considered the necessary prerequisite for the development of the socio-economy of a given area, the Coastal Zone is not an exception. The Coastal Zone, being the interface between the terrestrial and the marine environment, also represents the interface between terrestrial transport and marine transport (of goods and people) and, often, also the interface with airborne transport.

Problem - Interface Optimisation

The problem is represented by the fact that such interface is not always optimised for crossing traffic and for local traffic. Additional problems originate from the fact that the transport infrastructures do not always considered the peculiarities of the Coastal Zone and its "intrinsic dynamics". Too often in the past, design of transport networks has been conducted just considering the "occupation of space" and without really looking at the "geography".

Example
The railway running along the Adriatic Coast of the Italian Peninsula is a good example of transport infrastructure built by considering only one sectoral need and which is nowadays causing serious constraints to Coastal Space utilisation as well as problems with local erosion in many areas. It has to be considered that at the time it was constructed was the most economic way to proceed due to the general morphology of the Italian Peninsula (i.e. the path minimising somehow the need for tunnels and bridges).

Technological Solution - Optimise Transport Networks & Interfaces

Techniques for a better planning of the transport networks are highly recommended here, as well as the adoption of more "transversal" than "longitudinal" communication systems. If they must be longitudinal than, rather than build on the dunes, why not build under the dunes? Displacement from the coast of the high-density traffic network is also an option to be considered in order to increase local coastal resilience. Moreover, advance technical solution for the "crossing traffic" can ameliorate living conditions and local congestion, allowing, at same time for maintaining a larger "environmental connectivity" of the areas.

Problem - Increase of Maritime Traffic

Maritime traffic is expected to increase in many areas. Or even more, the shifting toward sea transport is being somehow stimulated by the European policies. In many situations this could dramatically increase the risks for accidents and casualties. Even if not so, long-term pollution or the introduction of exotic species could be a concern. Regulations from International and National organisms already cover the issue in a rather extensive way, also giving recommendations and rules for technological developments. Nevertheless it could be beneficial to further "integrate" maritime traffic planning and maritime traffic management with planning and management of coastal development.

Example
Examples are numerous along the European coasts. In general we could say that estuaries and straits represent the most critical areas. But we could also have examples of routes followed by vessels transporting dangerous goods close to Natural Parks or Marine Reserves.

Technological Solution - Adopt Simulation at Planning Stage

The further adoption, already at planning stage, of Vessel Traffic Management and Information Systems (VTMIS), even for areas that are not apparently critical for navigation, can help minimising long term environmental effects and reduce the risk for the environment. The implication of proposed developments and of proposed maritime traffic connections could be examined already in early stages such to avoid the introduciton of conflicts while implementing the measures.

Problem - Accessibility of Remote Coastal Areas and Small Islands

In the last decades the limited accessibility of remote Coastal Areas and Small Islands has caused a constant decrease of inhabitants. Tourism, and the connected activities, is producing an inversion of the tendency. However, it is characterised by a strong seasonality character (with additional problems connected to this, already introduced in §3.6). The problem is how to stimulate the more stable occupation in Coastal Areas and Small Islands and a more equilibrated (not only tourist-oriented) social structure?

Example
As examples were the issue could represent an important element of planning the future spatial development we can mention the Finnish and the Greek Arcipelagos.

Solution - Information Technologies

A part from the maritime link, that is necessary but also brings side-problems, information technologies could represent a way to bring work and occupation to remote Coastal Areas and Small Islands. Possibilities offered by tele-working and by the Internet should not be underestimated here.

3.9 Climate Change and (Relative) Sea Level Rise. The Need for Adaptation.

Natural catastrophes represent dangers to both humans and natural ecosystems. Climate change is expected to increase risk and vulnerability in many coastal areas. In particular, climate change and a possible rise in relative sea level (also due to subsidence) or changes in storms and storm surges could result in the displacement of wetlands and lowlands, erosion of shores and associated habitat, increased salinity of estuaries and freshwater aquifers, altered tidal ranges in rivers and bays, changes in sediment and nutrient transport, a change in the pattern of chemical and microbiological contamination in coastal areas, and increased coastal flooding (Jeftic et al., 1992; Bondesan et al., 1995; Gommes et al., 1998). In many areas, intensive human alteration and use of coastal environments already have reduced the capacity of natural systems to respond dynamically to such modifications of the "natural forcing factors" (e.g. Boesch et al., 1994). Nowadays, there is a growing discussion about the need to "anticipate" the possible effects of climate change in the coastal zone and to "adapt" to them (Bijlsma et al., 1996). Methodologies to assess adaptation strategies have been developed, also considering in a somehow empirical way the local technical capacity (IPCC, 1992). Certainly the engineering implication of a possible rise in relative sea level should not be underestimated (NRC, 1987). What is apparent is that relative sea-level rise would have a cost (Fankhauser, 1995) and such cost would be certainly lower if a more proactive approach would be followed in the adoption of coastal adaptation technologies (Klein and Nicholls, 1999).

Problem – Limited Coastal Resilience and High Vulnerability

Resilience is conventionally defined as the ability of bouncing back, or as elasticity in the face of pressure or disturbance. Extended to systems it is also defined as how a "system copes with major perturbations to its operating environment". A difficulty with the definition concerns temporal and spatial scale. In human societies it is concerned with preservation of day-to-day and other activities. ***Vulnerability***, instead of looking at the strength of communities or systems in the face of stressors, looks at their weaknesses. The reduction of vulnerability can be achieved together with market driven changes in many fields of activity. Bolsius et al. (1993) give suggestions for the European Agriculture. While traditionally, most human responses have been based on fighting nature (i.e. resistance and maintenance), there is increasing interest in policies that work with nature.

> ***Example***
> Coastal areas that have been constrained by the adoption of hard protection schemes or by the uncontrolled development of infrastructures have a very limited resilience nowadays. Vulnerability to possible relative sea level rise as well as to possible increase in storm frequency is likely to increase in those situations where natural dynamics have been altered by the extensive adoption of hard protection schemes.

Technological Solution - Monitor & Increase Resilience

While waiting for a better understanding of the climate change processes at local scale and for a better predictability of the effects, technologies for a continuous monitoring of changes at local scale are highly recommended. In addition technologies aimed at increasing resilience of the Coastal Zone should be developed and implemented. We refer, as an example, to the application of eco-technology to the management of coastal wetlands that can play an important role to contrast coastal erosion. We also refer to the application of soft protection technology (e.g. nourishment techniques) as an attempt to make use of natural sediment transport processes. Along the same line we attribute a strong importance to the use of "indicators" as a kind of value-added information.

Problem – Uncertainty about Forcing Factors and Coastal Dynamics

Because of uncertainty, climate change related issues could be manipulated by political and economic interest groups. One way in which the environmental regulatory community has begun to deal with the problem of true uncertainty, is through the "precautionary principle". The principle states that rather than await certainty, regulators should act in anticipation of any potential environmental harm in order to prevent it. The precautionary principle is so frequently invoked in international environmental resolutions that it has come to be seen by some as a basic normative principle of international environmental law. But the principle offers no guidance as to what precautionary measures should be taken. It "implies the commitment of resources now to safeguard against the potentially adverse future outcomes of some decision", but does not tell us how many resources or which adverse future outcomes are most important.

Technological Solution - Decision Support Systems to Handle Uncertainty

The solution, once again, goes beyond the sphere of support technologies. However, it certainly asks for long term monitoring systems and for operational forecasting systems to be properly installed and operated. Decision support systems, by aggregating the available knowledge with the information provided by monitoring and forecasting systems, can be used for scenario evaluation in an attempt to balance long-term development objectives and short term safety considerations (e.g. Chao and Hobbs, 1997).

Example
As an example we could mention here the problem to determine the future of an area like the ***Po Delta***, where extensive embankments could soon become unsustainable or the problem to decide about the technology to safeguard ***Venezia*** from "Acqua Alta" events. In this latter case the solution being examined is that of mobile gates closing the openings of the Lagoon during extreme events, however one of the reasons the opponents are using concern the large uncertainty about the future.

3.10 Nature Conservation & Biodiversity.

The term "biological diversity" is commonly used to describe the number and variety of living organisms on the planet. It is defined in terms of genes, species, and ecosystems which are the outcome of over 3,000 million years of evolution. The human species depends on biological diversity for its own survival. Thus, the term can be considered a synonym for "life on Earth".

Species extinction is a natural part of the evolutionary process (Odum, 1983). Due to human activities, however, species and ecosystems are more threatened today than ever before in recorded history. While these extinctions are an environmental tragedy, they also have profound implications for economic and social development. In addition, the richer the diversity of life, the greater the opportunity for medical discoveries, economic development, and adaptive responses to such new challenges as climate change.

Coastal and marine protected areas are being established around the world at a rapid rate. Some offer protection to pristine natural communities while others attempt to halt further deterioration of sensitive habitats or serve as fishery management tools for long term sustainability of coastal fisheries. Classification and understanding (Farinha et al., 1996) of dynamics of wetlands is a first important step towards their sustainable utilisation and the proper adoption of environmentally-compatible technologies. How to conciliate development objectives, restoration of environmental quality, and nature conservation objectives, and to what extent technologies can be included in the process, is an issue subject to a wide debate on many contexts (e.g. IVSLA, 1994).

Problem – Degradation of Natural Areas

Biological diversity will be threatened by rapid climate change and by changing land use patterns. The composition and geographic distribution of unmanaged ecosystems will change as individual species respond to new conditions. At the same time, habitats will be degraded and fragmented by the combination of climate change, deforestation, and other environmental pressures. Species that cannot adapt quickly enough may become extinct - an irreversible loss. The Coastal Zone represents the area where species are already subject to changing conditions and to strong environmental pressures, especially in lagoonal and wetland environments. Because of

Example
Examples are numerous along the European coasts particularly in the low-lying coastal area such as estuaries, deltas and lagoons. With reference to the Demonstration Projects we can mention here the example of the ***Waddensea*** Project which covers one of the largest wetland of importance for nature conservation in the European Union.
We can also mention here the Algarve Project and the Ria Formosa wetland area where the landscape has been radically transformed by human intervention (canals, salt production, farming).

this, additional changes could not be sustained.

Technological Solution - Maintenance

Technologies for the routine monitoring of "quality indicators" and maintenance of protected areas as well as sensitive areas in the Coastal Zone should be applied extensively. This is a particularly strong requirement for those situations where the impact of nearby infrastructures is likely to be felt. Technological developments are here required in order to reach easily and economically remote areas, and to maintain a synoptic and update monitoring.

Problem - Impact of Transport Networks

Transport networks represent often a "physical separation" of the territory where they are deployed (§3.8). Other than the obvious alteration of the water and sediment transport patterns, this can cause arm to the natural "population dynamics", thus altering the ecological structure of the environment. In a more subtle way, transport networks can be the vehicle by which alien species are introduced on relatively untouched areas, with all the connected problems.

Example

Coastal wetlands are particularly subject to the risks connected with the alteration of the mobility opportunities for existing species.

Technological Solution - Large Scale Infrastructures

Tunnels as well as bridges can be suitable solutions to limit the (operational) impact of a transport network on sensitive areas. Of course impacts will be present during construction phase, however they could eventually be mitigated.

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4. THE ROLE OF TECHNOLOGY IN PRESERVING COASTAL ZONE SPACE AND ITS RESOURCES.

In the present section we focus the attention on more specific, and typically more local scale, problems connected with or derived by the sectoral utilisation and exploitation of Coastal Zone Space and of its Resources. The issues hereby described ask for the adoption of preventive measures as well as of measures to mitigate the effects. The issues are all present, in a more or less explicit way, in the Demonstration Projects. Examples can be numerous along the whole European coastline.

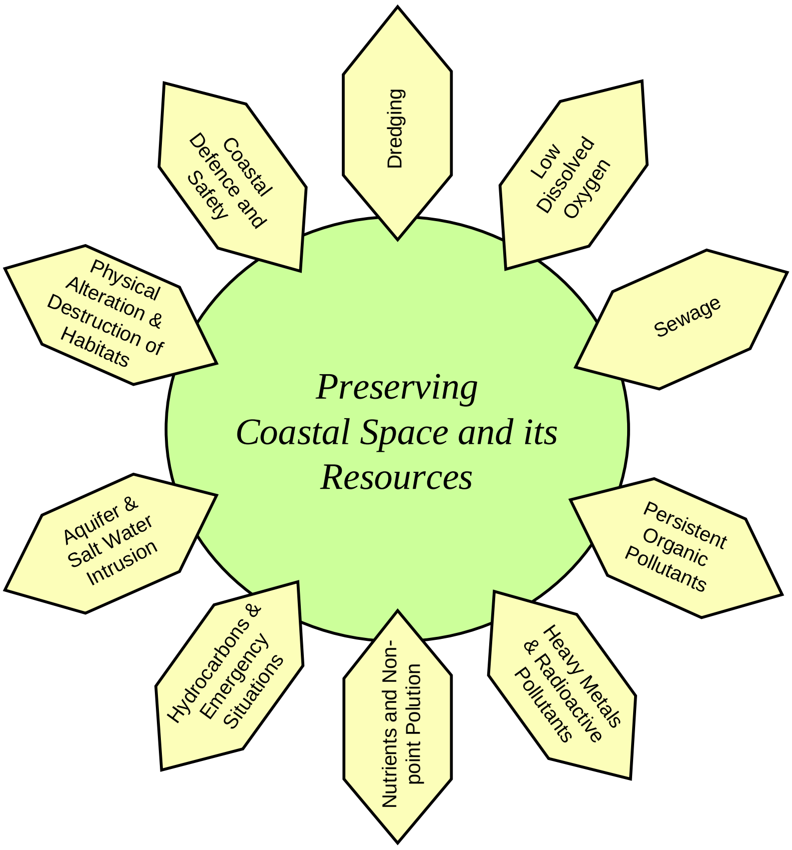

Fig. 4.1 - Some Specific Problem that should be Tackled to Contribute to the Preservation of the Coastal Zone Space and of its Resources

Once again we introduce, very briefly, the "technological side" of the solution. Roughly speaking, we can say that ***the technologies hereby introduced belong, if properly applied, to the class of the "ICZM-supporting" technologies***. This means that interventions might be needed "a-posteriori" in order to avoid the occurrence of certain impacts and in order to avoid that certain impacts "propagate" from the sector that originates them to other sectors.

It is useful to distinguish between long-term processes, that might require ***structural measures for mitigation***, and short-term processes/events, that might require ***emergency interventions***. The key difference anyway with respect to the previous Chapter is that here interventions are generally needed to protect and mitigate on a smaller scale.

4.1 Low Dissolved Oxygen.

Low dissolved oxygen, or hypoxia, represents a serious water quality impairment in the coastal waters. The annual summertime occurrence of hypoxia in the deeper waters reduces the amount of healthy habitat necessary to support fish and shell-fish. This has nature conservation implications as well as economic implications. Various sectoral activities can cause decrease of oxygen content (§3.2, §3.3, §3.4, §3.5).

Technological Solution - Remove the Source and Increase Oxygen

Technical solutions, both of hard and soft type, are available to counteract the problem either by removing the source at local scale or by increasing the oxygen level.

- *Creation of Artificial Wetlands.*
- *Monitoring Bottom Waters and Superficial Sediments.*
- *Aeration of Bottom Waters.*
- *Seaweed Farms.*
- *Relocation of Sewage Treatment Plant Outfalls.*
- *Tide Gates.*
- *Modifying the Morphology of the Basin.*

4.2 Sewage.

Recognising variation in local conditions, domestic waste water (§3.1) improperly discharged to freshwater and coastal environments may present a variety of concerns (EPA, 1997). Environmental effects associated with domestic waste-water discharges are generally local with transboundary implications in certain geographic areas. Domestic waste-water discharges are considered one of the most significant threats to coastal environments worldwide.

Technological Solution - Treatment and Monitoring

Technical solutions, both of hard and soft type, are available to counteract the problem. As far as Sewage Facilities are concerned, solution is based on the installation of appropriate and environmentally sound sewage facilities, and to this end ensure:

- *Building and maintenance of sewer systems and sewage-treatment facilities or other appropriate systems, in accordance with national policies and capacities and international cooperation available;*
- *Location of coastal outfalls so as to obtain or maintain agreed environmental quality criteria and to avoid exposing shell fisheries, water intakes, and bathing areas to pathogens and to avoid the exposure of sensitive environments (such as lagoons, coral reefs, seagrass beds, mangroves, etc.) to excess nutrient loads;*
- *Promotion of the reuse of treated effluents for the conservation of water resources.*
- *Promotion of primary, secondary and, where appropriate and feasible, tertiary treatment of municipal sewage discharged to rivers, estuaries and the sea;*
- *Establishment and improvement of monitoring programmes to control and assess effluent discharge, using minimum sewage effluent guidelines and water quality criteria and giving due consideration to the characteristics of receiving bodies and the volume and type of pollutants;*
- *Identification of the availability and sustainability of productive uses of sewage sludge, such as land-spreading, composting, etc.;*

4.3 Persistent Organic Pollutants (POPS).

Persistent organic pollutants (POPs) are a set of organic compounds that: (i) possess toxic characteristics; (ii) are persistent; (iii) are liable to bioaccumulate; (iv) are prone to long-range transport and deposition; and (v) can result in adverse environmental and human health effects at locations near and far from their source. Various sectoral activities can determine the supply of POPs in the coastal waters (§3.3, §3.4).

Technological Solution - Eliminate and Control

Remediation technologies are available for a large number of situations (DOD, 1994). Persistent Organic Pollutants represent a serious problem and the main solution that can be considered is that of strongly limit their use and rehabilitate the "contaminated" media. At local level we can consider the following type of technical interventions:

- ***Eliminate emissions and discharges.*** *To reduce and/or eliminate emissions and discharges of POPs that threaten to accumulate to dangerous levels in the marine and coastal environment;*
- ***Substitute Chemicals.*** *To give immediate attention to finding and introducing preferable substitutes for chemicals that pose unreasonable and otherwise unmanageable risks to human health and the environment;*
- ***Cleaner Production Processes.*** *To use cleaner production processes, including best available techniques, to reduce and/or eliminate hazardous by-products associated with production, incineration and combustion;*
- ***Pest Control.*** *To promote best environmental practice for pest control in agriculture and aquaculture.*

4.4 Heavy Metals and Radioactive Pollutants.

Heavy metals are natural constituents of the Earth's crust. Human activities have drastically altered the biochemical and geochemical cycles and balance of some heavy metals, especially as a side-product of industrial activities (§3.3). Heavy metals are stable and persistent environmental contaminants since they cannot be degraded or destroyed. Therefore, they tend to accumulate in the soils and sediments. Excessive levels of metals in the marine environment can affect marine biota and pose risk to human consumers of seafood.

Radioactive substances (i.e., materials containing radionuclides) have entered and/or are entering the marine and coastal environment, directly or indirectly, as a result of a variety of human activities and practices. These activities include production of energy, reprocessing of spent fuel, military operations, nuclear testing, medical applications and other operations associated with the management and disposal of radioactive wastes and the processing of natural materials by industrial processes. Other activities, such as the transport of radioactive material, pose risks of such releases.

Radioactive materials can present hazards to human health and to the environment. Suspected radioactive contamination of foodstuffs can also have negative effects on marketing of such foodstuffs.

Technological Solution - Detect and Eliminate

Technical solutions should be aimed either at eliminate them or at detect them (DOD, 1994; EPA, 1997a; USAEC, 1999). In addition technical solution for the "decontamination" of the marine environment and the marine biota are highly recommended.

Monitoring of the level of heavy metals within seafood is an extremely important issue.

Solution – Turning Radioactive Pollutants into an "Opportunity"

It is interesting to note the to some extent, radioactive substance represents a formidable opportunity to study and evaluate the nearshore dynamics, particularly the sediment dynamics close to river mouths.

4.5 Nutrients and Non-point Pollution.

4.5.1 Nutrients.

Eutrophication can result from augmentation of nutrient inputs to coastal and marine areas as a consequence of human activities (§3.1, §3.4). In general, such eutrophication is usually confined to the vicinity of coastal discharges but, because of both the multiplicity of such discharges and regional atmospheric transport of nutrients, such affected coastal areas can be extensive. The effects of the enhanced mobilisation of nutrients are enhanced productivity but these can also result in changes in species diversity, excessive algae growth, dissolved oxygen reductions and associated fish kills and, it is suspected, the increased prevalence or frequency of toxic algae blooms.

Technological Solution - Identify and Reduce

Technical solution should aim at reducing the supply of nutrients as well as removing nutrients from the water column and the sediments. In direct techniques based on algae harvesting can be almost self-paying in specific situations.

4.5.2 Nonpoint Source Pollution.

Nonpoint source (NPS) pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources (§3.1, §3.4). NPS pollution is caused by rainfall or snow-melt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water. These pollutants include:

- Excess fertilisers, herbicides, and insecticides from agricultural lands and residential areas;
- Oil, grease, and toxic chemicals from urban runoff and energy production;
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks;
- Salt from irrigation practices and acid drainage from abandoned mines;
- Bacteria and nutrients from livestock, pet wastes, and faulty septic systems;

Nonpoint source pollutants are transported to surface water by a variety of means, including runoff, snowmelt, and ground-water infiltration. Ground water and surface water are both considered part of the same hydrologic cycle when designing management measures. Ground-water contributions of pollutant loadings to surface waters in coastal areas are often very significant. Hydrologic modification is another form of nonpoint source pollution that often adversely affects the biological and physical integrity of surface waters.

Technological Solution - Source Control

Source control is the first opportunity in any nonpoint source control effort. Source control methods vary for different types of nonpoint source problems. Examples of source control include:

- ***Protecting riparian habitat*** *and other sensitive areas by an adequate adoption of wetlands as buffer zones. Examples include protection and preservation of riparian zones, shorelines, wetlands, and highly erosive slopes.*

- ***Protecting natural hydrology**. Examples include the maintenance of pervious surfaces in developing areas (conditioned based on ground-water considerations), riparian zone protection, and water management.*
- ***Reducing or eliminating the introduction of pollutants** to a land area. Examples include reduced nutrient and pesticide application.*
- ***Preventing pollutants from leaving the site** during land-disturbing activities. Examples include using conservation tillage, planning forest road construction to minimise erosion, siting marinas adjacent to deep waters to eliminate or minimise the need for dredging, and managing grazing to protect against overgrazing and the resulting increased soil erosion.*
- ***Preventing interaction between precipitation and introduced pollutants**. Examples include installing gutters and diversions to keep clean rainfall away from polluted areas, diverting rainfall runoff from areas of land disturbance at construction sites, and timing chemical applications or logging activities based on weather forecasts or seasonal weather patterns.*

4.6 Oils (Hydrocarbons) & Emergency due to Pollutants Discharge.

Many oils are liquid and gaseous hydrocarbons of geological origin[3]. While some oils are naturally occurring, a significant proportion of those in the marine and coastal environment have been derived from anthropogenic sources. The typical anthropogenic source is "accidental discharge".

Oil spills at sea threaten animals, plant life and other marine resources. Oil can also cause long term environmental and economic damage to the marine ecosystem near a spill.

Intervention techniques due to accidental discharge of pollutants are largely available[4]. The purpose is generally that to bring the natural resources or services affected to *baseline conditions*. Baseline means the condition of the natural resources and services that would have existed had the incident not occurred. Activities of interest in the context of emergency response are:

- ***Early Detection.*** Early detection is of interest of regulatory authorities as well as coastal authorities responsible for verification of correct application of regulation and procedures. Early detection might require a suitable placement of a monitoring system with respect to the possible source of impact. A permanent installation can be considered here.
- ***Long-term Monitoring.*** Long-term monitoring is mainly an issue of scientific interest but will increasingly become an activity of interest for licensing and long-term planning. Long-term monitoring might require a suitable placement of a monitoring system with respect to the possible receptor of the impact. A long-term installation has obviously to be considered here.
- ***Injury Assessment***. This is an issue of extreme interest in the context of emergency situations. Injury assessment might require the suitable placement of a number of monitoring systems with respect to the accident area according to local conditions. A medium duration installation can be considered here.

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[3] *A useful website for users looking for information on all aspects of Offshore Technology for Oil and Gas Industry is: http://www.offshore-technology.com*

[4] *Intervention is largely regulated by International and Global Conventions and we do not enter here into details (see Appendix E). It is however certainly true that suitable ICZM planning might include acquisition of technologies for intervention in key areas as well as a suitable logistical organisation.*

Technological Solution - Baseline Conditions

Technologies to describe the baseline condition, for early detection and for emergency interventions are needed here. Focus is on monitoring and early detection technologies.

Technological Solution - Contingencies

Technologies to fight accidental discharge of oils are increasingly available (Thomas and Wischmann, 1998). To a large extent is a matter of organisation and of definition of fighting strategies based on knowledge of hydrodynamic processes.

Solution – Containment and Removal Technologies

The best method is to contain the oil then physically recover it from the water. But mechanical removal of the oil isn't feasible if, for example, seas are too rough. The natural action of ocean waves can break up oil slicks into small droplets, especially if the seas are rough. But in cases where time is limited, chemical dispersants are used to quicken this natural break up of the oil The rougher the seas, the better the chance the dispersants will work. Dispersants are most effective on oils that flow readily, rather than thicker oils. And since fresh crude oils become stickier the longer they're exposed to water, the decision on whether or not to use dispersants must be made quickly. Risks and benefits should be assessed on a case-by-case basis to decide about the use of dispersants. A list of possible restoration actions is given in Appendix C; each of them involves some kind of supporting technology.

4.7 Aquifers and Salt Water Intrusion.

Salt water intrusion is the migration of salt water into fresh water aquifers under the influence of groundwater development. Salt water intrusion becomes a problem in coastal areas where fresh water aquifers are hydraulically connected with seawater. When large amounts of fresh water are withdrawn from these aquifers, hydraulic gradients encourage the flow of seawater toward the pumped well or wells. Salt water intrusion is a problem that affects coastal areas around the world.

Salt water intrusion causes many problems in these areas, perhaps the most severe being the limitation of potable drinking water. Also, salinity in irrigation water can be detrimental to agriculture, reducing yields and killing crops with low tolerances to salt. In some cases, conditions may necessitate a change to crops that are more salt tolerant.

Technological Solution - Monitoring

The first step in correcting problems with salt water intrusion is to evaluate the size and extent of the problems. This is commonly accomplished by the installation of monitoring wells, which are used to determine the boundaries of the salt/fresh water interface and the rate at which salinity levels are increasing. Using this data and information on the hydrologic and geologic properties of the contaminated aquifer, modelling is often incorporated into problem analysis in order to predict future conditions and to evaluate remediation alternatives.

Technological Solution - The Need for Modelling

Models are required to predict and characterise the movement of the transition zone in the aquifer where fresh water and salt water meet. Another purpose modelling is to predict the degree and extent of mixing that occurs in this transition region. In this way, models allow problems to be defined before they actually occur.

4.8 Physical Alteration and Destruction of Habitats.

The increase of populations and economic activities in Coastal Zones is leading to an expansion of construction and alterations to coastal areas and waters. Excavation, oil and gas exploration and exploitation, mining, such as sand and aggregate extraction, the building of ports and marinas and building of coastal defences and other activities linked to urban expansion are giving rise to alterations of coral reefs, shorelands, beachfronts and the seafloor. Important habitats are being destroyed. Wetlands are being transformed into agricultural lands and through coastal development.

Technological Solution - Renaturalisation Interventions

The development of eco-technologies is highly recommended. This means that re-naturalisation interventions can be undertaken (see Appendix D), such as:

- *Diversification of emerged areas level*
- *Restoration and Maintenance of Beach and Dune Systems*
- *Restoration of "valli" inland waters*
- *Interventions of naturalistic re-qualification*
- *Reorganisation and preservation of the coastal vegetation.*
- *Improving environmental conditions that are favourable to spontaneous vegetation in the lagoons and valleys inland.*
- *Reduce/remove any animal competitors.*
- *Wetland restoration*
- *Diversion of river branches*

4.9 Coastal Defence and Safety.

4.9.1 The Large-scale Aspects

Coastal defence is a broad term embracing both coast protection, that is techniques employed to slow down or prevent loss of (utilised) land due to "coastal erosion", and sea defence, which covers techniques intended to reduce or prevent flooding or tidal inundation of coastal land or, in other words, to reduce "coastal risk". It is interesting to note that erosion is being increasingly recognised as being a "unacceptable landward movement of the coastline". The fact that it is unacceptable depends on the fact that there is some kind of human interest or some kind of values that is affected (Leafe, 1998).

Coastal erosion and flooding are a concern for many who live or work immediately adjacent to the coast because of the risk, or perceived risk, of property loss or damage. Such fears have intensified in recent years due to widely publicised forecasts of increases in sea level which may result from global climate change. Because of the location of most defences, i.e. behind or upon beaches, there are also concerns relating to conflicts of interest between those favouring defence construction and those supporting other uses or attributes of the coastline such as nature conservation, landscape and amenity (NRC, 1990; NRC, 1995).

The issue of coastal defence and erosion present both a "strategic character" and more local implications.

Problem - Confusion of Causes and Effects

Causes and effects are being increasingly confused by large number of short term and small scale defence intervention typically based on the adoption and the misuse of "hard protection technologies". Often it is difficult to understand why all the effort is going toward an hopeless attempt to "save the remaining sand" while it is rather clear that the core of the problem is due to the "lack of sand". Also, in many cases the successive introduction of hard structures has complicated the functioning of the coastal system in such a way that it is extremely difficult to understand and predict what is going to happen. Modelling (De Vriend, 1996; De Vriend et al., 1993) here is an essential complement for the application of protection

> ***Example***
> With reference to the Demonstration Projects we can mention here the example of ***West Flanders*** on the Flemish coast where human intervention makes it difficult to appreciate the natural erosion of the Flemish coast. Overall, approximately two thirds of the Flemish coast is erosive.

technologies, not only for their detailed design but also for the overall planning in order to examine a variety of intervention scenarios.

Technological Solution - Qualify & Quantify Problems

The source of the problems should be carefully investigated, at all significant spatial and temporal scale, as a necessary prerequisite to find the most suitable solution. Techniques to better quantify and qualify the "Coastal Defence" and the "Coastal Risk" problems can represent a fundamental step for a better implementation of traditional or new intervention technologies. Also, it has to be recognised that, often, the solution inevitably must have a "temporary character". The idea of having the solution lasting forever is a utopia most of the times, which goes very much together with the adoption of hard technologies. Such mistake is less present when nourishment is considered, however organisation problems enter the scene here (CBNP, 1993; CUR, 1987).

Problem – Adoption of a Narrow View of the Beach Composition

In traditional coastal engineering practices the problem of erosion has mainly be considered as a problem of sand disappearing offshore. Particularly while looking at long term processes, the active role of the ecological component of the Coastal Zone should be taken into account (Capobianco and Stive, 1997).

Example
The majority of hard defence interventions in the past has been inspired to such philosophy and has subsequently shown their limitations. Also in many situations erosion appears not to be as it "should be", because of the influence of vegetation (and of bioturbation).

Technological Solution - Consider the Active Role of Vegetation

Dune re-vegetation can represent a significant opportunity for the adoption of a soft-technology which can help to conciliate protection needs, with needs of nature conservation and which can represent a more sustainable interface between natural and rural areas (cfr. 4.8). Specific technologies can be beneficial for:

- *Design, to understand the processes and to "engineer" the implementation and management phase;*
- *Implementation, to guarantee the survival and the protection of vegetation,* particularly *in the early stages.*

In this context, also the role of aeolian transport, even with all its uncertainties (Bauer et al., 1996), should not be underestimated while designing technical solutions to counteract the problem.

4.9.2 Counteracting Erosion at the Local Scale

Erosion can be considered as the "unacceptable landward movement of the coastline". The fact that it is unacceptable depends on the fact that there is some kind of human interest or some kind of values that is affected (FEMA, 1994). The issue is particularly relevant for low-lying coastal and deltaic regions with relatively gently sloping interlands. In principle we can distinguish between "Natural Erosion", due to the natural tendency towards some kind of equilibrium following changing environmental conditions, and "Human Erosion", as the disturbance to an existing natural equilibrium. Human intervention within the coastal zone has often taken place without full knowledge of how the development will effect local and regional hydrodynamic and geomorphological processes. Disruption to sediment transport pathways by development may in fact accentuate or induce erosional problems in the adjacent coastal region. Regardless of what is the cause and how remote from a specific coastal stretch it originates, there could be the necessity for "interventions".

Uncertainties are intrinsic to the coastal processes, due to their complex interactions (e.g., see Bauer et al., 1996, for what concerns aeolian processes).

Solution – Coastal Protection

A variety of technologies for intervention is available nowadays (see, for example, ECOPRO, 1996), including both traditional hard protection technologies and soft protection technologies (Pilarczyk, 1990):

- *Offshore Breakwaters, Submerged Breakwaters, Moored Breakwaters*
- *Sand By-passing*
- *Groins, Submerged Groins*
- *Beach Nourishment, Profile Nourishment (cfr. 4.10)*
- *Beach Drainage*
- *Seaweed planting, Mudflat Restoration*
- *Seawalls and Revetments*
- *Land Use Restrictions, Walkways*
- *Dune Reconstruction, Sand Stabilisation, Sand Trap Fencing, Grass Seeding (cfr.4.8)*
- *Managed Retreat, Do Nothing*

Concerning the application of soft protection technologies (see also Appendix D), it has to be mentioned that quite often procedural (Davison et al., 1993) as well has legal problems prevent their further application (Hamm et al., 1998).

4.10 Dredging: Impact on Environment.

The excavation process commonly referred to as "dredging" involves the removal of sediment in its natural (new-work construction) or recently deposited (maintenance) condition, either mechanically or hydraulically. After the sediment has been excavated, it is transported from the dredging site to the placement site or disposal area. This transport operation, in many cases, is accomplished by the dredge itself or by using additional equipment such as barges, scows, and pipelines with booster pumps.

The removal or excavation, transport, and placement of dredged sediments are the primary components of the "dredging process." In design and implementation of any dredging project, each part of the dredging process must be closely coordinated to ensure a successful dredging operation. Dredging should be carried out according to guidelines and used appropriately, to ensure that it serves as part of the solution to managing coastal problems, rather than as a new source of problems. In certain instances this might mean selecting alternatives to dredging.

Problem - Balance between Damages and Benefits

Dredging, in recent years has been somehow counteracted by environmental authorities and ministries of the environment, mainly because of possible sources of pollution or mobilisers of pollutants (EPA, 1998). Dredging can be however an important opportunity and can produce a number of "beneficial effects" (EPA, 1998).

Technological Solution - Beneficial Uses of Dredging

Dredging is, on the other hand, the basic action that is available to implement "soft interventions" and to adopt "eco-technology" practices where the human action just trigger changes, while the dynamics are natural at the maximum possible extent. Technologies to ameliorate the dredging process in the Coastal Zone are highly recommended.

> ***Example***
> The most comprehensive example we can give here is probably the ***US*** policy concerning dredging activities that, justifying by the need to maintain the extensive waterways network has been moving from a problem to an opportunity. According to Environmental legislation of most ***EU Member States***, dredged material has to be treated as a special waste, thus strongly limiting the possibilities for its utilisation.

Beneficial use includes a wide variety of options which utilise the material for some productive purpose (see Appendix F, for a more extensive description). Dredged material is a manageable, valuable soil resource, with beneficial uses of such importance that they should be incorporated into project plans and goals at the project's inception to the maximum extent possible.

Technological Solution – Detailed Survey and Mapping

Since the impacts of dredging may be far-reaching spatially, there is some difficulty in evaluating their impact (such as in conducting EIAs). Increased data and knowledge about coastal dynamics would certainly facilitate the process. Suitable survey and monitoring activities in order to properly map possible pollutants as well as long term morphological modification are an important requirement.

The adoption of the precautionary approach here can be a limitation to development. As an example we can mention the Dart Estuary where mussel farming could be promoted and made possible by dredging TBT-polluted sediment.

5. CURRENT ROLE AND POSSIBLE USE OF TECHNOLOGIES WITHIN THE DEMONSTRATION PROGRAMME

5.1 Questionnaire to the Projects.

The study, has been complemented by a questionnaire circulated to the various Demonstration Projects. Of the 35 Questionnaire that were distributed, 22 were returned, 3 of the Projects that did not send the questionnaire have been visited (see *Appendix H*), and the information for 5 of the others was complemented by outside sources. Thus a total of 30 over 35 Projects were examined in some details. One of the first questions was on the "definition of technology". Here is a selection of answers:

- ***Bantry Bay***. "Technology is the application of new scientific results to practical problems"
- ***Barcelona***. "The different skills that may serve to reach the objectives"
- ***Cyclades.*** "All the techniques used for the assessment, prevention and mitigation of environmental problems (research tools, sampling techniques, GIS, methods for monitoring, methods for data analysis and modelling)"
- ***Dorset***. "The equipment necessary to support project delivery"
- ***Forth Estuary***. "Technology is the use of man-made application created through innovative design and research"
- ***Ipiros***. "The technical means which help problem assessment, problem prevention, problem mitigation"
- ***Irish Beach and Dunes***. "The means by which science is implemented, usually in the form of tool or technique or system"
- ***Kent***. "Any extension to human capabilities"
- ***Kavala.*** "It is the medium (hardware, software, expertise), which supports the administration in the problem solving"
- ***Latvia***. "The full range of equipment & expertise availability for all aspects of the priority"
- ***Magnesia***. "A system of techniques leading to a specific result"
- ***Norwegian Coast***. "Computer tools that make the access to data and analyses easier and more efficient"
- ***Rade de Brest***. "Les technologies pour le traitement des pollutions et la préservation des milieux - les technologies comme outils de suivi de l'état des lieux, de synthèse, d'échange d'informations"
- ***RICAMA***. "Any system aiming at enhancing the flexibility for having things done and objectives reached".
- ***Storstrom***. "Technology mainly refer to special computer software and hardware in the work with handling data and map information. But we also have monitoring systems"

For what concerns the Role and Use of Technologies, the following aspects (with a number of specific questions for each of them) have been covered by the questionnaire:

- ***Framework of Activity***, to have an indication of the context which originated the ICZM effort
- ***Currently Used Technologies***, to verify which technologies are explicitly part of the ICZM activity;

- ***Technical Ability and Limiting Factors***, to describe the present attitude toward the adoption of technologies;
- ***Driving Forces for Technologies***, to assess whether there are specific problems pushing for the adoption of specific technologies;
- ***Technologies in the Demonstration Project***, to verify at what extent technologies are applied in the Demonstration Project;
- ***Outcomes of the Demonstration Project***, to have an indication about the possible conclusion of the Demonstration Project with respect to the need for technologies;
- ***Plans with Respect to Currently Adopted Technologies***, to verify the possible existence of specific plans concerning the application of technologies;
- ***Overall Perception of the Role of Technologies***, to assess whether or not technologies can be playing a role in ICZM according to ICZM-planners.

5.2 Analysis of the Responses.

It is interesting to look at the variety of answers. We must say that the definition of technology has been subject to a certain “evolutionary process” even in the course of the Demonstration Programme. During the first joint meeting between the thematic experts and the project leaders, held in Brussels on September ’97, the answers to the same question covered a much narrower range of options, being almost completely limited to Geographical Information Systems and Data-base Systems.

Two large clusters are present in the Projects, as the result of the two main sources of financial support, DGXI and DGXVI. In addition we have to consider that additional clusters are present in the TERRA Group (Coastlink, Concercoast, CZM, Posidonia)[5] and are representative of peculiar situations. However, from an overall point of view, the projects are representative of a large variety of situations which is useful to recall here:

- inhabitants ranging from a few thousands (***Strymonikos***) to millions (***Barcelona***);
- spatial scale from few square kilometres (***Bantry Bay***) to thousands square kilometres (***Dorset***) and more;
- administrative scale from a local level with few municipalities (***Ria de Aveiro***) to the level of a whole nation (***Latvia***);
- from rural environment (with focus on nature conservation aspects, e.g. ***Devon & Cornwall***) to urban environment (with focus on spatial planning, e.g. ***Athens and Napoli***);
- from fully connected regions (***West Flanders***) to isolated regions (***Kavala***), including arcipelagic islands (***Finland***);
- also for the islands, from single islands well connected (all type of connections) to the mainland (***Isle of Wight***) to small islands not connected to the mainland (***Cyclades***);
- from a voluntary approach to (local) management (***Kent***) to a regulatory approach to management (***Lithuania***);
- from estuarine environments with large tidal excursion (***La Gironde***) to long coastal stretches with small tidal excursion (***Regione Abruzzo***);
- from the north of Europe (***Storstrøm***) to the south of Europe (***Algarve & Huelva***),
- from a single dominating issue (***Irish Beaches & Dunes***) to multiple issues (***Taranto***);

5 It is worth to consider that other projects of the TERRA Program, not introduced formally into the Demonstration Programme on ICZM, can have a strong ICZM importance. We refer, as an example, to the cluster focusing on “river basins” (see http://www.inforegio.cec.eu.int/terra/terra.html).

- mainly looking on the mainland (***Palermo***) or with a strong marine character (***Norway***);
- from planning for sustainable coastal land use on the large scale (***Vale do Lima, La Costera-Canal***) to management for sustainable beach utilisation at more local scales (***Irish Dunes***);
- looking for the restoration of environmental quality damaged by past developments (***Cote d'Opale***) or trying to preserve RAMSAR sites (***Algarve***);
- from situations were a large number of administrative units are integrated at all levels (***Rade de Brest***) to situations were integration involves administrations across national boundaries (***Wadden Sea***);
- from areas promoting economic development (***Ipiros & Magnesia***) to post industrialised areas, looking at the possibility to preserve, maintain, or restore the environmental quality (***Forth Estuary***).

This large variety of situations makes it difficult to have a direct comparison of the answers and to assess their "statistical significance". On the other hand it represents the opportunity for a more comprehensive examination of the variety of conditions where technologies could actually play a role and be used.

5.3 Summary of the Most Significant Aspects.

To summarise the most significant elements deduced from the answers we focus on a few fundamental questions:

- ***What Technologies are used or could soon be used for in ICZM?*** The technology which at moment appears to be most likely to play a role in relation to ICZM (in the decision making community), is Geographical Information System (GIS). There is a general tendency to develop and apply GIS for the problem recognition phase and for the planning phase. Other technologies are not explicitly considered in the ICZM effort, thus indicating that CZM still has to complete its process of integration with the intervention phase and the evaluation phase, as well as the process of integration with many of the sectoral issues of the Coastal Zone.
  While problem prevention is also sometimes considered, problem mitigation is generally considered to be a technology-free activity. This can originate (or is also somehow connected with) the misleading assumption that once a decision to act is taken (e.g. to clean-up a beach), there will be a technique available for the action. This is not always true, of course.
- ***Do Used/Available Technologies Represent a Limiting Factor for ICZM?*** Technologies do not appear to be a limiting factor for ICZM, or at least they are not recognised as being limiting factors. Other aspects like information, participation mechanisms and procedures, coherence of plans and programmes, are generally considered as being the limiting factors at moment. To a large extent, there are elements that highlight the fact that through the adoption of suitable technologies a few of such limiting factors could be overcome.
- ***If Yes, in which Phases of ICZM Tasks?*** Technologies are reported to be limiting factors during problem assessment phase. However, it is not always explicit what phases are actually affected. Certainly it is apparent that a technological and an organisational effort in the problem recognition phase as well as in the implementation and evaluation phase could help the suitable completion of the ICZM loop. Particularly for the implementation phase it is not generally recognised the fact that any human

action on the Coastal Zone is in ultimate analysis undertaken by applying some kind of techniques or technologies.

- ***What are the driving forces for technology?*** Certainly the awareness of the importance of an informed decision making is increasing, even if the ingenuity that the information will come together with the GIS software is still present. Technology “pushers” are also most likely playing a role here.
- ***How do Technologies mutually interact?*** We use technologies to “look” at the coastal zone and technologies to “act” on the coastal zone, thus establishing a look where technologies represent both our senses and our arms. Technologies interact at least in an indirect way. If a certain decision-making technology determines the changes of the human activities (those undertaken on the basis of sectoral considerations) in the Coastal Zone, it actually determines the decision to use certain technologies or certain other technologies.
  Such mutual interaction of technologies is not recognised; it is a non-issue to a large extent, even if during bilateral conversations it is often accepted as an hidden phenomenon.
- ***How Technologies Influence/Impact the Coastal Zone?*** Technologies actually determine the way the fluxes of matter and of information between the various coastal compartments are regulated and actually occur in practice. Interesting to note here that even in those situations were disasters occurred due to technology (fire of a tanker in a bay, erosion due to groins, pollution of sediments due to antifouling, etc.), no evidence of “Influence/Impact of Technologies on the Natural Resources” in the Coastal Zone are reported.
- ***Where and When, Technologies can be properly applied?*** It is early to draw conclusions about where and when technologies can be properly applied, however it is important to recognise the fact that technologies are present in the ICZM loop more often than normally “suspected”, particularly when attention is given to the implementation phase.
- ***Should Technologies be modified?*** The answer should probably be given in a articulated way according to the various phases of the ICZM loop. For problem recognition and planning, rather than modify the currently adopted technologies, it is their use that should be better organised. For implementation and evaluation first of all it should be explicitly recognised by ICZM-planners that they actually enter the ICZM loop (which is generally not the case).
- ***Is the Demonstration Project Like to Suggest the Adoption of Technologies?*** Even if the average “ability” with respect to technical capacity is reported to be relatively over the mean value, there is a quite open attitude towards the possible changes that could be suggested by the activity of the Demonstration Project.
- ***Should the way Technologies are applied be changed?*** Certainly the way GIS are applied nowadays should be changed. In particular it has to be made clear that GIS is not just the piece of software producing the geographical representation of some data on a screen but a lot more. The same is true for observation and monitoring technologies, where they exist. They are still extensively responding to sectoral need and the potential given by a true integration and networking do not appear to be exploited.

In ultimate analysis it also emerges clearly the need to ***bridge the gaps of information*** between different disciplines and different institutions, and especially to put in contact the "offer" of technology with the potential "request" of technology for ICZM activities.

To summarise the most significant aspects that emerged from the Visits we underline:

- ***Better Understanding.*** A better understanding of problems in a given coastal location can only be obtained by the continued collection of data and development of information, and the subsequent interpretation of these data and information in the light of climate and socio-economic scenarios.
- ***Improve Monitoring***. There is a great need to improve monitoring capabilities in many countries, to standardise data collection and archiving, and to ensure simple, free and unlimited access to information provided by existing monitoring networks. This is obviously particularly the case for those ICZM initiatives focusing mainly on natural and rural coastal environment for which limited local funds can be mobilised.
- ***Effectiveness of Technology***. In order to obtain a better understanding of the effectiveness of the application of technology, it is crucial to develop a framework to evaluate the process of technology implementation. Using an extensive set of criteria, such an evaluation framework can provide insights into the extent to which the sectoral service has been provided minimising environmental impacts or the extent to which coastal risks has been successfully reduced.
- ***Clearinghouse for Technologies***. Information on available technologies is scattered, which makes it impossible for planners trying to identify appropriate technologies to oversee the entire spectrum of available options. The establishment of a clearinghouse for technologies applicable in the coastal zone could facilitate the task of technology selection and evaluation. Such a clearinghouse would develop and hold an extensive catalogue of available technologies, including information on their costs, performance, owner (if not publicly-owned), implementation requirements and other relevant issues.
- ***Local Capacity***. Local capacity is extremely important. Ideally, capacity building of all relevant stakeholders, including the public, should take place well before a technology is introduced, and should continue using local trainers.
- ***The Private Sector***. The private sector may be able to extend its role in supporting technology when provided with the right stimulus. These stimuli would tend to increase the profitability of environmentally-friendly technologies, and could include subsidies for investment and tax exemptions of income. The role of the private sector may also be extended by regulation.

5.4 Problems need solving, not moving.

The more parochial a definition of a problem, the more danger there is that the corresponding (technical) solutions will, by neglecting of feedback loops, make the underlying problem worse. The more broadly and strategically a problem is defined, the more chance there is of finding a proper (technical) solution. This will often entail defining problems at a higher level (that is to say more abstract or generic) than technical specialists have been accustomed to. In particular it requires problems to be solved rather than moved. This is particularly true when the temporary solution is involving the use of technologies that, like a medicine, always bring collateral effects.

Of course a very popular example here can be due to the application of breakwaters, but also more subtle ones can be mentioned, like the dredging of new canals on a shallow lagoon.

This is the key to reconciling the pursuit of sustainability with delivering day to day services. Indeed it will often help with the achievement of service objectives which are not necessarily related to sustainability, since unrecognised and unmanaged systems effects do not only frustrate sustainability goals.

5.5 General Considerations on the Application of Technologies.

A need that emerges clearly from such the analysis, is that of ***recognising the presence of (sectoral) technologies*** in the actions and the interventions currently undertaken in the Coastal Zone. The risk is that integrated planning and integrated management are intrinsically subject to failure in their implementation phase, simply because they not explicitly take into account the fact that technologies are there anyway and any action or intervention is "limited" by the characteristics of available technologies. The demand for sustainable development in the coastal zone appears to be characterised by indeterminacy; it appears that such indeterminacy is partly connected with the missing recognition of the presence of (sectoral) technologies.

Despite of some very holistic perspectives of what technology is, we must say that technology is not commonly considered as being an integral component of the ICZM loop even when the coastal zone being considered is actually full of technological solutions to sectoral problems. It is rather common to find water treatment facilities, coastal protection structure, harbours, etc. Without even mentioning the situation that characterise urban coastal areas.

From a functional point of view, this appears to be a potential limit to the effectiveness and the success of the ICZM initiative. It is like planning a trip or driving in the dark and in the country without knowing if the car has functioning lights or not, without knowing whether a all-terrain car or a luxury car is available, and without knowing whether there are sufficient seats for all the passengers. Even worst, there is no consideration about the availability of fuel along the path and there is no consideration about the state of the road and whether or not the road will be able to "sustain" the car. Situation at moment appears to be at the level of using a map to choose the path (the data collection stage, with possible utilisation of GIS technology) and with all the possible passenger "fighting" to change the path according to their own needs. Of course, to drive it is not necessary to be an expert of mechanics, but having a driving license certainly helps a lot.

A clear trend in coastal management can be identified here. There is an increasing reliance on technologies to collect and manage information. This trend stems from the recognition that designing an appropriate technology to protect, retreat or accommodate requires a considerable amount of data on a range of coastal parameters as well as a good understanding of the uncertainties involved in the impacts to be addressed. National, regional and global monitoring networks are being set up to help to assess adaptation needs and opportunities.

Concerning coastal protection there is a certain "greening" tendency. Until recently, protecting coastlines with hard structures occurred with limited consideration of the potential consequences of these structures on other parts of the coast. Increasing awareness of unwanted effects of hard structures on erosion and sedimentation patterns has led to growing recognition of the benefits of "soft" protection (*e.g.*, beach nourishment, wetland re-creation) and of the adaptation strategies retreat and accommodate (Capobianco and Stive, 1997). This recognition originated in the scientific community and is gradually spreading among coastal planners and decision-makers (Hamm et al., 1997). An increasing number of private companies are now discovering market opportunities for implementing soft-protection options.

Different pathways for the adoption of technologies can be distinguished based on the stakeholder that is the primary driving force in the coastal zone management initiative: the government, the research community or the community at large. We do not find the private sector directly involved in the initiatives of the Demonstration Projects, with the only exception of the Coastal Fora. Market opportunities, investment procedures and profitability criteria are key words to discuss the incentives and behaviour of both the technology provider and recipient. Only in cases where a particular stretch of coastline provides direct financial benefits the private sector directly invest in coastal management. Prime examples of this case are coastal tourist resorts, for which beach erosion represents a direct threat to their profitability, and ports and harbours, which will have to raise their infrastructure as sea level rises. Community-driven pathways may be found in places where local needs for management are recognised but no government or private-sector interests are anticipated. It is also very interesting to look at initiatives being promoted by research community where the inertia of government, private sector and the community is maximum.

5.6 Geographic Information Systems within the Demonstration Programme.

Because of the importance attributed to GIS by the Demonstration Projects, it is worth examining the application of GIS in some details, bearing in mind the collocation of GIS in the context of the “information chain” (Fig. 2.1). Further expansion of such analysis is described by Capobianco (1999b).

A major objective of a GIS is to develop spatial relationships between mapped geographic features. The GIS has two distinct utilisation capabilities - the first pertaining to querying and obtaining information and the second pertaining to integrated analytical modelling. However, both these capabilities depend upon the core of the GIS - the database that has been organised. Many GIS utilisations have been limited because of improper database organisation. The importance of the GIS database stems from the fact that the data elements of the database are closely interrelated and thus need to be structured for easy integration and retrieval. The GIS database has also to cater to the different needs of applications. In general, a proper database organisation needs to ensure the following:

- a ***flexibility*** in the design to adapt to the needs of different users.
- a ***controlled and standardised*** approach to data input and updating.
- a ***coherent*** treatment of datasets from different sources.
- a ***system of validation*** checks to maintain the integrity and consistency of the data elements.
- a level of ***security*** for minimising damage to the data.
- minimising ***redundancy*** in data storage.

The issue of designing and organising a GIS database has to be considered in its entirety and needs a conceptual understanding of different disciplines, cartography and map-making, geography, GIS, databases etc.

While the above is a general consideration for database organisation, in a GIS domain the considerations are pertinent with the different types and nature of data that need to be organised and stored. Broadly categorised, the basic data for the GIS database has two components:

- ***Spatial data*** - consisting of maps and which have been pr-pared either by field surveys or by the interpretation of Remote Sensing (RS) data. Some examples of the maps are the soil survey map, geological map, land use map from RS data, village map etc. Much of these maps are available in analog form and it is of late that some map information is available directly in digital format. Thus, the incorporation of these maps into a GIS depends upon whether it is in analog or digital format - each of which has to be handled differently.

- ***Non-spatial data*** - attributes as complementary to the spatial data and describe what is at a point, along a line or in a polygon and as socio-economic characteristics from census and other sources. The attributes of a soil category could be the depth of soil, texture, erosion, drainage etc and for a geological category could be the rock type, its age, major composition etc. The socio-economic characteristics could be the demographic data, occupation data for a village or traffic volume data for roads in a city etc.

Much of the information is often in the possession of individuals in various government agencies, research institutes and universities. Further, the data are often collected on the basis of very specific (and often narrow) objectives and in a wide variety of formats-including written records, digital and hardcopy maps, satellite imagery, aerial photography, real-time buoy, seismic profiles, and a range of electronic media. In practice an effort should be made to rationalise the various phases of information gathering, information development and information use

We do not discuss details of the activities within the Project here, however, practically speaking, a number of aspects can be recalled:

- ***Compatibility*** between the landward side and seaward side
- ***Update*** of information and need to put more emphasis on the data updating problem,
- the ***costs*** of computer hardware and most GIS software, are often not easily quantifiable; they are hidden or embedded into a large number of parallel/overlapping/diverging/converging activities;
- ***Compatibility*** of formats
- ***Lack of consistency*** between data sets (especially in time);
- ***Restrictions*** on free and quick access to information;
- ***Data quality*** is still in its infancy,
- ***Interchange of data*** is still a major issues,
- User-oriented GIS nowadays need integration with "***multimedia***",
- ***Integration*** of sectoral-specific GIS
- ***Missing organisation*** for GIS utilisation
- A number of GIS are being used basically to access in digital form information traditionally given in ***paper form***
- Some Projects are considering the development of a ***Coastal Zone-specific information system***
- Most of the Projects face the problem of ***dealing with "existing information sources"***. The long-lasting problem of standardisation comes here into the discussion.

5.7 Technological Support to Information, to Participation, and to Cooperation.

5.7.1 General Considerations on Information Technologies

A technical answer is becoming increasingly available for a large number of specific as well as generic needs (§2). In order to do this we can explore what technologies help conducting specific activities and what technologies enable the conduction of generic activities:

- ***Technologies to Support Coastal Zone Management.*** We mainly refer here to the so-called ICZM-enabling technologies that mainly cover the "information chain": (i) information gathering collection of the basic information from the Coastal Zone, the possible use of advanced marine technologies or of satellite systems is considered here;

(ii) information development for the understanding of the on-going processes, the possible use of sectoral as well as integrated models is considered here; (iii) information use for the scenario evaluation and the decision making process, the possible use of GIS and of DSS methodologies is considered here.

- ***Organisational Structures to Support Coastal Zone Management.*** Coastal Zone Management can be largely improved also through the adoption of specific Organisational Structures such as: (i) Co-ordinated Intervention Centres for the sharing of technologies, (ii) the Coastal Zone component of the Global Ocean Observing System (GOOS), (iii) Large Scale Experiments specific for the Coastal Zone Issues or Problems, (iv) Networking for the sharing of knowledge and experience, (v) Education about the application of ICZM-friendly, ICZM-supporting and ICZM-enabling technologies.

All the tools described in Chapter 2 are significant for the development of the capacity of coastal managers and other partners to deliver sustainability. Capacity is more than technical competence, knowledge and methods; it is also crucially dependent on the confidence and motivation of individuals, the flexibility and openness of structures, the commitment and leadership of elected representatives and the credibility and goodwill which an administration commands in the broader community - that is, with aspects of organisational culture. These may be hard to measure, but they are essential to success. The tools set out should be used with these broader objectives in mind.

5.7.2 Supporting the Activities of the "Thematic Analyses"

Looking at the other Thematic Analyses, we can argue that Participation and Sectoral Cooperation greatly benefit from the provision of Objective Information about the status of the Coastal Zone and about the Coastal Dynamics. Information Use and Information Development processes all start with Information Gathering which is quite often, a technological problem. The existence of "facts" constructed by integrating the available (scientific) knowledge with the available information help achieving mutual understanding and acceptance assumed that uncertainty is properly handled. The availability of an integrated knowledge, possibly implemented into specific Decision Support Systems, could be extremely beneficial also to evaluate "off-line" without actual implementation, the role of possible amendments to EU Policies and of role of possible Legislation.

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The target must be:

- Introduce those ICZM-enabling Technologies which are useful for the ICZM initiative;
- Use Sectoral Technologies in a better way and prefer ICZM-friendly technologies when options are available;
- Coordinate the deployment and the use of ICZM-supporting technologies.

NGOs offer a new channel for creating diffusion networks at the grassroots level; the benefits are certainly expected for what concerns information, participation, and cooperation. Moreover, they also hold a formidable potential for pushing for the adaptation of national legistation and EU policies. They have risen to fill the gap where the private sector and government are not interested or unable to act. NGOs have the unique capability of reaching isolated communities and stakeholders to provide the proper cultural and socio-economic contexts required for successful technology co-operation and to create capabilities within the receiving country to sustain technology renewal. However, NGOs, are still largely characterised by some kind of "green orientation" that, although it is clearly an evolving process, makes them somehow "technology-reluctant".

5.8 Development, Innovation and Diffusion of Enabling Technologies for ICZM.

Most development and innovation of coastal-adaptation technologies occur in the context of research and development (R&D) programmes sponsored by national governments, either directly by government-owned or -controlled laboratories or indirectly by research universities and R&D consortia. The predominant nature and goal of coastal management strategies and the technologies developed for their implementation require a form of cooperation that differs from current explanations of the cooperation process and the conditions under which it takes place. Enabling technologies for coastal management - with few exceptions - are not developed and owned by business and industry. Economic considerations are a major force in driving technology co-operation for coastal management, but objectives are less focused on purely commercial terms, such as business development and trade. Rather, considerations of public well-being are essential, such as the reduction of loss of property and lives, and the protection of essential coastal habitats. The deployment of enabling technologies for coastal management technologies worldwide has occurred mostly as a result of societal interventions -whether direct governmental expenditures, regulations and policies, or public choices- and not as a consequence of market forces. Each stakeholder - governments, universities and government-sponsored R&D laboratories, the private sector, local communities, and non-governmental organisations - has its own specific interests, directions and objectives, and incentives for technology co-operation vary according to each of these agendas.

To develop new techniques earlier it is necessary to encourage the education and training of creative technologists and to educate new generation of scientists and technicians that may play a role in the integration of disciplines. There is a need for communication of science and for better communication among sciences. In defining or identifying mechanisms for the transfer of (technological) knowledge from source (universities / R&D organisations) to value-added users (industrial companies, service providers), three groups of communication mechanisms can be distinguished.

- ***non-personal interaction***: papers, reports, or articles in professional journals, patents, databases, documentation, hardware/ software;
- ***the personal interaction***: networking, meetings, discussion groups, workshops, computer interaction, programming of university R&D by industry, conferences courses, seminars, exhibitions, demonstration of products or services;
- ***mobility***: secondment of professors/teachers/researchers from University/R&D organisations to industry, PhD research in industry, secondment of students to industry, secondment of researchers from industry to University/R&D organisations, including funding chairs, secondment of students from industry to university, employment of R&D personnel in industry, spin-off companies.

5.9 Bridging the Gap Between Technology Developers and Possible Users.

Communication is a two-way activity: users need to communicate needs to technology developers; developers need to communicate results to users. Experts groups are often constituted by the European Commission or at national level, in order to formulate research proposals and policy recommendations. The academic and industrial scientists play an important part in these groups, but the expertise coming from the "structured interfaces" is rarely integrated. These expert groups are, however, thematic and targeted and should be a possible relay for problem areas coming from society.

In the consultation processes about R&D, the "structured interfaces" are rarely involved, although they have an original scientific experience and good relationships with social groups. Some events and " interface support initiatives ", as described above, take the advantage of disclosing problems to the public opinion, either on a passive way (memorandums, surveys) or by active means (forums, consensus conferences).

It is not possible to separate the problem of communication between the scientific and technical community and the end-users community from the problem of quality of the (R&D) work carried out by academia, as both are inextricably linked. In fact, one factor widely accepted to assess the effectiveness of the academia's R&D work is its relevance to practical problems. Therefore, all actions leading to increase the quality of work by academia would affect the communication problem.

However is rather apparent that, with only few exceptions, little knowledge exists throughout the end-users (coastal management) community of the R&D work done by academia. Hence, experience in communication is still very low and concentrated on the "wrong" mechanisms. One of the most relevant findings of the study is what could be called the "experience learning effect". Those with experience in any mechanism believe it is a better instrument than those with no experience at all. The experienced people and organisations have at least a fairly positive opinion on all mechanisms, for every application (from gaining awareness to make a product or process).

In general, it is not possible to give a definite opinion in terms of what mechanism would be the most efficient and effective way to communicate. There are mechanisms which are best, depending on how and for what they are applied. Mobility based mechanisms are better than any other when the application is to carry out research activities or to make a product or process. These are the mechanisms considered efficient and effective for applications other than gaining awareness of new technological advances. Major differences are not linked to sectors or technologies, but to the type of organisations, i.e. between SMEs, large companies and academia. Above all else, the problem of communication between academia and user community is cultural, associated to its very different objectives.

What seems widely recognised is that there are enough initiatives in support of communication. What is needed is that initiatives already in place should be further extended and improved. This is also confirmed by the generally positive opinion obtained on all the schemes which have been analysed in depth. In any case, any action should start with making academia and industry aware of each other's goals, making both "culturally closer".

5.10 Cross-fertilisation between Coastal Management & Coastal Research.

One of the major obstacles to achieve progress in present understanding of coastal processes is the limited availability of field evidence at appropriate space and time scales. The international cooperation in coastal research projects has not yet resulted in removing this obstacle. The equipment available to individual nations is often too sparse to run experiments at a sufficient scale. Mechanisms promoting the pooling of international equipment resources for joint research projects in coastal areas are not yet well developed. Conflicts arise from national priorities and from incompatibility of different measuring systems. Many features of the coastal system exhibit a variability in space and time which is distributed over a broad spectrum of frequencies. The development and calibration of integrated predictive models therefore require experimental facilities capable of covering phenomena at a broad range of scales.

The coastal management practice and research activities can cross-fertilise themselves reciprocally. This is especially the case when monitoring and observation networks are activated and data are used for the immediate operational and decision making needs, but also for long-term needs of understanding. The set-up of local research agendas is also a fundamental prerequisite for cross-fertilisation.

In so far as EuroGOOS provides a framework for long term experiments (§2.10), and model validation, there is a parallel need for large scale experiments of limited duration. In this context large refers both to spatial coverage and to the number of observations, such as are beyond the capacity of one national team or laboratory. European collaboration is needed to bring separate teams together, as presently supported in some MAST projects. European research theme's should aim in bringing equipment together in field programmes on a scale which is not accessible to present national programmes. An appropriate funding mechanism should stimulate the development of such programmes, and the procuring of necessary equipment for field measurements and data processing.

The establishment of intervention facilities with the possibilities to exchange information and intervention systems should be stimulated. There is certainly a lot of work to be done here particularly from the organisational point of view. Once these are solved, the flux of information and knowledge, first, the exchange of intervention systems, second, can start.

6. POLICY ISSUES - PROMOTION OF THE SUSTAINABLE USE OF TECHNOLOGIES FOR ICZM.

The following considerations are derived, to a large extend, by a study undertaken by OECD concerning policies to promote technologies for cleaner production and products (OECD, 1995c). Inspiration also comes from other general (non ICZM-specific) studies (CEC; 1998d). The possibility to adopt any of such policies (Fig. 6.1) for the promotion of the informed application of technologies in ICZM has been investigated by an additional Questionnaire circulated among the National Representative of the Member States. A total of 5 replies have been obtained; not many for a "statistical significance" of the outcomes, but well distributed geographically. The possibilities hereby listed can be further expanded into possible actions at EU level, at the level of Member States, and by the Private sector (Capobianco, 1999a).

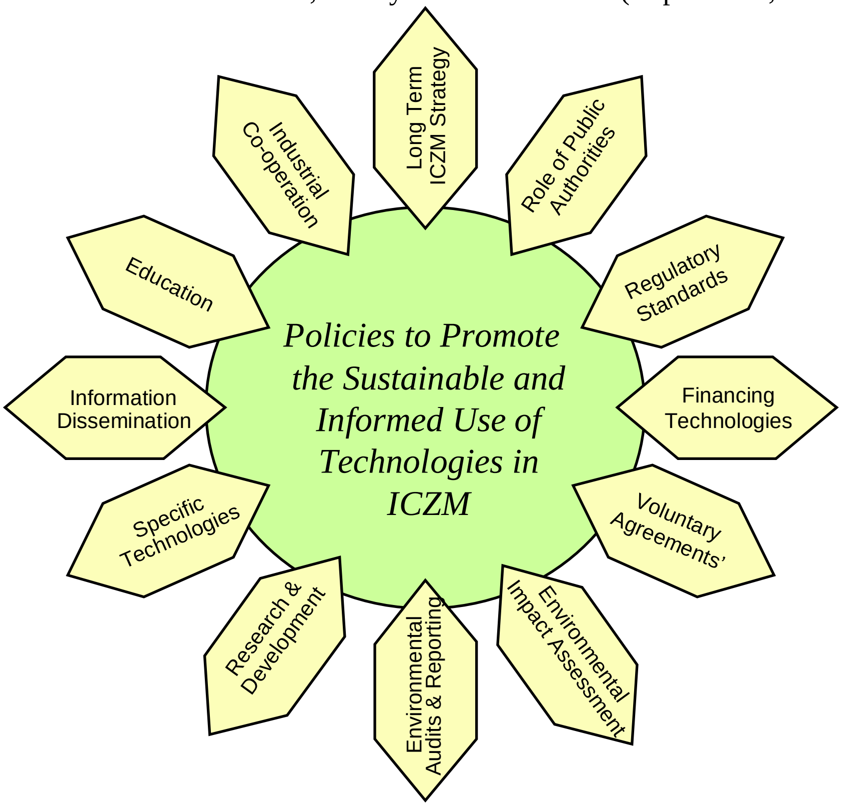

Fig. 6.1 - Possible Policies to Develop a Suitable Adoption of Technologies.

The Questionnaire was divided into eleven main categories, each dealing with a broad policy approach affecting development and implementation of technologies: (a) Long-term ICZM Strategy, (b) Regulatory Compliance and Enforcement, (c) Voluntary Agreements for the Adoption of ICZM-friendly Technologies, (d) Economic Instruments Aimed at Stimulating ICZM-friendly Technologies, (e) Governmental Institutions' Purchasing Policies, (f) Environmental Impact Assessment, (g) Environmental Audits and Environmental Reporting, (h) Research and Development (R&D), (i) Technologies and the Demonstration Programme, (j) Information Dissemination about Environmentally-friendly Technologies, (k) Education about Environmentally-friendly Technologies The replies were meant to help assess whether current or planned policies are helping, hindering or not affecting development and implementation of technologies.

6.1 Long-term ICZM Strategy.

Growing interest in Integrated Coastal Zone Management will eventually stimulate Member States to undertake a strategic re-evaluation of their environmental policies in order to help delineate and pursue longer-term sustainable development objectives for the Coastal Zone. Long-term planning can provide opportunities for more comprehensive strategies since the planning objectives are often achievable only through joint and co-operative actions among different sectors of the economy and the society. Any hypothesis for the future should, therefore, be negotiated with all relevant parties, widely disseminated and, above all, be workable in a practical sense.

The adoption of a long-term strategy necessarily has to be based on a suitable consideration of the long-term changes and on the consideration of integral effects.

> ***Action to speed-up the process - Coherence***
> The adoption of technologies to respond to specific sectoral issues should be coherent with such strategy. This means that the adoption of technologies should not only satisfy the short term needs but also take into account their long-term projection, not only consider the operational phase but also the possible demobilisation phase.
> The adoption of a long-term ICZM strategy would not allow nowadays to undertake the extensive enbakments or polderisation of deltaic or lagoonal areas, unless the risks connected with such choice are suitably evaluated.

The changing attitude of governmental organisations towards the process of ICZM includes that of giving a role to NGO's (OECD, 1995b), which they sometimes even subsidise to be a knowledgeable counterpart. A problem here though is that of the democracy aspect: even though they may have public support, their opinion is not backed up by a true democratic representation.

6.2 Modernisation of the Role of the Public Authorities.

The role of the customer in a quality policy is vital. The process of creating quality begins when the needs of the customer are set down in the brief for the call for tender. On the other hand, sustainable development begins with practices of local authorities (Mehra, 1997). The role of public authorities as customers in public procurement is also crucial in this respect. The needs of the authorities must be clearly expressed, both in technical and economic terms. The price/quality ratio is a key factor for the authorities responsible for awarding public procurement contracts.

New governmental technology policies that provide increased support for helping users to obtain, adapt and use technology. This includes major investments in information infrastructure, in training and education of the workforce, and in outreach and extension services (web-based environmental data sets and links to information clearinghouses; GIS-based and other information products; and training for management and planning).

> ***Action to speed-up the process - Suitable Definition of Needs***
> A certain lack of attention to a suitable definition of needs has often represented the source of the adoption of technical solutions producing high impacts.
> Contracting entities can make full use, where necessary, of the possibility offered by EU procurement legislation to award contracts to the most economically advantageous and ICZM-friendly tender.

Governmental Institutions are major purchasers of a very wide variety of goods and services and specifically of technologies. Specifications for government purchasing tend to have a significant effect on how suppliers will respond both in preparing the product and its final characteristics. Thus, governmental institutions have the opportunity to influence their suppliers toward use of more environmentally-friendly technologies by means of their purchasing behaviour, specifications for goods and activities.

6.3 Regulatory Standards.

Setting of standards by means of regulations, whether in the form of emissions standards or other types of requirements, remains the primary policy instrument in many Countries for stimulating the public to develop and implement technologies for environmentally-friendly activities. Similar approach could be developed for ICZM-friendly activities. Yet, inflexible technological specifications and/or short-term deadlines for attaining compliance with new regulations can discourage investments for innovative more environmentally-friendly technologies.

Process changes with or without more environmentally-friendly technologies are evolutionary in nature. Such changes often require major capital investments and normally are only undertaken after carefully considering whether investment, installation and exploitation of the new technology will improve the competitive position of the firm and allow it to fully comply with all applicable regulations.

Although government policies help to define and shape markets for coastal-adaptation technologies, regulatory frameworks not only often lack incentives for innovative technology application but also may include disincentives to the development and adoption of new technologies (e.g. nourishment). For example, certain regulations may prescribe the use of specific technologies, and approval of new, more efficient or effective technologies must first go through lengthy legal processes to change the regulatory code. Further, relevant government agencies may be fragmented, which impedes decision-making on all aspects of technology co-operation.

> ***Actions to speed-up the process - Financial Tools and Taxes***
>
> Since a basic issue for implementing more environmentally-friendly technologies is to influence change in capital investment decisions of private sector firms, regulatory requirements need to be sufficiently stable to allow for long-term investment strategies to incorporate environmentally-friendly technologies. Moreover, site-specific licensing requirements need to be flexible enough to allow the private sector to develop and deploy more environmentally-friendly technologies to meet the environmental goals.
>
> The EU suffers high unemployment, high labour costs compared to industrial competitors, and unsustainable levels of energy use, raw materials depletion and waste production. Yet labour, income and value added are all heavily taxed while energy, resources and wastes are taxed little if at all. Shifting taxation away from employment and towards environmentally undesirable impacts could help to address all three of these problems at once. This could be the most important integrative tool for an environmentally and socially sustainable economy.

6.4 Financing Technologies.

Costs for adoption of technologies should be somehow divided; they should not represent in any case a limit to the willingness to proceed toward ICZM. How to proceed clearly depends on the type of technology being adopted and on the local organisation setting (§7.8). Here we only discuss about the possible role of "financial institutions". "Financial institutions which assume the risk of companies and plants can exercise considerable influence - in some cases control - over investment and management decisions which could be brought into play for the benefit of the environment". If we look at sustainable development from the point of view of capital allocation we can conclude that financial institutions interact with the environment in a number of ways:

- as *investors* - supplying the investment needed to achieve sustainable development.

- as *innovators* - developing new financial products to encourage sustainable development - e.g. in energy efficiency.
- as *valuers* - pricing risks and estimating returns, for companies, projects and others.
- as *stakeholders* - as shareholders and lenders they can exercise considerable influence over the management of companies.
- as polluters while not "dirty" industries, financial institutions do consume considerable resources.
- as victims of environmental dynamics - e.g. from climate change, from floods, from storms.

Financial markets present an opportunity for environmental policy, particularly useful in view of the need for a wider range of policy instruments. In view of the indirect nature of many of the interactions above, policies are likely to be most effective if they aim to complement and work with existing financial activity. A key issue in the inclusion of environmental issues is the ***significance*** of environmental issues -while potentially of some relevance, many environmental issues are of insufficient importance to be a priority, particularly in view of other concerns and practical difficulties. Improving information flows would be an effective way of making it easier for financial institutions to incorporate environmental considerations. There is still potential to reinforce the link between environmental performance and financial performance, notably through the use of economic instruments such as environmental taxes.

The Role of Commercial Banking
The greatest potential of the commercial banking sector is in its relationship with Small and Medium sized Enterprises, where banks can be very influential through their lending practices and by providing information. Commercial banks have less influence over largest companies. There is, however, scope for them to influence consumer behaviour through the financial products they offer.

The Insurance Sector
The potential of insurance sector in achieving sustainable development lies in its ability to price various types of environmental risk and to help pay for environmental damage. Potentially environmental issues can affect risks in a number of areas, but to date the industry has taken an issue based approach and has focused on the environment in two main areas; in particular environmental liability has had a seriously adverse affect on the industry and has resulted in the industry taking a very cautious approach to environmental issues.

Beyond these areas, however, there has been little research by the industry of the implications of sustainable development for the insurance sector at a fundamental level. Similarly, many outside the industry have a poor understanding of the practicalities of the industry, leading to limited work on how insurance could contribute to sustainable development.

The Role of The Investment Sector
The potential of the investment sector lies in the influence it has over large companies. It can send signals to industry in the pricing of new capital for companies and in the on-going valuation of quoted companies as well as directly through the use of its rights as shareholders and owners. To date, as whole, investors are probably less interested in the environment than bankers. However, a key concern for the investment sector is the relationship between environmental performance and investment performance. Here the evidence on balance suggests that environmental performance does contribute to good financial performance.

To encourage the investment sector to incorporate environmental issues a number of obstacles need to be overcome. Two key obstacles are market inertia in investment practices, and the balance between long term and short term analysis. However, the most important issue is probably difficulties in obtaining good quality information in ways that the sector can understand and use. Ways need to be found to provide relevant information to the sector.

6.5 Voluntary Agreements.

Voluntary agreements can be effective means of promoting the adoption of appropriate technologies in the coastal zone, including cost-effective methods to reduce pollution. Voluntary agreements can be an effective means of achieving ICZM objectives and can often work more quickly and with more flexibility than regulatory regimes. Voluntary programmes are an adjunct to rather than a replacement for regulations and economic instruments for protecting the environment.

Voluntary agreements may play an important role in decisions to develop and deploy ICZM-friendly technologies, however they must be carefully examined to ensure that they do not directly or indirectly discourage investments. In practice, voluntary agreements are a pledge by one or more sectors of the economy to behave in a certain way in order to attain environmental goals. In most cases, voluntary agreements by the private sector are almost always motivated either by government threats of regulations and/or taxes or by government pledges of financial support. For any voluntary agreement, a key issue is to decide on an objective basis how well the agreement is being implemented by parties to it. This problem has not been fully solved as yet, and policies in this area are still evolving. Choosing a segment of the private sector which can offer a unified negotiating stance, monitoring compliance and assuring accomplishment of the terms of the voluntary agreement on each subscriber are particularly difficult issues.

> ***Action to speed-up the process - Eco-Labelling Approach***
> The EU Eco-Label award scheme is based on life cycle assessment of products. A part from the obvious benefit of its application to activities in the Coastal Zone, it could be possible to extend the application to services/activities/plans.

6.6 Environmental Impact Assessment.

EIA can be an extremely important tool for ICZM (Capobianco, 1998e). The most important aim of EIA is to introduce effectively a systematic consideration of environmental issues into all important decision-making stages on specific proposed development activities (CEC, 1985; CEC, 1997). Many of such activities involve the adoption of technologies. Virtually all proposed developments are subject to an authorisation process whereby a formal decision, or a series of decisions, is made by an official body on the "future" of the proposal. Without the appropriate permit, license or approval a project may not proceed. The authorising agency(ies) takes a variety of factors into account when deciding whether to issue an approval. The role of EIA is to ensure that the environment is one of the factors which is considered in decision-making.

It is realised, increasingly, that project-level EIA needs to be supplemented or amended

> ***Action to Speed-up the Process - Consider Earlier in the Planning Process and make it Mandatory***
> One of the means by which environmental implications can be considered earlier in the planning process is by undertaking environmental assessment of *policies* while development plans are being prepared. Formal Environmental Impact Assessment can be a powerful tool for anticipating the likely consequences of *projects*, and ensuring that adequate controls are in place to minimise environmental damage either through planning legislation or parallel pollution control regulations. In fact EIA was the first development control tool to be applied throughout Europe, although implementation is still rather variable. Leaving impact assessment until project proposals are brought forward has disadvantages, particularly in European countries where the development plan is the legal framework.
>
> Taking the environment as a starting point is fundamental to sustainability but it is not easy to achieve in practice and taking all aspects of sustainability as a starting point will be still more difficult. Extending the methodologies of EIA and SEA to developing methods of sustainability appraisal in spatial planning may provide a way forward.

so that the environmental consequences of all development-related actions can be incorporated in decision-making (OECD, 1992). In the past few years there has been great interest, on the part of governments and international agencies, in the potential role of strategic environmental assessment (SEA). SEA is seen as a promising approach by which the benefits of EIA can be greatly enhanced by applying the principles of EIA at a strategic level (in the form of SEA) to supplement the advantages being obtained, currently, from project-level EIA (CEC, 1996c). The advantages of SEA are considered to outweigh, significantly, the cost of implementation. SEA is seen increasingly as the best available approach, especially if combined with decision-making based on sustainability criteria, to halt the continuing trend of global environmental decline. At present, SEA is still a relatively new concept, but experience and expertise are rapidly expanding. The wider adoption of Strategic Environmental Assessment will be dependent upon the development of tools compatible with the method of development plan preparation in each Member State. A starting point could be to understand the interactions between objectives for the different sectors to be included within the plan. For example a land use objective of minimising the consumption of space for urban development may support action in other areas such as in nature conservation, whereas the achievement of this objective may be obstructed by insufficient capacity for sewage disposal.

6.7 Environmental Audits and Environmental Reporting.

Many segments of the private sector are becoming convinced that improved environmental performance is an important contributor to competitive position. Environmental performance in a manufacturing firm includes its production facilities' use of energy and raw materials, reduction of use of hazardous substances, maintenance and its releases per unit output sent to market. A similar example can be made with reference to a large tourist setting where environmental performance includes minimisation of environmental risks and reduction of long term impacts. Auditing can provide facility managers with a systematic, documented, regular and objective evaluation of environmental performance. Results of audits can be used to reduce costs to prepare products and to reduce adverse environmental effects.

The results of the audits can encourage use of more environmentally-friendly technologies to reduce energy, materials, releases and costs. There is considerable debate, however, about how to obtain, use and publish audit and environmental performance information. In particular, reporting of audit results ideally should be uniform but sufficiently confidential to be of use in improving competitive performance of a firm, e.g., by

Solution - ISO14000 and EMAS

The ISO 14000 framework (ISO, 1995a-1995b) represents a move toward integrating sustainable development principles into our free market economic system (IISD, 1996). It is an important first step toward adopting a system of natural economics as referred to in this issue's accompanying papers. ISO 14000 is expected to incentive self-organising and self-regulating approaches to environmental protection that will lay the groundwork for continuous performance improvements. We expect the strong linkage of ISO 14000 with ISO 9000 to further drive this trend. Benefits derived from the total quality management movement in the 1980s provided strong incentives for businesses to seek ISO 9000 registration. Like quality management, environmental management follows a continuous improvement model. ISO 14000 will encourage significant changes in the way we have traditionally valued both renewable and non-renewable natural resources. ISO 14000 will also create a market-driven framework for balancing environmental protection with socio-economic needs and will foster the concepts embodied in sustainable development and natural economics.

ISO 14000 standard, in a more mature ICZM setting, could also provide a framework for analysis of the functioning and performance of the ICZM activities.

encouraging capital investments in more environmentally-friendly technologies. Large dissemination of information is expected to occur in the case of the large tourist setting.

6.8 Information Dissemination about Environmentally-friendly Technologies.

Businesses cannot implement Environmentally-friendly technologies if they do not know about them. But disseminating information about more environmentally-friendly technologies particularly to small and medium-sized enterprises has proven difficult to do in an effective manner. Governments are currently using a variety of information transfer approaches including technical publications, computer data bases, local workshops and demonstrations, telephone "hot-lines" and video presentations. The effectiveness of these approaches in promoting implementation of more environmentally-friendly technologies is not known quantitatively, but a number of observers have suggested that results are not very impressive to date. Many believe that, especially for small and medium-sized enterprises, the most effective information transfer approach for promoting more environmentally-friendly technologies is by means of consultants who work on-site for some period of time.

Most of the research establishments in Europe are still government-run. Consequently, the dissemination of results is not always optimal, as their main customer, the government, tends not to have the same objectives as industry, at least not the same extent. There is a need to develop a more integrated approach where all partners in the ICZM process are involved.

There is an acute shortage of adequate and accurate information on the impacts of anthropogenic and natural processes on coastal systems and adaptation possibilities. This information is required to underpin public and private spending on coastal-adaptation technologies. Availability of data does not automatically result in increased information use for decision-making. Coastal information often involves huge sets of unprocessed data. Unless a bridging organisation exists to “translate” data into usable information products, such as GIS analyses or assessments, and present it to the user community (*e.g.*, via training programmes), these data sets go unused. Furthermore, as the

Solution - Dissemination of Good Practice and Expertise

The poor dissemination of information and knowledge represents one of the major barriers to innovation in ICZM. Indeed, many innovative practices are not taken-up within the industry, primarily due to poor access to relevant advice and information.

There is an urgent need for better and wider dissemination of good practice and expertise in this field. Sustainability should become a strand running through all local economic development activities and “toolkit” methods and techniques to achieve could soon be developed. The need now is to make such information more widely available.

Making the communication channels more efficient

A preliminary recommendation for the interest groups is to promote a better "management of rarity and efficiency" of the representative functions that are allowed to them in various consultative bodies in which R&D issues are discussed.

Therefore the European valorisation and dissemination of positive experiences and "best practices" at the regional or national level can have a learning and stimulating effect on the representatives of social groups within R&D consultative bodies, who often assume their task in a difficult context.

It is also useful to let know the working methods which allow a better synergy between the institutionalised forms of relay and communication, and other informal or punctual initiatives of consultation or involvement of public opinion.

Organising and supporting "communication events" between research and society at the European level, that should have a " Problem Oriented " character rather than a classical popularisation approach.

means for collecting this information become more sophisticated, the diffusion process is delayed by a lack of technology-verification programmes meant to inform public officials of technology performance and by a lack of training programmes meant to maintain a workforce technically skilled in application of the new technologies. Conveying information to the public can be problematic because of limited reception of messages that are not readily related to immediate concerns.

MaESTro

In May 1991, UNEP's Governing Council took a decision to further strengthen UNEP's role in sustainable urban and freshwater basin management by calling for the creation of an International Environmental Technology Centre (IETC). MaESTro is a database which contains information on a full range of environmental technologies, institutions and information sources including air and water pollution, environmental management, human settlements, recycling toxic substances, solid waste, wastewater, water augmentation and more. The information is regularly updated by IETC as well as contributors, individual users, organisations and institutions (http://maestro.unep.or.jp/).

TIO

The U.S. Environmental Protection Agency, Technology Innovation Office (TIO) was created in 1990 to act as an advocate for new technologies. TIO's mission is to advance the use of new technologies for characterisation and remediation. To accomplish this mission, TIO works in concert with states, other federal agencies, professional associations and private companies to create a marketplace with a rich diversity of cost-effective solutions for the Nation's remediation needs. TIO produces numerous one-time and periodic publications and electronic information on technologies and markets (EPA, 1999c) for soil and ground water remediation (http://www.clu-in.org/).

6.9 Education about Environmentally-friendly Technologies.

The European Commission, DG XIII D, launched the European Awareness Scenario Workshop (EASW) Initiative in 1994 as a pilot action to explore new possible actions and social experiments for the promotion of a social environment favouring innovation in Europe. The initiative focused on two particular fields of action which, in the opinion of experts, should benefit the most from the introduction of the European dimension:

- Assessing the transferability of best practices between different cultural and political contexts, including identification of conditions for success.
- Identification and further development of instruments and tools to support the know-how transfer processes.

From one side, the local/regional context appeared as one of the most appropriate for raising public awareness and articulating demand around scientific and technological options, from the other, the method associates the main social actors in view of the formulation of a common vision for sustainable development. Through this initiative, the Commission intended to provide actors of innovation, with instruments and tools that they can use in a rather independent way. The adoption of common methodologies contributes to the establishment of a networking process

Action to Speed-up the Process - Concerted Education Efforts

Unless education is used to engender a strong preference and demand for cleaner production and products, technologies to create them will have little market. Educators have the opportunity to build long-term commitment to more environmentally-friendly technologies. Unless such concerted educational efforts are widely implemented, a major source of demand for more environmentally-friendly technologies public insistence that they be used -could be seriously weakened. Perhaps the future competitive position of nations could be altered as well.

changing the potential obstacles like linguistic and cultural diversity into opportunities (Rautalahti-Miettinen and Ripatti, 1998).

Incorporation of environmental considerations into all types of activities is a basic precondition for achieving an environmentally sustainable economy (STAN, 1998). Training is an important action to be further promoted, and positive examples exist also in the context of coastal management (IOC, 1995). Education systems will have to play an important role in bringing about the needed changes in everyday attitude. Thus, information about environmental and natural resource issues should be introduced into the curricula of schools at all levels. Not only could the environmental consequences of energy and material consumption and the release of contaminants to be illustrated, but the importance of clean technologies and life-cycle approaches in minimising these environmental harms could be emphasised as well.

Effective technology co-operation depends on the ability of the technology source to deliver the desired technology and on the capabilities of the technology recipient to employ it. Guidelines and manuals can play an extremely important role here (e.g. MAFF, 1995, for the practical guideline to shoreline management plans). On the other hand, scientists in government and university laboratories may be very far from the “marketplace” for their innovations. Barriers to the process may include (*i*) lack of technology awareness among government officials, (*ii*) lack of a trained workforce in terms of technical skills, know-how, maintenance skills and organisational development (Colecchia and Papacostantinou, 1996).

6.10 Research and Development (R&D).

Research universities that are becoming more deeply engaged in applied R&D are expanding ways for accelerating technology diffusion to end-users at all levels of government and the private sector. Mechanisms that have proven to be effective include joint university-business research parks to promote collective R&D. Many countries have financial assistance programmes aimed at promoting development and implementation (demonstration) of environmentally-friendly technologies. Along the same line the could be the promotion of ICZM-enabling technologies, ICZM-friendly technologies, and ICZM-supporting technologies. Phases of the process of development and diffusion of more environmentally-friendly technologies (conception, development, demonstration, diffusion) tend to call for different types and amounts of financial support. This depends upon the risk both technical and financial of the innovation and the number and type of parties involved, e.g. firms, research institutes, universities, etc.

There is a trend away from basic R&D toward support for the demonstration phase. Still, OECD research (OECD, 1997b) indicates that programmes in place are not as efficient or effective as they could be. Countries are currently engaged in evaluating the effectiveness and efficiency of these programmes in increasing the supply of more environmentally-friendly technologies.

Action to Speed-up the Process – Research on Integrated Assessment Methodologies

The needs is thus increasingly that of moving toward integrated assessment methodologies...
R&D should be oriented towards competitiveness and environmental friendliness at the same time. From this point of view, the Community’s framework programme for research, in which several aspects are related to ICZM could provide both a pilot-model and a template for stimulating the development and co-ordination of international quality research at a European level (see the proposal for a Council Decision adopting a specific programme for research, technological development and Demonstration on “Preserving the Ecosystem” - 1998 to 2002). The problem here is that the relationships are not always explicit but they are most of the time “sectoral”.

The Third and the Fourth Framework Programme for Research have originated a large number of Research Projects, often characterised by a sectoral view. The Fifth Framework Programme for Research could represent the opportunity to promote integration (see *Appendix G*, for Links to relevant EU Web sites).

The scientific world:

- could and should go further to integrate these scientific findings into policy
- alternatives, calculating their cost, benefit, impact and risk. It is of course up to the
- policy-maker to make the choice, depending on his or her ideology, value systems and
- constituency, but it's not fair to criticise policy-makers for failing to make decisions, if
- they are not offered reasoned alternatives.

The transfer and exploitation of RTD results from the places (or people) where it takes place (universities, research centres, etc.), to the users can be carried out in many different ways depending on a great variety of variables and circumstances. This process tends to be non-standardised and complex. It is definitely one of the issues to be tackled in order to improve the results of the European R&D programmes. A study supported by DG XIII under the Value II programme "Interfaces", focused on the global approach to the problem of communication as the only way to arrive at valuable conclusions with respect to best practices. The major aim of the overall study was to analyse the most effective communication practices and provide a set of recommendations. In that sense, the research has been designed to answer one basic question: Which are the most efficient means of communication? The answer would allow the design of future RTD results diffusion and exploitation initiatives, and actions to foster the communication links between academia and industry (Funnell, 1998). Geographical area, sector, technology and type of actor (academia, companies, mediators, associations) constitute the key parameters of the study.

In most of the European countries and at Community level, there are consultative councils and committees whose role is to work out advice and statements about the orientations of R&D policies and the contents of research programmes. Some of them are dedicated to research, some others are general socio-economic councils and some others are dedicated to specific areas: environment, public health, working conditions. The representation of the civil society in the consultative bodies suffers from two main problems:

- the system of representation and delegation acts as a filter and the concrete questions and problems coming from social groups are not easily passing through; the qualification of the representatives in the scientific field may not be sufficient to forward these questions
- the representative system may be affected by unbalanced composition of councils or inequalities in the access to information.

6.11 Development of Industrial Co-operation and Ensure Fair Competition.

Maritime industry of the European Union, despite its strong position in certain markets, faces a wide range of challenges which must be addressed if it is to maintain, and if possible, improve its competitiveness. Competitiveness requires a wide-ranging perspective (Merrifield, 1990). The Commission could, in co-operation with European industry representatives and Member States, progressively put into place a structured action plan, and actively follow the evolution of the competitiveness of the European Maritime sector and the adoption of the various measures.

Companies increasingly see environmental issues as being of relevance to their business development, yet financial markets, particularly investors are uninterested. Companies are increasingly aware of the environmental pressures they are under and have developed a range of practical tools to address them. There is increasing understanding of the financial implications of these pressures among leading specialists, yet most in the financial community pay only limited attention to them. *Information* is the key to financial evaluation, but there is limited useful information on environmental performance and management.

The environmental business sector consists of businesses ranging from traditional environmental businesses, such as waste management, to emerging "green" pioneers, such as renewable energy and eco-tourism. They have a critical role to play in achieving sustainable development and thus ensuring they have access to private sector finance is crucial. Despite apparently good prospects, with rapidly growing markets, the financial performance of the sector has been disappointing to date. Indeed, the poor performance of many high profile companies has been a major factor in creating a negative impression about the environment with financial institutions.

Explicit the First Mover Advantage
"First mover advantage" in developing green technologies has enabled some countries, notably Germany and Denmark, to develop lucrative new industry sectors. Economic regeneration is more likely to achieve economic objectives if local communities are actively involved in ensuring that proposals meet social as well as economic objectives, and that environmental quality improves both well-being and an area's attractiveness for developers.
Cooperation and integration is also likely to be beneficial to the environment; e.g. integrated transport networks might ask for more efficient solutions for integration.

A number of factors are identified for this. Several of them are closely related to the public sector and policy issues, both in the way that the environmental markets are often dependent on policy development and in the active role of public sector finance in this area. Generally speaking, public-private partnership in science and technology should be further promoted (Cervantes, 1998), with a view toward the needs of ICZM.

6.12 Specific Technologies.

Innovation is one of the key factors in industrial competitiveness, but is also a key factor to preserve and restore environmental quality (EPA, 1999c). To enable European research to achieve its full impact, mechanisms need to be set up to foster innovation, encourage the widespread take-up of research findings and stimulate the emergence of innovative companies. Furthermore, innovation in ICZM should be stimulated through modifications in the process leading to more competition on the basis of quality instead of competition based upon price.

The co-ordination of interested parties should be one of the most important tasks for governments and public bodies, through the adoption of common objectives and approaches. The authorities responsible for public procurement could also better exploit their privileged position in awarding contracts, for example by using contracting practices providing incentives to include technical innovation for the works in question.

Technology verification is also an activity to explore further (EPA, 1997b), eventually through the definition of technology indicators.

Promoting (Low-Cost) Technological Innovation

- ***Developments in Autonomous Systems****. Support the development of in-situ benthic laboratories, capable of physical, chemical and biogeochemical experiments over lengthy periods to examine processes at this understudied boundary. Support the development of simple autonomous packages to be installed on cooperating ships.*
- ***Developments in Sensing Techniques****. Support the development of new sensing methods, e.g.: molecular probes, chemical sensors, non-invasive acoustic, optic and electromagnetic systems; biomarkers for environmental stress.*
- ***Optimization of Resources****. Support the sharing of facilities, instruments and intercalibration exercises in order to optimize the available resources. Initiatives like the Large Scale Experimentation Facilities are valuable and should be maintained.*
- ***Technologies for Interventions****. There is a strong need to develop new technologies to be applied in the possible emergency situations and a need to evaluate the effects of man activities, including the proposed management and protection activities, on a long term basis.*
- ***Transfer of Technologies and Methodologies****. Both from the hardware and the software point of view. Multidisciplinarity must be strongly incentivated. Solution sometimes is almost available and "simply" need to be applied. There are valuable examples, also in the context of MAST activities, of the benefits that may be obtained from a transfer of technologies; it would probably be a good idea to set up specific programs aimed to transfer of technologies (eg. Stockdale, 1996, for the experiences in the USA).*

7. DISCUSSION AND CONCLUSIONS

7.1 General Trends.

Technology Push, Coastal Management Pull

We recognise the need for technologies, both those drawn and adapted from other scientific areas (***technology push***) and those developed specifically for coastal management application (***coast management pull)***. We also see the need for some new organisational structures to make the most cost effective progress. While these are described in generic forms, we also conclude that certain more specific recommendations can be identified clearly now.

Technology either come ready made from recent developments obtained elsewhere (in this sense it pushes), or from developments made as a consequence of the definition of the need of coastal management (pull). The former “simply” costs capital to coastal management, the latter requires efforts and generally takes longer. This means that coastal management starting tomorrow will have to use technologies available today, while technology developed now will be available for coastal management in 5-10 years.

The Current Situation

Certainly, concerning ICZM-enabling technologies, we can say that the push forces are stronger than the pull forces. Particularly the market pressures for the adoption of GIS appear to be rather strong. It is relatively easy to decide about the acquisition of the GIS software for the potential user. For the provider, GIS guarantees large profits with relatively safe investments.

More in general, technology is hardly considered as being an integral component of the ICZM effort. From the examination of the Role and Use of Technologies in relation to ICZM it appears that:

- ***technologies represent a tool*** to support ICZM in all its aspects; possibly a very important tool and a very important support, however, they cannot be justified by themselves, but only in relation to their use and the role they play;
- there is a need to ***bridge the communication gaps*** existing between the different languages and the different disciplines; at a more practical level, there is a need to ***bridge the gaps of information*** between the different disciplines, and especially to put in contact the "offer" of technology with the possible "request" of technology;
- there is a need to ***recognise the importance of methodologies*** in the effective design and application of technologies; the need to put technologies into a general context arises from the examination of the typical mistakes connected with their application;
- it is indeed useful to ***analyse the role and use of technologies*** on typical CZM tasks, and it is useful to ***analyse the effect and the influence of the adoption of technologies*** on the natural component of the Coastal Zone;
- it is useful to ***verify with the various involved actors whether or not technologies represent a limiting factor*** to achieve ICZM;
- there is a need to ***collect the available information on the application of technologies*** and set-up some kind of “scoring system”.
- technology must be accompanied by ***training and capacity building initiatives***, involving all relevant actors.

In spite of the availability of a range of proven technologies, many coastal zones face important barriers to employ them. Prevailing barriers are associated with (*i*) technology and human-resources capability; (*ii*) cultural and social acceptability; (*ii*) financial limitations; and (*iv*) political and legal framework. Meanwhile, the development of new technologies that can play a role in coastal zone management is evolving rapidly, even though few true innovations will make it into routine and widespread use.

The Barriers

Among the universally-accepted barriers to the transfer and diffusion ***of the informed and sustainable application of technology*** (without any specific reference to enabling, supporting, or sectoral activities) are: (*i*) lack of information, knowledge and awareness; (*ii*) lack of credible performance information convincing potential users that the technology can meet its claims; and (*iii*) lack of investment capital. Finally, prevention activities are often hampered by a number of factors: (*i*) the uncertainty about the location, rate and magnitude of impacts; (*ii*) the site-specific nature of coastal-adaptation requirements; (*iii*) the absence of global benefits of coastal-adaptation projects, which constrains their financing; and (*iv*) the fact that adaptation is often not considered a development objective.

Many of the barriers listed above are linked. Technology developers often lack the technical information, skills, tools and facilities to test their technologies in situations similar to those their products or processes are designed to address. Potential users of innovative approaches must be persuaded that new technologies perform as well as or better than conventional methods. Investors will not invest until a clear market for the product is defined and the product can achieve some sort of management or regulatory acceptance. Managers and regulators will not allow its use until they are convinced by credible performance data that a product can meet its objectives. The result is slow acceptance of technologies that may be able to help coastal communities to increase their adaptive capacity and reduce their vulnerability faster, better and less expensively.

The choice of the most appropriate technologies should be guided by the sustainability objectives. The ***promotion of the informed and sustainable application of technology*** for coastal management requires four important and universal issues to be addressed:

- lack of data, information and knowledge to identify adaptation needs and appropriate technologies;
- dependence of customers on suppliers of technology for operation, maintenance and duplication;
- disconnected organisational and institutional relationships between relevant actors;
- access to financial means.

Many barriers to the sustainable utilisation of technology relate to fundamental and intrinsic characteristics and principles of today's society, and adjusting the process of technology co-operation to accommodate societal imperfections will be easier to accomplish than the reverse. The main reason for this is that private-sector interests are secondary to considerations of public well-being, such as the reduction of loss of property and lives, and the protection of essential coastal habitats. The strongest and most direct incentives to adapt are therefore with the public sector. Addressing these issues does not require setting up new large-scale national or international institutions or mechanisms. Instead, existing activities and institutions need to be refocused so as to improve the efficiency and effectiveness of investments in coastal-adaptation technology cooperation. Further, information on existing technologies (*e.g.*, performance, cost, availability) needs to be made more accessible, and the transfer and diffusion of these technologies, if found to be appropriate, needs to be stimulated.

7.2 Bridge the Communication Gaps.

The presentation to user communities of the work carried out by university and R&D organisations is far from right. Communication initiatives should respond to needs: the delivery mechanisms should stress that companies, and actors involved in general, should make an effort first on the identification of needs and then on looking for the more appropriate communication mechanism. In addition they must be country specific, in terms of the channels (hence the mediators) used. A brief set of recommendations can be drawn up by considering the issue of communication from the perspective of policy makers:

- ***Purpose of Communication.*** "Pushing" organisations to communicate, regardless of the way used to achieve it and independently of the purpose of the communication, probably has a trigger effect for continuing with the process. The extension of the use of current successful schemes is more important than setting up other new initiatives.
- ***Actors Involved.*** A balance in objectives must be found: academia must learn to adjust its R&D to respond to shorter-term goals, while users need to be prepared for longer-term objectives. This balancing should occur at all levels, local (providing the basic knowledge), national (providing the necessary support and continuity), European (for the "methodological" developments).
- ***Delivery Mechanisms.*** In general, additional efforts should be made in order to let users know the different ways of collaboration it can develop with academia. In particular, communication initiatives such as the ones promoting the mobility of personnel should stress what the benefits are and which are the more suitable applications for the mechanisms being supported.
- ***Clearinghouse for Technologies***. Information on available technologies is scattered, which makes it impossible for planners trying to identify appropriate technologies to oversee the entire spectrum of available options. The establishment of a clearinghouse for technologies applicable in the coastal zone could facilitate the task of technology selection and evaluation. Such a clearinghouse would develop and hold an extensive catalogue of available technologies, including information on their costs, performance, owner (if not publicly-owned), implementation requirements and other relevant issues. Also the present study represented an opportunity to verify what information, and from what sources, is actually readily available (or available on-line). It must be noted here that EU-based information is still rather limited and largely overcome by US Agencies.

7.3 Proposals in the Field of Coastal-Management-Oriented R&D.

Improving the formulation of research problem areas. The scientists who are working in the different types of interface structures are developing a specific experience and skill, which combines both multi-disciplinary academic approach and social approach. Putting together and sharing this specific experience at the European level can give it an added value. There are many means to consider: thematic networks, international working seminars, joint publications, exchange of results and methods. The implementation of these means requires a form of public support at European and national / regional level. A criteria for successful exchange and sharing is the identification of the "optimal level of thematic specialisation" for the networks to be set up.

Developing a mediation capacity. The mediation capacity is a part of the scientific qualification, which expresses itself in the ability to detect the emergent or recurrent research issues that are underlying in the social needs. The mediation capacity is also a methodological issue. Therefore methods have to be developed for the organisation of public debates and for the expression of the expectations of social groups. New and existing methods for public debate must be developed, with a specific concern for methods involving both organised groups and non-organised citizens.

Giving a structure to the "missing links". Among the different means of relay and communication between the society and the R&D system, two missing links have been identified: between experts groups and interest groups in the" civil society "; between the councils and bodies for R&D programming and the scientists coming from the interface structures. Several solutions can be considered. A first proposal leads to the recommendation to integrate scientists who have the specific skill resulting from the interface structures, into the experts committees that take part in the design of research programmes at the European or national level.

7.4 Perspective for ICZM-Enabling Technologies.

Concerning the possible role and use of those technologies specifically introduced to serve the needs of Coastal Zone Management, the application of tools for sustainable management requires to apply conventional management approaches in a more informed way, with a more sophisticated understanding of their limits, and within a broader framework informed by ***systems thinking***. The key challenge for policy making implied by this is to find means of pursuing sustainable development objectives which take implicitly into account the existence of uncertainty in the knowledge of coastal processes, and help to solve problems at all spatial scales (rather than moving problems to different scales or locations).

A suitable support to such policy objectives has necessarily to be based on a suitable understanding of the integral functioning of the Coastal System as well as an update evaluation of its status based on a suitable management of available information. Thus the importance of the technologies that can support the Information Chain (Fig. 2.1).

Role of technology is increasing recognised while assisting the assessment phase and the protection phase of an ICZM initiative. Use of technology is very likely to increase fast here. A selection of the policies discussed in Chapter 6 could help organise the initiatives of system thinking.

7.5 Perspective for ICZM-Friendly Technologies.

Concerning the possible role and use of those technologies introduced to serve the needs of sectoral uses of the Coastal Zone (ref. Chapter 3), it appears that the adoption of best environmental practice (BEP), best available techniques (BAT) and integrated pollution prevention and control (IPPC) to those technologies adopted to satisfy sectoral needs in the Coastal Zone represent an important factor of “Coastal Zone Protection” at least for what concerns the “pollution-related” issues and problems. Strictly speaking it is not, however, Integrated Coastal Zone Management. At this respect it is rather more important to recall the importance of Environmental Impact Assessment and eventually of Strategic Environmental Assessment.

More in general, it is clear that specific technologies are or can be made available to solve specific problems. It is also useful to recall the possibility to adopt specific policies for the “promotion” of the informed and sustainable application of technologies such as those discussed in Chapter 6.

If a further selection of such policies has to be made we believe that a specific reference has to be made to Voluntary Agreements and the possibility to adopt Eco-Labelling schemes, Environmental Impact Assessment, Environmental Audits and Environmental Reporting, and Education about Environmentally-friendly Technologies.

In addition "research activities are clearly crucial in generating a more competitive technological base for European industry and in fostering the transition to a sustainable world, which will involve both a transformation of working practices and an optimised use of resources" (Commission of the European Communities, 1998). The challenge here is to adapt such objective to the peculiarities of the Coastal Zone Space and the Coastal Zone Resources.

We recall once again the idea of friendliness of those technologies that are normally there for other purposes than ICZM. It is our opinion that such judgement of friendliness is a basic requirement that has to be satisfied and will increasingly be satisfied by applying Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) regulations. The fact is that while looking at the status of technologies applied in the Coastal Zone, it is certainly relevant to consider that many technologies are there since a long time and the need to maintain or even extensively renew them, arises. On the other hand, many technologies could be considered for future implementation and their impact should be carefully assessed and mitigated. Such considerations certainly calls for a routine application of EIA practices for specific interventions or even SEA practices in the framework of the whole ICZM strategy.

7.6 Perspective for ICZM-Supporting Technologies.

With reference to the problems connected with or derived by the sectoral utilisation and exploitation of Coastal Zone Space and of its Resources, a certain optimism appears. Three trends can be distinguished concerning the introduction of technologies to prevent and/or mitigate problems:

- Coastal adaptation is putting ***increasing emphasis on technologies to collect and manage information***. This trend stems from the recognition that designing an appropriate preventive and mitigative technology requires a considerable amount of data on a range of coastal parameters, and a good understanding of the uncertainties involved in the impacts to be addressed.
- Many efforts are being initiated to ***enhance awareness of the need for appropriate coastal adaptation***. In view of the many sectoral interests in coastal zones it will become increasingly important to involve non-coastal decision-makers and other stakeholders in this process.
- Until recently, protecting coastlines with hard structures happened with only limited consideration of the potential consequences of these structures on other parts of the coast. ***Increasing awareness of unwanted effects*** of hard structures on erosion and sedimentation patterns has led to growing recognition of the benefits of "soft" protection interventions and of the adaptation strategies retreat and accommodate.

The optimism is further enhanced by the observation that a number of non ICZM-specific laws and regulations are posing limits to the impacts connected with the sectoral utilisation and exploitation of the coastal zone having in mind many of the specific problems of Chapter 4.

More significant problems arise while looking at those coastal situations that appears to be already seriously compromised by excessive past exploitation activities. Here, remediation technologies, as well as technologies to ameliorate environmental quality will have to be considered. A selection of the policies discussed in Chapter 6 could help giving priorities.

7.7 Incremental vs. Radical Change.

Given the complexity and uncertainty of organisational and technological changes, and the significant investments required, many organisations and institutions certainly favour an incremental approach to development rather than radical changes to tasks, processes, or organisational relations. An incremental approach is certainly preferable due to the intertwined nature of technological and organisational choices. Indeed, organisational change often requires technological change, and vice versa; one rarely gets very far ahead of the other. In this view it is better to work for the possible rather than to make plans for the impossible.

On the other side of the medal, without more radical changes, resulting from a creative integration of several goals and several technologies into changed organisational structures, the incremental approach may risk building only a "scaffolding" with efficiency gains such as cost savings, rather than a structure that would allow greater effectiveness through new kinds of policy decisions, or new processes for reaching these decisions. Even though more radical technological and organisational change holds promise for improved planning and policy, it's unlikely to come about easily, and may require outside pressures (and often outside resources as well).

Three additional criteria may help in directing this choice: (*i*) define problems at the right level; (*ii*) manage problems at the right spatial level; (*iii*) use composite instruments to achieve multiple aims.

Define problems at the right level

In seeking new management approaches it is essential that problems are defined at the ***appropriate conceptual level***. Most non-trivial problems can be defined in several different ways. Each definition implies a different kind of solution, i.e. a different kind of ICZM-supporting technologies. For example, erosion can be seen:

- as a local problem, the solution to which might be build a breakwater;
- as a local reduction of the space available for umbrellas, in which case a solution might be to build a chain of groins;
- as damaging the seafront, suggesting the construction of seawalls;
- as damaging to "liveability" of the beach, possibly solved by adopting a soft protection approach; or
- as a regional problem, to be addressed by managing the whole watershed of the adjacent rivers.

Manage problems at the right spatial level

Similarly, it is necessary to manage problems at the ***right spatial level***. The structure and responsibilities of local and regional government vary greatly between Member States. There is no one "correct" pattern. However, management for sustainability does require that attention is paid to the concepts in Agenda 21 of the appropriate scale of decision making. Agenda 21 repeatedly points out that effective planning of resources such as water is far easier if the units of planning correspond to natural domains such as river catchments. Agenda 21 applies the same logic to human settlements, although they are not literally "natural domains". For example, urban transport needs to be planned at the level of the "commutershed" - usually the whole city and a substantial area around it.

Most European countries have tiered systems of regional and local government in which responsibilities, powers and resources are distributed amongst the tiers. Coastal cities rarely have complete governmental jurisdiction over their Coastal Areas making policy integration more difficult, especially for services which need to be provided at a strategic level. The structure and organisation of local government are therefore important factors in determining the ease or difficulty of formulating and implementing sustainable development policies and the application of ICZM-friendly technologies.

Use composite instruments to achieve multiple objectives

In addition, when devising new policy approaches for sustainability it is generally necessary to devise composite instruments to ***achieve multiple objectives***. Much policy thinking is based on the doctrine that policy instruments should be designed to solve one problem at a time. This is obviously attractive as a way of imposing some clarity and accountability on policy processes. But the ecosystems model requires recognition that this pattern is so exceptional as to be almost unknown.

Instead, it should be assumed that any problem will require a combination of policy instruments to solve it - and that each of these components should in turn help to solve more than one problem. Composite instruments to achieve multiple objectives must be the standard approach to policy making. It is in this way that ICZM-enabling technologies can more fruitfully be applied.

7.8 Financing the Adoption of Technologies.

At the beginning of the present analysis, financing technologies and financing ICZM, appeared to be a potential serious barrier. At the end of this tour it rather appears to be a problem of organisation: ICZM is actually a mean to save (public) money and beneficial use of environmentally-friendly technologies can be financed without actually increasing current expenditures. The problem is that benefits of ICZM may appear later or take longer than if one would strive for sectoral approaches to management. This requires a longer time horizon for evaluation. Moreover the whole life cycle of a technology should be considered for the determination of its costs and it benefits (design, deployment, maintenance, decommissioning).

Of course we did not undertake a full financial analysis, however some positive elements can be given:

- Decision making about the possible expenditure on certain resources for ICZM-enabling technologies must have an ***adequate projection in time***; the correct evaluation of the real deployment costs cannot be limited to the cost of acquisition of the technologies.
- ***Decision making should be undertaken with a multidisciplinary attitude***; the benefits of a technology which contributes to the better understanding of the coastal system go beyond the understanding itself: they allow to spend in a more efficient way resources for problem prevention and problem mitigation.
- The different attitude and the various priorities in spending money clearly play an important role; ultimately, even if the pros and cons are all well identified, the ***choice is always a matter of political decisions***.

- Technologies are used already to support sectoral activities. Technologies are also extensively used to undertake restoration and mitigation activities. This clearly means that the opportunity for their ***"better" utilisation***, eventually inspired by ICZM principles, exist. ICZM should not directly pay for them.
- Work toward ICZM-friendly, ICZM supporting, and ICZM-enabling technologies requires ***requalification of existing of existing expertise***, especially in the administrations, as well as the introduction of new type of jobs.
- Large amount of ***money is obviously needed for the initial deployment of restoration technologies*** and of infrastructures for protection and safeguard. But this must be done anyway.
- ***The introduction of ICZM-enabling technologies can play a role in triggering and sustaining a positive ICZM-formation process***; once the possibilities for monitoring and problem assessment are there, and information is distributed, discussion on "what to do with the coastal zone" can start (also where it is not starting by other means).

Among these, the possibility for job creation should not be underestimated. Whether or not advanced technologies can be justified and purchased, the availability of human resources defines the practical realm of technologies.

According to our classification of technologies, the ideal target for technologies in relation to ICZM could be:
- ***Introduce*** those ICZM-enabling Technologies which are useful for the ICZM initiative;
- ***Better Use*** of existing and/or required Sectoral Technologies and preference to ICZM-friendly technologies, when options are available;
- ***Coordinate*** the deployment and the use of ICZM-supporting technologies.

Type of Technology	Cost Attribution for Deployment	Organisation Costs	Costs for Skill Development
ICZM-Enabling	Initial deployment with Institutional Support	Institution	Public
ICZM-Friendly	Private Sector	Private Sector	Public
ICZM-Supporting	Public-Private Partnership	Public	Public

Tab. 7.1 - Sources of Financing for Technologies

Type of Technology	Cost Attribution
Hardware on a Large Area	National Institution
Hardware on a Local Area	Regional or Provincial Institution
Software for Networking	Institution
Software for Decision Making	Everyone who takes the initiative

Tab. 7.2 - Financing Enabling Technologies

Costs should be somehow divided; they should not represent in any case a limit to the willingness to proceed toward ICZM. Costs related to the assessment of the impacts of specific projects should be charged to the projects; similar for mitigation interventions and for specific monitoring activities requiring specific technologies. In view of the above-mentioned targets, the distribution of costs can be related to the type of technologies (Tab. 7.1 and Tab. 7.2).

Also, we should verify whose interest it is that of limiting the adoption of modern technologies. Without entering the details and making names (for obvious reasons), there could be the case of a modern technology, which cost something initially, that allows for a certain job to be quickly and economically made in a certain period of time. Well, maybe someone could have the interest of using the traditional technology that requires the same job to be made, more expensively, on a longer period of time. It is a matter of different interest groups and different political attitudes, of course.

Financial institutions can exercise considerable influence over investment and management decisions which could be brought into play for the benefit of the environment. Financial institutions represent an opportunity to support the adoption of ICZM-enabling, ICZM-supporting, and ICZM-friendly technologies, once the connection between “environmental performance” and “economic performance” is made clear (see §6.4).

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8. CONCLUSIONS ABOUT THE ROLE OF THE EU

While waiting for the definition of a European Strategy for ICZM, still there are possibilities to anticipate actions at European level that could ameliorate the "use" of technologies. It is interesting to look at what could be the Role of the European Union in relation with ICZM. Focus of this chapter is on the Role of the European Union with reference to Technologies; validity of the various considerations is however clearly wider than that and can be transferred to various levels of activity. In principle, the role of the EU is to provide a general framework of coherent actions which stimulates Member States to work toward sustainable development of coastal zones.

- ***"Define" the Framework for technologies in relation to ICZM***; On the basis of a common understanding of the objectives of ICZM, define a set of criteria for the attribution of the status of ICZM-friendly, ICZM-enabling, and ICZM-supporting technology, with a view to applying them in a flexible way in the varying EU regional contexts.
- ***"Trigger" the proper consideration of the role of technologies in relation to ICZM***; this means that the European Union, recognising the importance of the recognition of the role played either implicitly or explicitly by technologies, will recommend their proper consideration at various administrative levels, through either direct obligations or conditionality for funding.
- ***"Support" the adoption of technologies for ICZM*** (providing tools, technologies, methodologies); this means that the European Union, recognising the importance of certain tools, technologies, and methodologies, should favour their development, dissemination, acquisition, and their routine application at all levels.
- ***"Suggest" and/or "Impose" the adoption of ICZM-Friendly Technologies*** (ICZM-Friendly Label?), this means that the European Union, recognising the fact that a number of technologies, often adopted to answer to sectoral issues, can represent a threat to the Coastal Zone (or to the Environment in general), should define specific criteria for the adoption of ICZM-Friendly Technologies.
- ***"Adapt" Individual EU Sectoral Policies.*** EU legislation has a major and growing impact on national coastal laws, particularly in the context of fisheries, water quality, nature conservation and environmental assessment. A range of EU sectoral policies have actual or potential beneficial effects on the coastal environment, particularly directives on pollution, nature conservation and environmental assessment. Various beneficial activities are also financed under the structural funds. However, there is a significant amount of EU policy that either works against the objectives of ICZM (by promoting counter-ICZM technical solutions), or does not fulfil its potential to support ICZM-friendly technical solutions.
- ***"Promote" EIA and SEA.*** Complement list of projects subject to EIA in the coastal zone. Define lists of policy decisions that should be subject to Strategic Environmental Assessment of their impact (environmental, socio-economic and spatial) at least at regional level. An initiative in this context would certainly limit the adoption of counter-ICZM technical solution to sectoral needs.
- ***"Raise Awareness"***. Raise awareness about the beneficial effects of the informed application of technologies. Disseminate targeted information on good practices in the application of technologies in the coastal zone.
- ***"Enable" ICZM***. Enabling ICZM actions to be successfully activated requires an improvement in the formulation of research objectives. In the new Framework Program for research ICZM is not explicitly considered. We can consider it to be implicitly

there when sustainability objectives have to be achieved in the coastal zone. However care must be taken in order to actually work to bridge the gaps.

We should not forget to mention the role of the European Environment Agency as well as the Environment Agencies of the Member States. Science-intensive policy decisions depend on obtaining and interpreting trusted, high-quality, up-to-date information. Information-sharing infrastructures would allow detailed information to be left in the care of those who collect it, maintain it, and know it best. This would maintain its accuracy and proper use; while allowing users to obtain the information directly from the source when needed. The EEA in particular has the potential to play a major role in the provision of supporting information for ICZM and, more in general, in supporting the whole information chain. However, it appears that there is still a certain inertia in fulfilling completely the mandate. The EEA could also probably play the role of the ***clearinghouse of information*** on good and bad practices with respect to the use of technologies in relation to ICZM. Moreover, the possibility to move from the approach of survey of the state of the coastal environment to the approach of on-line, near real-time, monitoring of the state of the coastal environment, would represent a very important progress.

9. REFERENCES

Aarninkhof, S.G.J. and Holman, R.A., 1999. Argus video-based monitoring of the nearshore zone: A tool for both nearshore science and coastal zone management. In: Backscatter, The magazine of aquatic remote sensing. V. 10, N. 2, May 1999. The Alliance for marine remote sensing (AMRS), Bedford, Nova Scotia, Canada [in press].

ACRI, CARMEL, GKSS, MARNET, MEDIAS, CLS, EUROCOAST, 1995. Collect User Requirements from an Experimental User Community on Coastal Zone. Final Report, CEO Pathfinder Study on Coastal Zone, DGXII-JCR, 152 pp. +Ann.

Atkinson J.F., Gupta S.K., DePinto J.V., Rumer R.R., 1998. Linking Hydrodynamic and Water Quality Models with Different Scales, Journal of Environmental Engineering, v. 124, n. 5, pp. 399-408.

Atturio J.M. (ed.), 1997. State of Technology Report-Ocean and Coastal Engineering Division, MTS Journal, v. 31, n.2, pp. 36–49.

Banks R., James C., 1998. Fisheries Offences - The Rationale, The Perspectives and Control Options, EEZ Technology, ICG Publishing n. 3, London, pp. 193-199

Bauer B.O., Davidson-Arnott G.D., Nordstrom K.F., Ollerhead J., Jackson N.L., 1996. Indeterminacy in Aeolian Sediment Transport Across Beaches. J. of Coastal Research, v. 12, n. 3, pp. 641-653.

Bijlsma, L., C.N. Ehler, R.J.T. Klein, S.M. Kulshrestha, R.F. McLean, N. Mimura, R.J. Nicholls, L.A. Nurse, H. Pérez Nieto, E.Z. Stakhiv, R.K. Turner, and R.A. Warrick, 1996: Coastal zones and small islands. In: Climate Change 1995—Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses [Watson, R.T., M.C. Zinyowera, and R.H. Moss (eds.)]. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, pp. 289–324.

Boesch D.F., M.N. Josselyn, A.J. Mehta, J.T. Morris, W.K. Nuttle, C.A. Simenstad, and D.J.P. Swift, 1994: Scientific assessment of coastal wetland loss, restoration and management in Louisiana. Journal of Coastal Research, special issue #20.

Bolsius E.C.A., Clark G., Groenendijk J.G. (eds.), 1993. The Retreat. Rural Land-use and European Agriculture. Faculty of Environmental Sciences, University of Amsterdam, pp. 170.

Bondesan M., Castiglioni G.B., Elmi C., Gabbianelli G., Marocco R., Pirazzoli P.A., Tomasin A., 1995. Coastal Areas at Risk from Storm Surges and Sea-level Rise in Northeastern Italy. J. of Coastal Research, v. 11, n. 4, pp. 1354-1379.

Bosman J., Flemming N.C., Holden N., Taylor K., 1998. “The EuroGOOS Marine Technology Survey”, EuroGOOS Pub. No. 4, Southampton Oceanography Centre, Southampton. ISBN 0-904175-29-4.

Brimicombe A.J., 1992. Flood Risk Assessment Using Spatial Decision Support Systems. Simulation, December 1992, pp.379-380.

Brown W.S., Garrison K.G, and MacBeth M., 1994. Prototype Environmental Data and Information Management Systems (EDIMS). http://gulfofmaine.unh.edu/edims/edims_description.html

Burrough P.A., 1989; Principles of Geographic Information Systems for Land Resources Assessment, Clarendon Press, Oxford.

Çakiroğlu C., Yurteri C., 1998. Methodology for Predicting Cooling Water Effects on Fish, Journal of Environmental Engineering, v. 124, n. 7, pp. 612-618.

Capobianco M., 1999b. The Role and Use of GIS in relation to ICZM. Tecnomare Report 636A0753-RAP-D100-006.

Capobianco M., 1999a. Suggested Actions Tecnomare Report 636A0753-RAP-D100-005.

Capobianco M., 1998e. Discussion Document on EIA&ICZM Tecnomare Report 636A0753-RAP-D100-004.

Capobianco M., 1998c. Twenty Questions on ICZM Tecnomare Report 636A0753-RAP-D100-003.

Capobianco M., 1998c. Discussion Document on "Fundamentals" for ICZM, Tecnomare Report 636A0753-RAP-A200-002.

Capobianco M., 1998b. Peculiarities of the Coastal Zone, Tecnomare Report 636A0753-RAP-A200-001.

Capobianco M., 1998a. "Predictability for Long-term Coastal Evolution - Handling the Limiting Factors". In Proc. 3rd Marine Science and Technology Conf., 23-27 May, Lisbon, Portugal.

Capobianco, M, H.J. de Vriend, R.J. Nicholls, and M.J.F. Stive, 1999: Coastal area impact and vulnerability assessment: a morphodynamic modeller's point of view. Journal of Coastal Research, in press.

Capobianco M., Stive M.J.F., 1997. "Soft Protection Technologies as a Tool for Integrated Coastal Zone Management", MEDCOAST '97, Malta, November 11-14

Capobianco M., Otter H.S., 1996. "Modelling Land-use and Land-cover Changes in Deltaic Areas", Int. Workshop on the State-of-the-Art of ICZM in the Mediterranean and Black Sea: Immediate Needs for Research, Education & Training, & Implementation, Iberotel Sarigerme Park, Turkey, November 2-5

CBNP (Committee on Beach Nourishment and Protection), 1995. Beach Nourishment and Protection, National Research Council, National Academy Press, Washington, D.C., 334 pp.

CCC (California Coastal Commission), 1993. Seawater Desalination in California, http://ceres.ca.gov/coastalcomm/desalrpt/dtitle.html

Chao, P.T. and B.F. Hobbs, 1997: Decision analysis of shoreline protection under climate change uncertainty. Water Resources Research, 33(4), 817–829.

(CEC) Commission of the European Communities, 1999. Towards a European Integrated Coastal Zone Management (ICZM) Strategy—A Reflection Paper. Discussion document from the Demonstration Programme on Integrated Coastal Zone Management, CEC, Luxembourg, In press.

(CEC) Commission of the European Communities, DGXI, 1998d. "Integrated Product Policy - A study analysing national and international developments with regard to Integrated Product Policy in the environment field and providing elements for an EC policy in this area". Executive Summary from the Final Report, 16 pp.

(CEC) Commission of the European Communities, 1998c. "Communication from the Commission to the European Council. Partnership for Integration - A Strategy for Integrating Environment into European union Policies", 10 pp.

(CEC) Commission of the European Communities, 1998b. "Communication from the Commission to the European Council. The Future for the Market in Fisheries Products in the European Union: Responsibility, Partnership and Competitiveness, 22 pp.

(CEC) Commission of the European Communities, 1998a. Amended Proposal for a Council Directive establishing a framework for Community action in the field of Water Policy, (COM-98-76-final), 57 pp.

(CEC) Commission of the European Communities, DGXVI, 1997. European Spatial Development Perspective – First Official Draft, 72 pp.

(CEC) Commission of the European Communities, 1996c. *Proposal for a Council Directive on the assessment of the effects of certain plans and programmes on the environment*, COM(96) 511 final, Brussels, 4.12.1996

(CEC) Commission of the European Communities, DGXVII, 1996b. European Energy to 2020: a Scenario Approach, 120 pp.

(CEC) Commission of the European Communities, 1996a. "Communication from the Commission - Energy for the Future: Renewable Sources of Energy. Green Paper for a Community Strategy", (COM-96-576), 48 pp.

(CEC) Commission of the European Communities, 1995b. "Communication from the Commission to the Council and the European Parliament on the Integrated Management of Coastal Zones", (COM -95 - 511), 35 pp.

(CEC) Commission of the European Communities, 1995a. "White Paper. An Energy Policy for the European Union", (COM-95-682), 47 pp.

CEC-DG XII, MAST and IOC/IODE, 1993. Manual of Quality Control Procedures for validation of Oceanographic Data. UNESCO Manual and Guides n. 26, 436 pp.

CEO (Center for Earth Observation), 1999. Recommendations on Metadata, Report SSSA / ES / 001, 118 pp.

Cervantes M., 1998, Public/Private Partnerships in Science and Technology: An Overview, STI Review No. 23, OECD, Paris, 12 pp.

Colecchia A., Papaconstantinou G., 1996. The Evolution of Skills in OECD Countries and the Role of Technology, STI Working Papers, No. 8, OCDE/GD(96)183, OECD, Paris, 36 pp.

(CEC) Council of the European Communities, 1997. *Council Directive of 3 March 1997 amending Directive 85/337/EEC on the assessment of the effects of certain public and private projects on the environment,* Official Journal of the European Communities No L73, 14.3.97

(CEC) Council of the European Communities, 1985. *Council Directive of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment*, Official Journal of the European Communities No L175, 5.7.85

Costanza, R. and M. Ruth. 1997. Using Dynamic Modeling to Scope Environmental Problems and Build Consensus, Environmental Management,Vol. 22, pp. 183-196.

Costanza, R., F.H. Sklar and M.L. White, 1990. Modelling Coastal Landscape Dynamics, BioScience, Vol. 40, No. 2, pp. 91-107.

Costanza, R., L. Wainger, C. Folke and K.G. Mäler, 1993. Modelling Complex Ecological Economic Systems, BioScience, Vol. 43, No. 8, pp. 545-555.

Crout R.L., 1997. Coastal Currents from Satellite Altimetry. Sea Technology, v. 38, n. 8, pp. 33-37.

(CVN) Consorzio Venezia Nuova, 1993-1998. Quaderni Trimestrali, Consorzio Venezia Nuova, Venezia.

Davison T.A., Ulrich C.P., Nicholls R.J., 1993. Accreditation of Beach Nourishment projects: An Issues Discussion, Shore & Beach, J. of American Shore & Beach Preservation Association, v. 61, n. 4, pp. 9-15.

Delft Hydraulics, 1987: Manual on Artificial Beach Nourishment. Centre for Civil Engineering Research Report No. 130, Rijkswaterstaat, The Hague, The Netherlands, 195 pp.

De Vriend H.J., 1996. Mathematical Modelling of Meso-tidal Barrier Island Coasts, Part I: Empirical and Semi-empirical Models. In: P.L.F. Liu (ed.), Advances in Coastal and Ocean Engineering, Vol. 2, World Scientific Publishing Company, Singapore.

De Vriend H.J., Capobianco M., Latteux B., Chesher T., Stive M.J.F., 1993. Long-Term Modelling of Coastal Morphology: A Review. in H.J. de Vriend (ed.), Coastal Morphodynamics: Processes and Modelling. Coastal Eng., v. 21, pp. 225-269.

DOD, 1994. "Remediation Technologies Screening Matrix and Reference Guide - Second Edition", Environmental Technology Transfer Committee, 597 pp.

ECOPRO, 1996. Environmentally Friendly Coastal Protection – Code of Practice, Government Publications, Dublin, 320 pp.

EEA, 1998. Framework on Integrated Models and Indicators for European Coastal Zone Management. European Environment Agency. European Topic Centre on Marine and Coastal Environment. February 1998.

Earth Observation Sciences, 1998. CEO Water Companies, Final Report, Document No: EOS-242-RP-002, Issue No. 2.0, 60 pp.+Ann

(EPA) Environmental Protection Agency, 1999c. Technology Innovation Office, http://www.epa.gov/swertio1/abttio.html

(EPA) Environmental Protection Agency, 1999b. Technical Tools and Models, http://www.epa.gov/epahome/datatool.htm

(EPA) Environmental Protection Agency, 1999a. Geographic Information Systems Tools, http://www.epa.gov/epahome/gis.htm

(EPA) Environmental Protection Agency, 1998. EPA's Contaminated Sediment Management Strategy, Office of Water, EPA-823-R-98-001, 100 pp. + xiv.

(EPA) Environmental Protection Agency, 1997. "Reducing Risks from Waste", EPA530-k-97-04, 41 pp.

(EPA) Environmental Protection Agency, 1997. Environmental Technology Verification Program - Verification Strategy, EPA/600/K-96/003, 18+v pp.

(EPA) Environmental Protection Agency, 1997. Identification of Pollution Prevention (P2) Technologies for Possible Inclusion in Enforcement Agreements Using Supplemental Environmental Projects (SEPs) and Injunctive Relief. Environmental Protection Agency Publ. No. 300-R-97-001, 61 pp. + ann.

(EPA) Environmental Protection Agency, 1996. Treasured Waters: Protecting Our Coastal And Marine Resources, EPA/842/B-96/001, Office of Water, http://www.epa.gov/OWOW/ oceans/treasure/covpage.html

(EPA) Environmental Protection Agency, 1994. The Dredging Process in the United States: An Action Plan for Improvement, The Interagency Working Group on the Dredging Process, Office of Wetlands, Oceans, & Watersheds, http://www.epa.gov/OWOW/oceans/ndt/report.html

ESA, 1995. Coastal Zone Earth Workshops, ESTEC 28, 29-03-95, ESRIN 5, 6-4-95, Workshop for the Definition of ENVISAT Coastal Zone Mission, ESA, Paris.

Essaid, H. I., 1990. "A multilayered sharp interface model of coupled freshwater and saltwater flow in coastal systems: model development and application," Water Resources Research, v. 26, n. 7, pp. 1431-1454.

EU, 1976. Council Directive concerning the Quality of Bathing Water (76/160/EEC).

Fankhauser S., 1995. Protection versus Retreat: the Economic Cost of Sea Level Rise. Environment and Planning, v. 27, pp. 299-319.

Farinha J.C., Costa L., Zalidis G., Matzavelas A., Fitoka E., Hecher N., Tomàas Vives P., 1996. Mediterranean Wetland Inventory: Habitat Description System. MedWet/Instituo da Conservacao da Naturaleza (ICN)/Wetlands International/Greek Biotope/Wetland Center

(FEMA) Federal Emergency Management Agency, 1994: Mitigation of Flood and Erosion Damage to Residential Buildings in Coastal Areas. FEMA-257, Mitigation Directorate, Federal Emergency Management Agency, Washington, DC, [page numbers].

Finnish Environment Institute, 1998. Integrated Monitoring: Environmental Assessment through Model and Empirical Analysis. Final Results from an EU/Life Project, Project Report, LIFE05/FIN/A11/EPT/387, Publication n. 218, 172 pp.

Funnell, C., 1998: Europe's ocean industry must be ready for the EC's FP5. International Ocean Systems Design, 2(1), 15–18.

Funtowicz S.O. and J.R. Ravetz, 1995. Planning and Decision Making in an Uncertain World: the Challenge of Post-Normal Science, in: Natural Risk and Civil Protection, Horlick-Jones T., A. Amendola and R. Casale (eds), Chapman & Hall, London, pp. 554.

Garbuglia E., Piantoni R., 1996. Caratterizzazione Tecnological degli Impianti di Maricoltura nell'Ambiente Mediterraneo, Biol. Mar. Medit., v. 3, n. 1, pp. 167-175.

Garbuglia E., Berti D., Capobianco M., 1994. "Marine Science: Prospective and Technological Needs for the year 2000 and Beyond", Oceanology International '94, Brighton, U.K., March 8-11.

Georges T.M., J. A. Harlan, R. R. Leben, and R. A. Lematta, 1998. "A Test of Ocean Surface-Current Mapping with Over-the-Horizon Radar," IEEE Trans. Geosci. Remote Sensing, vol. 36(1), pp. 101-110

Georges T.M. and J. A. Harlan, 1994. "Military over-the-horizon radars turn to ocean monitoring," Mar. Tech. Soc. J., 27, 4, pp. 31-38.

Greco N., 1990. La Gestione Integrata delle Coste. Franco Angeli Libri, Milano, pp. 363.

Greidanus, H., C. Calkoen, I. Hennings, R. Romeiser, J. Vogelzang, G.J. Wensink. Inter-comparison and validation of bathymetry radar imaging models, 1997. In *Proceedings IGARSS '97*, Aug. 3-8, 1997, v. III, pp. 1320-1322.

GI2000, 1996. "Towards a European Policy Framework for Geographic Information - A Working Document", Commission of the European Communities, DGXIII, November 1996.

Goldberg, E.D., 1994: Coastal Zone Space—Prelude to Conflict? IOC Ocean Forum I, UNESCO Publishing, Paris, France, 138 pp.

Gommes, R., J. du Guerny, F. Nachtergaele, and R. Brinkman, 1998. Potential Impacts of Sea-Level Rise on Populations and Agriculture. FAO SD-Dimensions Special, http://www.fao.org/sd/eidirect/Eire0045.htm.

Gorman, L., A. Morang, and R. Larson, 1998: Monitoring the coastal environment; part IV: mapping, shoreline changes, and bathymetric analysis. Journal of Coastal Research, 14(1), 61–92.

Hamm L., Hanson H., Capobianco M., Dette H., Lechuga A., and Spanhoff A., 1998. "Beach Fills in Europe - Projects, Practices, and Objectives", Proceedings of the 26th ICCE, Copenhagen, ASCE.

Heaton G.R., R.D. Banks and D.W. Ditz, 1994. Missing Links: Technology and Environmental Improvement in the Industrialising World, World Resources Institute, 51 pp.

Herz K.O., 1996, Science and Technology for Sustainable Development, FAO SD-Dimensions, Research & Technology Development, http://www.fao.org/sd/RTdirect/RTre0004.htm

International Institute for Sustainable, Development, 1996. "Global green standards: ISO 14000 and sustainable development", 106 pp.

IOC, 1997. GOOS Coastal Module Planning Workshop Report, Workshop Report No. 131, UNESCO, 57 pp.

IOC, 1995. International Training Workshop on Integrated Coastal Management Workshop Report No. 120, UNESCO, 74 pp.

IPCC CZMS, 1992: A common methodology for assessing vulnerability to sea-level rise—second revision. In: Global Climate Change and the Rising Challenge of the Sea. Report of the Coastal Zone Management Subgroup, Response Strategies Working Group of the Intergovernmental Panel on Climate Change, Ministry of Transport, Public Works and Water Management, The Hague, The Netherlands, Appendix C, 27 pp.

International Organization for Standardization, 1995a. Environmental management systems - Specification with guidance for use, ISO/DIS 14001, Geneva, *22 pp*.

International Organization for Standardization, 1995b. Environmental management systems - General guidelines on principles, systems and supporting techniques, ISO/DIS 14004, Geneva, *45 pp*.

Istituto Veneto di Scienze, Lettere ed Arti, 1994. Il Fiume e la sua Terra. Atti del Convegno di Studi, Rovigo, 27-28 Settembre, 1991, pp. 234.

Klein, R.J.T. and R.J. Nicholls, 1999. Assessment of coastal vulnerability to climate change. Ambio, in press.

Krohn S., 1999. Offshore Wind Energy: Full Speed Ahead, Danish Wind Turbines Manufaturers Association, http://www.windpower.dk/articles/offshore.htm

Jeftic L., J. Milliman, and G. Sestini (eds.), 1992. Climate Change and the Mediterranean—Environmental and Societal Impacts of Climatic Change and Sea-Level Rise in the Mediterranean Region. Edward Arnold, London, UK, xii+673 pp.

Jones, A.R., 1995: GIS in coastal management: a progress review. In: CoastGIS '95 [Furness, R. (ed.)]. Proceedings of the International Symposium on GIS and Computer Mapping for Coastal Zone Management, Cork, Ireland, 3–5 February 1995, University College Cork, Cork, Ireland, pp. 165–178.

Jung C., Krutilla K., Boyd R., 1996, Incentives for advanced pollution abatement technology at the industry level: An evaluation of policy alternatives, Journal of Environmental Economics and Management, n. 30, pp. 95–111.

Larson, R., A. Morang, and L. Gorman, 1997: Monitoring the coastal environment; part II: sediment sampling and geotechnical methods. Journal of Coastal Research, v. 13, n.2, pp. 308–330.

Leafe, R., J. Pethick, and I. Townend, 1998: Realising the benefits of shoreline management. The Geographical Journal, 164(3), 282–290.

Leick A. 1995. GPS Satellite Surveying. 2nd. ed. John Wiley & Sons, New York.

Lillycrop, W.J. and L.L. Estep, 1995: Generational advancements in coastal surveying, mapping. Sea Technology, v. 36, n. 6, pp. 10–16.

Lillycrop, W.J., Parson, L.E., and Irish, J.L., 1996. "Development and Operation of the SHOALS Airborne Lidar Hydrographic System," SPIE: Laser Remote Sensing of Natural Waters From Theory to Practice, Vol. 2964, pp. 26-37.

Maglia S., Santoloci M., 1996. Il Codice dell'Ambiente, Casa Editrice la Tribuna, Piacenza, pp. 2431.

(MAFF) Ministry of Agriculture, Fisheries and Food, Welsh Office, Association of District Councils, English Nature, and National Rivers Authority, 1995: Shoreline Management Plans—A Guide for Coastal Defence Authorities. Her Majesty's Stationery Office, 24 pp.

Martuccelli A.M., 1994. Il Ruolo della Bonifica per la Costruzione, Tutela e Gestione del Territorio Polesano. in "Il Fiume e la sua Terra. Tutela e Gestione del Territorio a Quarant'Anni dall'Alluvione del Polesine. 1951-1991. Atti del Convegno di Studi.

Mehra M., 1997. Towards Sustainable Development for Local Authorities - Approaches, Experiences and Sources, European Environment Agency, 157 pp.

Merrifield, D.B. 1990: Industrial competitiveness. In: Technology Commercialization and Competitiveness. IC^2 Institute, University of Texas, Austin, TX, pp. 23–29.

Mitsch W.J. & B.C. Reeder. 1991. Modelling nutrient retention of a freshwater coastal wetland: estimating the roles of primary productivity, sedimentation, resuspension and hydrology. Ecological Modelling 54, pp. 151-187.

Mitsch, W.J. & J.G.Gosselink 1993. Wetlands. 2nd Edition. New York: Van Nostrand Reinhold.

Myers E.P., Harding E.T., 1983. Ocen Dicposal of Municipal Wastewater: Impacts on the Coastal Environment, Sea Grant College Program, MIT, Cambridge MA, Vol. 1, 518 pp.

Morang A., Larson R. and Gorman L., 1997. "Monitoring the Coastal Environment; Part I: Waves and Currents", J. of Coastal Research, v. 13, n. 1, pp. 111-133.

Morang, A., R. Larson, and L. Gorman, 1997b: Monitoring the coastal environment; part III: geophysical and research methods. Journal of Coastal Research, v. 13, n. 4, pp. 1064–1085.

Nicholls, R.J. and J. Branson (eds.), 1998: Enhancing coastal resilience—planning for an uncertain future. The Geographical Journal, v. 3, n. 164, pp. 255–343.

(NOAA) National Oceanographic and Atmospheric Administration, 1996. Injury Assessment - Guidance Document for Natural Resource Damage Assessment Under the Oil Pollution Act of 1990, Damage Assessment and Restoration Program. Damage Assessment Center National Oceanic and Atmospheric Administration, Silver Spring, Maryland

(NOAA) National Oceanographic and Atmospheric Administration, 1999. C-CAP - Coastal Change Analysis Program, Coastal Services Centre, http://www.csc.noaa.gov/ccap/

(NRC) National Research Council, 1987: Responding to Changes in Sea Level: Engineering Implications. National Academy Press, Washington, DC, 148 pp.

(NRC) National Research Council, 1995. Science, Policy and the Coast: Improving Decisionmaking. National Academy Press, Washington, DC, 85 pp.

(NRC) National Research Council, 1990: Managing Coastal Erosion. National Academy Press, Washington, DC, 522 pp.

(NSTC) National Science and Technology Council, 1995: Bridge to a Sustainable Future. Interagency Environmental Technologies Office, Washington, DC, vi+87 pp.

Odum H.T. 1983, 1993. Systems Ecology (reprinted as Ecological and General Systems). Univ. Press of Colorado, Niwot, CO, 644 pp.

(OECD) Organisation for Economic Co-operation and Development, 1997. Information Technology Outlook. OECD Publication, Paris, 234 pp.

(OECD) Organisation for Economic Co-operation and Development, 1997. The Evaluation of Scientific Research: Selected Experiences Report OCDE/GD(97)194, 112 pp.

(OECD) Organisation for Economic Co-operation and Development, 1992. Good Practices for Environmental Impact Assessment of Development Projects, OECD Development Assistance Committee, Guidelines on Aid and Environment, No. 1, 15 pp.

(OECD) Organisation for Economic Co-operation and Development, 1996. Technology, Productivity and Job Creation, OECD Publication, Paris 35 pp.

(OECD) Organisation for Economic Co-operation and Development, 1995. Technology and Environment - Policies to Promote Technologies for Cleaner Production and Products: Guide for Government Self-Assessment, Report OCDE/GD(95)21, 48 pp.

(OECD) Organisation for Economic Co-operation and Development, 1995. Guidelines for Aid Agencies on Global and Regional Aspects of the Development and Protection of the Marine And Coastal Environment, OECD Development Assistance Committee, Guidelines on Aid and Environment, No. 1, 51 pp.

O'Regan, P.R., 1996: The use of contemporary information technologies for coastal research and management—a review. Journal of Coastal Research, v. 12, n. 1, pp. 192–204.

Orlikowski W.J., 1992. The duality of technology: rethinking the concept of technology in the context of organisations, Organisation Science, v. 3, n. 3, pp. 398-427.

OTA (U.S. Office of Technology Assessment), 1995. Renewing Our Energy Future, OTA Renewable Energy & Energy Efficiency Reports, 300 pp.

Parson, L.E., Lillycrop, W.J., Klein, C.J., Ives, R.C., and Orlando, S.P., 1996. "Use of Lidar Technology for Collecting Shallow Bathymetry of Florida Bay," Journal of Coastal Research, Vol. 13, No. 4

Penning-Rowsell E., P. Winchester, and G. Gardiner, 1998. New approaches to sustainable hazard management for Venice. The Geographical Journal, v. 164, n.1, pp. 1-18.

Penning-Rowsell E., 1997. A General Model for Promoting the Integration of National Natural Resources Management, GeoJournal, v. 43, n. 3, pp. 247-262.

Penning-Rowsell E., C.H. Green, P.M. Thompson, A. Coker, S.M. Tunstall, C. Richards, and D.J. Parker, 1992. The Economics of Coastal Management—A Manual of Benefit Assessment Techniques. Belhaven Press, London, UK, 140 pp.

Pfeiffer K.D, Knauth H.D., Schröder F., Nies H., Grisard K., 1998. The MERMAID-OPMOD System A Flexible System and Application Approach for Management and Sustainable Development of Exclusive Economic Zones, EEZ Technology, ICG Publishing n. 3, London, pp. 183-188

Pilarcyzk, K.W. (ed.), 1990. Coastal Protection. Balkema, Rotterdam, The Netherlands, 500 pp.

Plant, N.G. and R.A. Holman, 1997. Intertidal beach profile estimation using video images. Marine Geology, v. 140, n. 1–2, pp. 1–24.

Rautalahti-Miettinen E., Ripatti V., 1998. Development of Environmental Awareness, Workshop on Education and Learning for Sustainable Consumption, 14-15 September, OECD Headquarters, Paris.

Ruth, M. and J. Lindholm. 1997. Dynamic Modelling of Multispecies Fisheries for Consensus Building and Management, Environmental Conservation, Vol 23, No. 4, pp. 332-342.

Science and Technology Awareness Network, 1998. “Planning and Implementing Science Awareness Activities”, Centre for Marine Geology, Dalhousie University, Halifax, CA, 90 pp.

Shen J., Kuo A.Y., 1998. Application of Inverse Method to Calibrate Estuarine Eutrophication Model, Journal of Environmental Engineering, v. 124, n. 5, pp. 409-418.

Smith System Engineering, 1997. “EO data utilisation: requirements of the civil engineering industry”, Final report CA277D020/1.1, 97 pp.

(STAN) Science and Technology Awareness Network, 1998: Planning and Implementing Science Awareness Activities. Centre for Marine Geology, Dalhousie University, Halifax, Canada, 90 pp.

Staples G.C., Nazarenko D.M., Freeberg M.H., 1997. Coastal Zone Monitoring with RADARSAT, Sea Technology, v. 38, n. 8, pp. 27-30.

Stockdale, G, 1996: Federal technology transfer-oceans of opportunity for industry. MTS Journal, v. 30, n.3, pp. 40–42.

Stone G., Kraus S., Hutt A., Martin S., Yoshinaga A., Joy L., 1997. Reducing By-Catch: Can Acousting Pingers Keep Hector’s Dolphins Out of Fishing Nets?, MTS Journal, v. 31, n. 2, pp. 3-7.

Thomas L.W., Wischmann S.M., 1998. A Technological Solution to the Challenges of Better Management of Complex Environmental Incidents, EEZ Technology n. 3, ICG Publishing, London, pp. 189-192

Thompson P.M., Sultana P., 1996. Embankment Options and Uses to Reduce Maintenance Problems, ICID Journal, v. 45, n. 2, pp. 93-107.

Tol, R.S.J, R.J.T. Klein, H.M.A. Jansen, and H. Verbruggen, 1996. Some economic considerations on the importance of proactive integrated coastal zone management. Ocean & Coastal Management, v. 32, n. 1, pp.39–55.

Turner R.K., W.N. Adger and I. Lorenzoni, 1998. Towards Integrated Modelling and Analysis in Coastal Zones: Principles and Practices. LOICZ Reports and Studies No. 11, IGBP/LOICZ, Texel, The Netherlands, iii+122 pp.

Turner, R.K. and W.N. Adger, 1996. Coastal Zone Resources Assessment Guidelines. LOICZ Reports and Studies No. 4, IGBP/LOICZ, Texel, The Netherlands, iv+101 pp.

Vallega A., 1992. "Sea Management - A Theoretical Approach", Elsevier Applied Science, pp. 259.

Verhagen, H.J., 1989: Sand waves along the Dutch coast. Coastal Engineering, v. 13, n. 2, pp. 129-147.

Verrone, 1996. Sea level in the Mediterranean: a first step towards separating crustal movements and absolute sea-level variations. Global and Planetary Change, v. 14, n. 1–2, pp. 1-48.

Von Alt C., De Luca M.P., Glenn S.M., Grassle J.F., Haidvogel D.B., 1997. LEO-15: Monitoring & Managing Coastal Resources. Sea Technology, v. 38, n. 8, pp. 10-16.

Voronovich, A. G. and V. Goncharov, 1993. An experiment on matched field acoustic tomography with continous wave signals in the Norway Sea, J. Acoust. Soc. Am., vol. 93, pp. 1873-1881

Uljee I., Engelen G., White R., 1996. *RamCo -Demo Guide - Version 1.0*. Work-document CZM-C 96.08, Coastal Zone Management Centre, The Netherlands, pp. 63.

UNESCO, 1996. “Oceanographic Survey Techniques and Living Resources Assessment Methods”, IOC Manuals and Guides No. 32, 35 pp.

(USACE) U.S. Army Corps of Engineer, 1999. Automated Coastal Engineering Software, Waterways Experiment Station, Coastal & Hydraulics Laboratory, http://chl.wes.army.mil/software/aces/

(USACE) U.S. Army Corps of Engineer, 1998. “Considerations for planning nearshore placement of mixed dredged sediments”, Waterways Experiment Station, Technical Note DOER-N3, Vicksburg, MS.

(USACE) U.S. Army Corps of Engineer, 1999, SHOALS, Waterways Experiment Station, http://shoals.sam.usace.army.mil/

(USAEC) U.S. Army Environmental Center, 1999. Army Environmental Requirements and Technology Assessments (AERTA), Pollution Prevention & Environmental Technology Division http://aec-www.apgea.army.mil

Woods H., Dahlin L., Droppert M., Glass S., Vallerga S. And Flemming N.C., 1996. ”The Strategy for EuroGOOS”, EuroGOOS Pub. No. 1, Southampton Oceanography Center, Southampton.

WCC’93, 1994: Preparing to Meet the Coastal Challenges of the 21st Century. Report of the World Coast Conference, Noordwijk, The Netherlands, 1–5 November 1993, Ministry of Transport, Public Works and Water Management, The Hague, The Netherlands, 49 pp. + apps.

Wensink G.J., Campbell G., 1997. Bathymetric map production using the ERS SAR, *Backscatter*, The Magazine for the Marine Remote Sensing Community, v. 8, n. 1, pp. 17-22.

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APPENDIX A
RELATIVE IMPORTANCE OF REMOTE SENSING IN THE SHORT TERM AND LONG TERM

SECTOR	ISSUE	ST	LT
Knowledge and Management	**(Ocean and coastal environment)**		
Marine sciences	identifying and understanding the ocean systems, their behaviour and interactions, including coastal zones and open seas;	♦ ♦	♦ ♦
	understanding the mutual interactions between ocean, atmosphere, geosphere and the anthropic activities and the role of the oceans in the global climate;	♦	♦ ♦
	improving ocean observations and the oceanic component of climate prediction models to reduce uncertainties in predicting future changes	♦	♦ ♦
Ocean and coastal management	protecting the oceans, seas, estuaries, coasts and their wildlife from physical degradation and pollution,	♦ ♦	♦
	monitoring and improving their morphology, quality and biological productivity,	♦ ♦	♦
	conserving, managing (and exploit) their natural resources	♦	♦
	managing emergencies caused by both natural and man related events	♦ ♦	♦
Exploitation of Marine Resources	**(Offshore Hydrocarbons)**		
Exploration	collecting seismic and geological data for subsea hydroc. basins assessment		♦
	identifying and sampling promising areas by spot drilling (wild cat wells)		♦
	locating, delimiting and estimating reservoirs by appraisal drilling, pressure and temperature measurements and flow capacity testing		♦
Drilling, Production		♦	♦
Offshore storage & offloading	short term accumulation of product to allow continuous production with intermittent ship transport,	♦ ♦	♦
	medium-long term accumulation of gas to allow a suitable strategic reserve.	♦	♦
	long term accumulation of by-product gas in view of delayed production.	♦	♦
Sealine transport	transporting hydrocarbons products to shore.	♦ ♦	♦
Shipping	transporting oil or gas, as LNG or NGL, in an easily marketable and flexible phase, suitable for long distance and diversified destination.	♦ ♦	♦
Exploitation of Marine Resources	**Other marine resources**		
Energy exploitation	producing energy by exploiting clean, renewable sources, with balanced, environmentally compatible approach and technologies,		♦
	assuring suitable low overall cost energy to remote social communities.		♦
Inorganic resources exploitation	assessing the extension and properties of minerals/metals rich sediments, encrustations and waters, to exploit valuable resources		♦
	performing production tests to validate exploitation technologies and costs,		♦
	producing minerals from natural beds on or underneath the sea bottom		♦
	extracting metals and useful inorganic substances from sea water.		♦
Biological resources exploitation	assessing the productivity of biomass of sea water basins and areas,	♦	♦
	monitoring fish flocks movements, to improve catches,	♦ ♦	♦
	fishing, within proper limits to preserve ecosystems and natural capacity,	♦ ♦	♦
	grow fish and biomass in artificial or protected conditions (mariculture).	♦ ♦	♦

SECTOR	ISSUE	ST	LT
Ocean Space Utilisation	**Maritime transports**		
Ports & infrastructures	providing services and structures for the management, preservation, accommodation or local transport of goods and passengers, including connection with internal navigation network and other transportation networks.	♦	♦ ♦
Carriers	transporting goods of various nature and passengers through sea surface.	♦	
Traffic control	preventing accidents (collisions) and consequent human lives losses and damage to environment,	♦ ♦	
	monitoring and planning traffic for safe and optimum transports economics.	♦ ♦	♦
Ocean Space Utilisation	**Industrial Activities at Sea**		
Communications	cable communications across seas and oceans.		♦
Power generation and transport	locating conventional power generation plants at sea, to avoid space loss in congested areas		♦
	transporting electric energy through long distances across seas and oceans,		♦
	converting electric energy in energy intensive materials.		♦
Wastes treatment and disposal	offshore disposing of large quantities of urban and industrial wastes far from inhabitated areas, by environmentally compatible methods,	♦	♦
	offshore disposing of dangerous, long decay materials (chemical or radioactive) in self-protected and shielded formations, by environmentally compatible methods.		♦
Hazardous activities	transferring to sea any activity creating safety or health problems on land..		♦
Freshwater supply	producing potable and industrial waters from sea water or subsea freshwater springs,		♦
	transporting freshwater across seas.		♦
Marine biological resources processing	on site processing of raw marine biomass and fishes into marketable or intermediate products (pharmaceuticals, chemicals, fodd, etc.)to optimize economics (transport of lower tonnage of high value goods), quality and variety of sale products.	♦ ♦	♦
Marine laboratories & test facilities	performing in real environment under controlled conditions scientific or technological experiments.	♦ ♦	♦
Ocean Space Utilisation	**Civil Activities at Sea**		
Urbanization	expanding congested coastal urban communities (living quarters and/or commercial and health services) to nearshore and offshore facilities ("ocean towns"), to preserve land environment for recreation and contain demographic density.		♦
Leisure and education	increasing common knowledge and enjoyment of the sea by more direct or closer visual contact.	♦	♦
Waterfront protection	preserving coastal manmade environments from natural degradation phenomena, either in the long (greenhouse induced effects) or in the short term.	♦ ♦	♦ ♦
Rail/road transports	establishing not existing transport links through sea or inner waters,		♦
	increasing the capacity of existing transport links between lands facing water areas.		♦
Air transports	offshore expanding or establishing air links and related services in areas affected by land shortage.		♦

APPENDIX B
FIRST 20 RANKED VARIABLES FOR CATEGORIES
(THE EUROGOOS MARINE TECHNOLOGY SURVEY, 1998)

Category A Instruments and Sensors		Category D Data Trasmission		Category E - In Data Input to Numerical Models		Category E - Out Data Output From Numerical Models		Category F Data Products	
No.	Name	No.	Name	No.	Name	No.	Name	No.	Name
001	Sea surface temperature	001	Sea surface temperature	016	Hourly mean sea level – Instantaneous	016	Hourly mean sea level - Instantaneous	001	Sea surface temperature
003	Current Velocity	011	Wave height	118	Suspended sediments	013	Wave swell	008	Sea surface salinity
016	Hourly mean sea level - Instantaneous	012	Wave Period	152	Wind speed	118	Suspended sediments	097	Chlorophyll & Fluorescence
097	Chlorophyll & Fluorescence	016	Hourly mean sea level - Instantaneous	001	Sea surface temperature	010	Wave direction spectrum	011	Wave height
011	Wave height	003	Current Velocity	002	Sea surface Wind speed or direction	011	Wave height	003	Current Velocity
079	Bathymetry	098	Nitrate	003	Current Velocity	009	Wave spectrum	016	Hourly mean sea level - Instantaneous
008	Sea surface salinity/CTD	100	Oxygen	008	Sea surface salinity	003	Current Velocity	010	Wave direction spectrum
027	Upper ocean salinity	099	Phosphate	153	Wind direction	033	Salt transport	012	Wave Period
012	Wave Period	002	Sea surface Wind speed or direction	151	Atmospheric pressure	012	Wave Period	004	Current Direction
004	Current Direction	137	Year-long time series	010	Wave direction spectrum	001	Sea surface temperature	098	Nitrate
100	Oxygen	004	Current Direction	011	Wave height	038	Surface currents	002	Sea surface Wind speed or direction
118	Suspended sediments	072	Deep ocean salinity	005	Heat flux	106	Artificial radionuclides	101	Silicate
071	CTD sections	101	Silicate	007	Precipitation	098	Nitrate	118	Suspended sediments
121	Transmissivity	152	Wind speed	092	Stratification	110	PAHs	109	Trace metals
152	Wind speed	155	Air temperature	013	Wave swell	104	Pathogens	009	Wave spectrum
151	Atmospheric pressure	151	Atmospheric pressure	155	Air temperature	107	Petroleum hydrocarbons	020	Oceanic tides
009	Wave spectrum	097	Chlorophyll & Fluorescence	097	Chlorophyll & Fluorescence	111	Pharmaceutic al wastes	100	Oxygen
153	Wind direction	071	CTD sections	071	CTD sections	008	Sea surface salinity/CTD	108	Pesticides & Herbicides
155	Air temperature	020	Oceanic tides	004	Current Direction	109	Trace metals	099	Phosphate
010	Wave direction spec	008	Sea surface salinity/CTD	120	Depth of photic zone	036	Upper ocean velocity fields	013	Wave swell

APPENDIX C
NATURAL RESOURCES AND RESTORATION ACTIONS (ADAPTED FROM NOAA, 1996)

Type of Action	Object of Interest	Detailed Action
1. Natural Recovery - Monitoring		Monitoring
2. Direct Restoration	*a. Direct Habitat Restoration*	Contaminant Removal Reconstruction Replanting Accelerated Degradation Monitoring Maintenance
	b. Direct Resource Restoration	Restocking Harvest Alteration Enhancement Monitoring Maintenance
3. Rehabilitation	*a. Habitats*	Contaminant Removal Reconstruction Replanting Accelerated Degradation Monitoring Maintenance
	b. Resources	Stocking Harvest Alteration Enhancement Monitoring Maintenance
4. Replacement	*a. Habitats*	Enhancement Creation Monitoring Maintenance
	b. Resources	Reconstruction Replanting Accelerated Degradation Monitoring Maintenance
	c. Non-biological Services	Recreational Commercial Cultural
5. Acquisition of Equivalent Resources		Zoning Acquire Property Rights Protection or Management
6. Combination of the Above		

APPENDIX D
RENATURALISATION INTERVENTIONS FOR THE PO DELTA (CAPOBIANCO, 1996)

#	Objective
1	**Diversification of emerged areas level**
1.1	Variation in the water levels; i.e. increase morphological variability.
1.2	Return some agricultural land which is currently below sea level to a more natural wetland status and/or to a lagoonal status if possible (see also 5). Such result might be achieved through controlled diversion of Po river branches.
1.3	Building of new emerged surfaces, partly seasonally submitted to floods. In this way the pattern of vegetation settlement would diversify, giving origin to varied micro-habitats. The resulting situation will be less sensitivity to relative sea level rise and of remarkable value for vegetational diversity and fauna as well.
1.4	Splitting by means of banks some portion of the valli to be restored
2	**Restoration and Maintenance of Beach and Dune Systems**
2.1	Beach and Dune systems are of critical importance because they protect natural habitats as well as developed areas
2.2	Plans should be implemented to manage Beach and Dune Systems. Natural sediment transport dynamics should be used at the largest possible extent to allow for the feeding of the sediment starved areas. Sediment redistribution from the prograding areas should be incentivated.
3	**Restoration of valli inland waters**
3.1	Bringing in waters with different salinity level in precise portion of the valli, would increase the habitat intrinsic variety.
3.2	The recovery plans for eutrophic valli foresee three phases: drainage - which involve the drastic reduction of micro-algae populations; planting secondary elofites and submerged hydrofites, so increasing the oxigenation; at the same time flooding with water not as rich in nutrients, in order to start new natural processes.
4	**Interventions of naturalistic re-qualification**
4.1	Naturalistic restoration of those "natural areas" located on or near the coast. Coastal erosion and accretion is an important factor for their evolution. Conversely natural areas have their effect on coastal evolution.
4.2	Unfortunately, measures taken to recover the area are not always carried out with careful attention paid to the requirements of the vegetation.
4.3	Breaking the banks and removing the sand from the fossil dunes as building material not only damages the vegetation that has already settled there, but hinders future settlements because the soil is impoverished of the organic substances present in the upper layers.
4.4	Variations in the water supply in the wetlands prevent the consolidation of the stable communities in favour of the floating consortia with rapid development.
4.5	Eutrophication, especially in brackish basins, causes blooms of microalgae with subsequent phenomena of anoxia, turbidity of the water, organic decomposition and increase in temperature, that are all harmful for the communities of submerged macrophytes.
4.6	If the vegetation of partially flooded ground is not moved, this favours silting up, which is to be avoided in certain cases in order to maintain diversity.

#	Objective
5	**Reorganisation and preservation of the coastal vegetation.**
5.1	The coastal strip requires a definitive organisation so that the sections that are destined for tourism do not increase further and remove other areas to the vegetation, and also to avoid what happened in the past, with attempts at building ports or tourist villages which were never completed, but whose impact affected only the natural habitat. In this way it will be possible to carry out measures to recover the natural aspect of certain coastal dunes by implanting edifying herbaceous species and subsequently triggering natural dynamic processes. The following sites are potential sites for the above mentioned operations: the shoals found to the north-east of the Venetian Delta (Scanno del Palo, Gallo, Barbamarco), the beach to the north of the Lido di Volano and the one near the coast at Bellocchio.
5.2	An accurate control should be carried out at the Scannone di Goro in order to maintain its natural dynamics, which proceed at a considerable rhythm: avoid granting easy access to private individuals, which might cause even greater alterations.
6	**Improving environmental conditions that are favourable to spontaneous vegetation in the lagoons and valleys inland. Reduce/remove any animal competitors.**
6.1	It is necessary to improve the quality of the water in certain lagoons; the measures include a plan to temporarily drain several valleys, carry out an artificial implant of macrophytes and then flood them with good quality water in order to eliminate microalgae.
6.2	The above mentioned sites with vegetation whose dynamics are not lasting, require regular mowing in order to maintain its characteristics: continue the management by the farms that are entrusted with this task.
6.3	It is advisable to eliminate the nutria throughout the territory, since this species is foreign to the indigenous fauna and its harmfulness has been demonstrated both as regards the vegetation and the avifauna, as well as the stability of the embankments!!!
7	**Wetland restoration**
7.1	Whenever the socio-economic balance of the uses of water is achieved, thus leading to a stabilized flow of water that allows for certainty and "natural regularity" in the maintenance of the level of the water table, there are opportunities for wetland restoration that can be foreseen or simply disregarded by the legal system. At the same time, the practice of using artificial wetlands as flood prevention tool, or as a means of cleaning up run-off pollution (typically fertilizer agricultural run-off or parking waste oils run-off), is increasing everywhere.
7.2	Wetland destruction due to irrigation projects should be prevented through a serious socioeconomic cost-benefit analysis imposed in the legislation instead of mandating the restoration of the wetland if the irrigation project fails.
7.3	The fostering of flood control in wetland restoration, or even creation, seems an alternative worthy of encouragement (never imposed) by the flood control legislation, so that public funds, otherwise necessarily channelled towards classical public works, can be considered to be dedicated to wetlands creation-restoration techniques that might enhance their total number in order to achieve a "no net loss" policy.
8	**Diversion of river branches**
8.1	The introduction of local diversion in the terminal part of some of the river branches could in principle be considered as a mean to achieve a quick redistribution of sediment. Additional benefits could be the direct achievements of many of the above mentioned objectives.
8.2	The needs of flood protection objectives should be particularly taken into account. In addition the possibility to speed up water discharge during river floods could also be beneficial for the plain.

APPENDIX E
INTERNATIONAL AGREEMENTS/CONVENTIONS INFLUENCING THE ADOPTION/USE OF TECHNOLOGIES

1. OECD Council Recommendations

Promotion of monitoring technologies could come also from OECD recommendations. On 23 July 1992, the Council of the OECD adopted a set of recommendations to its Members on integrated coastal zone management. In making these recommendations, the OECD Council reiterated that coastal zones and the oceans are areas where improved policy integration is necessary through integrated resource management strategies and comprehensive land use planning. "RECOMMENDS that, in view of the diverse and often conflicting uses of and pressures on coastal zone resources, Member countries should employ policy instruments, individually or in combination, in integrated coastal zone planning and management, including:

- Collection and updating of relevant information, and development of coastal environment indicators to guide planning and monitoring of coastal zone activities and processes;
- Establishment of environmental objectives for: land use planning and zoning, coastal waters planning, (including inland waters, semi-enclosed seas, estuaries) conservation requirements, ecosystem protection and restoration, discharge limits, water quality for receiving waters and waters flowing into the coastal zone, and control and reduction of inputs from polluting and hazardous substances;
- Establishment and maintenance of monitoring and enforcement procedures for environmental objectives and targets;
- Environmental assessment incorporating economic and social criteria;
- Public education and participation in decision-making at an early stage of policy formulation and project assessment, and adoption of wider public participation procedures;
- Application of regulations and economic instruments within the framework of the Polluter-Pays Principle, and pricing coastal zone resources to reflect social costs of use and depletion;
- Where appropriate, enactment of national legislation to enforce coastal zone management objectives;"

2. London Convention

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, as amended (London Convention).
The intention of this convention is to prevent pollution of the marine environment through the dumping of waste materials at sea. The convention identifies specific controls for selected wastes and the methods of their disposal. It should be noted that the convention does not directly address the reduction of land-based marine pollution at source.

3. MARPOL 73/78

The International Convention for the Prevention of Marine Pollution from Ships 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78).
This convention is the most comprehensive global treaty covering marine pollution from ships. Specific details of the convention include regulations governing :

- Annex I: oil pollution (dirty ballast waters, fuel residues, etc.);
- Annex II: pollution by noxious liquid substances in bulk;

- Annex III: pollution by harmful substances in freight or packaged forms;
- Annex IV: pollution from ship-generated sewage;
- Annex V: pollution from ship-generated litter and garbage.

The convention also identifies “Special Areas” where stricter methods for prevention of marine pollution must be applied. Special areas are designated on technical, ecological or oceanographical reasons and include the Baltic, Mediterranean, North, Red, Black and the wider Caribbean Sea areas, the Antarctic Ocean, the Gulf of Aden and the Persian Gulf area. However, due to lack of reception facilities, this “Special Area” status is not in force in all of the mentioned areas.

4. OPRC Convention

The International Convention on Oil Pollution Preparedness, Response and Co-operation 1990 (OPRC Convention).
This convention was initiated because of the severe local damage that can be caused by routine operational oil spills and major accidents and their all too frequent occurrence. Obligations of contracting parties include preparation of:

- oil pollution emergency plans for tankers and other ships, offshore gas or oil platforms, seaports and oil handling facilities;
- a national contingency plan having designated national authorities and operational focal points for oil spill management;
- national and regional (where possible) systems for preparation and response to oil pollution incidents;
- oil spill combating equipment;
- a programme of exercises for response organisations and training of relevant personnel;
- co-operation and mutual assistance programmes;
- bilateral or multilateral co-operation plans;
- research and development programmes.

5. Other International Conventions

Other international conventions or instruments having bearing on the marine environment are:

- 1969 International Convention on Intervention on the High Seas in Cases of Oil Pollution Casualties
- 1969 International Convention on Civil Liability for Oil Pollution Damage (CLC)
- 1971 International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND)
- 1973 Protocol Relating to Intervention on the High Seas in Cases of Pollution by Substances other than Oil — London, 2 November 1973 (in force, 1983 —amended in 1991, amendments in force)
- 1982 United Nations Convention on the Law of the Sea (UNCLOS) —Montego Bay, 10 January 1982 (in force, 1994)
- 1985 Montreal Guidelines for the Protection of the Marine Environment against Pollution from Land-based Sources, Montreal, 24 May 1985 (surpassed by entry into force of UNCLOS III)
- 1989 International Convention on Salvage (SALVAGE)
- 1992 Framework Convention on Climate Change, New York, 9 May 1992
- 1992 Convention on Biological Diversity, Nairobi, 24 May 1992

6. Maritime Safety Conventions

The following maritime safety conventions through their regulations, codes and guidance contribute significantly to the prevention of marine pollution:

- 1972 Convention on the International Regulations for Preventing Collisions at Sea (COLREG)
- 1974 International Convention for the Safety of life at Sea (SOLAS) as amended and as modified by the Protocols of 1978, 1988 and 1992
- 1978 International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), being amended in 1995

7. The Regional Seas Programme

Regional action plans, adopted at inter-governmental meetings, are the backbone of the Regional Seas Programme. Since the Programme was launched in 1974, ten regional action plans for the protection and development of specific marine and coastal areas have been adopted: Mediterranean (1975), Red Sea and Gulf of Aden (1976), Gulf (1978), Wider Caribbean (1981), East Asian Seas (1981), South-East Pacific (1981), West and Central African (1981), South Pacific (1982), Eastern African (1985) and Black Sea (1992) regions.
The structure of the action plans follows the framework adopted by the United Nations Conference on the Human Environment (Stockholm 1972) for the Action Plan for the Human Environment and consists of three basic components:

- environmental assessment (evaluation and review, research, monitoring, information exchange);
- environmental management (goal setting and planning, international consultation and agreements); and
- supporting measures (education and training, public information, technical co-operation, organisation, financing).

In spite of the formal similarity of the action plans, they are highly specific in their details to respond to the actual problems, priorities, needs and capabilities of the participating countries.
The explicit goal of all action plans is the protection and development of the environment and resources in geographic areas covered by the action plans. This goal is to be achieved, gradually, through a cross-sectoral approach taking into account the urgency of the problems as perceived by the relevant governments and their capacity (financial, manpower, institutional) to tackle the problems in a realistic way.

The initial focus was on marine pollution monitoring, assessment and, later, control which was assigned a high priority and required a harmonised regional policy and strategy. However, the common experience of all action plans soon confirmed that inappropriate development was at the roots of most environmental problems, and that lasting environmental protection is inseparable from social and economic development. As a result, the focus of the action plans gradually shifted — but still not very evident — from pollution control to integrated coastal zone planning and management. Information exchange, training, technical assistance and regional co-operation projects are seen as important components of the action plans.

Each convention is supplemented with at least two protocols dealing with specific problems such as co-operation in cases of pollution emergencies, control of pollution from dumping and land-based sources and protection of endangered species and ecologically sensitive areas. For the purpose of the protocols on control of pollution from land-based sources and on protection of endangered species and sensitive areas, the convention areas have been enlarged to include internal waters, up to the freshwater limit, as well as specific selected coastal areas.

8. The Mediterranean Action Plan

The Mediterranean action plan is probably the best known of the Regional Seas Programmes because it is the oldest and most mature. The Mediterranean action plan, although not typical of all action plans serves to illustrate the development, achievements, problems and failures of the wider Programme.

By the early 1970s, it was agreed, generally, that the environmental problems of the Mediterranean basin required urgent attention and that solutions should be sought through the international co-operation of all 18 coastal states. Therefore, in 1973, the Mediterranean was selected by UNEP to test the regional approach to the protection of marine areas.

In spite of considerable differences in political and socio-economic systems and levels of development it proved relatively easy for 17 of the Mediterranean's coastal states to reach agreement on an action plan (Albania did not join until 1990). This plan specifically called for:

- integrated planning of the development and management of theresources of the Mediterranean basin;
- co-ordinated programme of research, monitoring and exchange of information; and
- development of a framework convention and related protocols.

Shortly after the adoption of the action plan the Co-ordinated Mediterranean Pollution Monitoring and Research Programme (MED POL) was launched to provide the assessment of the sources, levels and effects of pollutants on a continuous basis. The programme was based on networks of national institutions and on an agreed common methodology. The number of institutions participating in the network has grown and, today, the programme has more than eighty active members.

Less than two years after it was signed, the convention and the two protocols entered into force, and today 20 Mediterranean countries and the CEC are parties to them. In June 1995, the Conference of Plenipotentiaries to the Barcelona Convention adopted further amendments to the Convention and to the Dumping Protocol, as well as a new Protocol concerning Specially Protected Areas and Biological Diversity. There are now 5 protocols to the Barcelona Convention.

The assessments carried out after the adoption of the Mediterranean Action Plan (MAP) revealed that land-based sources were the single most significant source of pollution. As a result, negotiations for an additional protocol on approaches to curb pollution from land based sources was initiated in 1977. The negotiations proved to be lengthy and difficult, as they touched on the sensitive subject of economic development, transfer of technologies, and mutual assistance.

While recognising the need for urgent action, the developing countries rightly felt that the developed countries, which contribute about 80 per cent of the Mediterranean's land-based pollution load should not restrict legitimate development goals of the developing country partners. The protocol was finally adopted and signed (Athens 1980) by 12 Mediterranean countries and the CEC and entered into force in 1983 and today 16 Mediterranean countries (all except Lebanon and Syria) and the CEC are parties.

In parallel with the efforts to deal with the problems related to marine pollution, another protocol dealing with specially protected areas was signed (Geneva, 1982). Large scale study of existing and expected Mediterranean development, the Blue Plan, was undertaken; and a series of projects were initiated as part of the action plan's Priority Action Programme. They dealt with subjects such as; soil protection, tourism, rehabilitation of historic settlements, freshwater resource development, solid and liquid waste disposal, renewable sources of energy, aquaculture, environmental impact assessment, coastal zone planning and management.

At the June 1995 Conference of Plenipotentiaries to the Barcelona Convention, MAP Phase II was designed, taking into account the achievements and shortcomings of MAP's first twenty years of existence. The Parties also adopted Priority Fields of Activities for the Environment and Development in the Mediterranean (1996-2005) as an appendix to the Barcelona Resolution on the Environment and Sustainable Development in the Mediterranean Basin.

APPENDIX F
LIST OF POSSIBLE DREDGING ACTIVITIES

The Selection of proper dredging and transport equipment and techniques must be compatible with disposal site and management requirements. Three major alternatives are available (EPA, 1994): (i) Open-water disposal; (ii) Confined disposal; (iii) "Beneficial use".

Each of the major alternatives involves its own set of unique considerations, and selection of a management alternative should be made based on environmental, technical, and economic considerations (USACE, 1998).

Open-water disposal is the placement of dredged material in rivers, lakes, estuaries, or the sea via pipeline or release from hopper dredges or barges. Such disposal may also involve appropriate management actions or controls such as capping. The potential for environmental impacts is affected by the physical behaviour of the open-water discharge. Open-water disposal sites can be either predominantly nondispersive or predominantly dispersive. At predominantly nondispersive sites, most of the material is intended to remain on the bottom following placement and may be placed to form mounds. At predominantly dispersive sites, material may be dispersed either during placement or eroded from the bottom over time and transported away from the disposal site by currents and/or wave action. However, both predominantly dispersive and predominantly nondispersive sites can be managed in a number of ways to achieve environmental objectives or reduce potential operational conflicts.

Confined disposal is placement of dredged material within diked nearshore or upland confined disposal facilities (CDFs) via pipeline or other means. CDFs may be constructed as upland sites, nearshore sites with one or more sides in water (sometimes called intertidal sites), or as island containment areas.

Beneficial use includes a wide variety of options which utilise the material for some productive purpose. Dredged material is a manageable, valuable soil resource, with beneficial uses of such importance that they should be incorporated into project plans and goals at the project's inception to the maximum extent possible. Ten broad categories of beneficial uses have been identified, based on the functional use of the dredged material or site. They are:

- Habitat restoration/enhancement (wetland, upland, island, and aquatic sites including use by waterfowl and other birds).
- Beach nourishment.
- Aquaculture.
- Parks and recreation (commercial and noncommercial).
- Agriculture, forestry, and horticulture.
- Strip mine reclamation and landfill cover for solid waste management.
- Shoreline stabilisation and erosion control (fills, artificial reefs, submerged berms, etc.).
- Construction and industrial use (including port development, airports, urban, and residential).
- Material transfer (fill, dikes, levees, parking lots, and roads).
- Multiple purpose.

APPENDIX G
LINKS TO RELEVANT EU SITES

Looking at coastal research initiatives, ELOISE (European Land-Ocean Interaction and Shelf Exchange Studies) is an initiative of the ENVIRONMENT & CLIMATE and the MAST research programmes of DG XII of the European Commission, acting in concert with the programme of International Cooperation (INCO) of DG XII and the research programmes of the Member States. Focus is on the important question of how the land-ocean interaction operates and on how this is influenced by human activities.

Even if not strictly Coastal, it is also interesting to look at the "Human dimensions of environmental change" Area of the Environment and Climate Research Programme which includes research on the social and economic causes and impacts of environmental change with the aim “to assist in the formulation of the European Union's environmental policies and thus facilitate their implementation”.

Document Web address (updated February ’99)

EU Demonstration Programme on ICZM	**http://europa.eu.int/comm/dg11/iczm/home.htm**
CORDIS	http://www.cordis.lu/home.html
European Commission [searchable server]	http://europa.eu.int/geninfo/query_en.htm
European Commission DGXII (Research) [ongoing activities, various reference documents]	http://europa.eu.int/comm/dg12/index.html
Decision on the 5 thFramework Programme	http://www.cordis.lu/fp5
European Commission DG XI (Environment)	http://europa.eu.int/comm/dg11/index.html
European Commission DG XI (Environment) Directives	http://europa.eu.int/comm/dg11/docum/index.htm
Framework for Community Action in the Field of Water Policy	http://europa.eu.int/comm/dg11/docum/9749sm.htm
European Commission DG XIV (Fishery)	http://europa.eu.int/comm/dg14/dg14.html
EU policy on water quality	http://europa.eu.int/water/
Agriculture and environmental policy	http://europa.eu.int/comm/dg06/envir/index_en.htm
European Spatial Development Perspective and Cohesion policy	http://www.inforegio.cec.eu.int/wbdoc/docoffic/communic/envir/home_en.htm
European Environment Agency	http://www.eea.dk/
Convention on Biological Diversity	http://www.biodiv.org/chm/conv/default.htm
EC Seveso Directive	http://www.ess.co.at/HITERM/REGULATIONS/82-501-eec.html
OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic	http://www.ospar.org/
MARPOL (convention for the prevention of marine pollution from land-based sources	http://www.ifs.univie.ac.at/intlaw/konterm/vrkon_en/html/doku/marpol.htm
Conservation of natural habitats	http://europa.eu.int/comm/dg11/nature/habdir.htm

APPENDIX H
PROJECT VISITS

#	Where	What	When
1	Brussels	Project leaders workshop	September '97
2	Brussels	Thematic experts meeting	December '97
3	London	Thematic experts meeting	02 February '98
4	Brussels	Project leaders workshops	01-03 April '98
5	London	Thematic experts meeting	28 April '98
6	Lisbon	Thematic experts & Project leaders meetings	10-11 June '98
7	Ria de Aveiro	Joint Project Visit	12-13 June '98
8	Regione Abruzzo	Thematic experts seminar	8-11 July '98
9	Regione Abruzzo	Joint Project Visit	8-11 July '98
10	The Southern Coast of Finland	Joint Project Visit	5-9 August '98
11	Devon and Cornwall	Project Visit	20-21 August '98
12	Isle of Wight	Project Visit	19 August '98
13	Barcelona	Thematic experts meeting	16-18 Sept '98
14	Barcelona	Joint Project Visit	16-18 Sept '98
15	Bantry Bay	Project Visit	21-22 Sept '98
16	Göteborg	Thematic Experts meeting and ESDP/ICZM forum	25-28 Oct '98
17	Napoli	1st Terra Projects Meeting	5-6 Nov '98
18	Taranto	Project Visit	7-8 Nov '98
19	Cyclades	Project Visit	16 Nov '98
20	Strymonikos	Project Visit	17-18 Nov '98
21	Kavala	Project Visit	17 Nov '98
22	Palermo	Project Visit	2 Dec '98
23	Forth Estuary Forum	Joint Project Visit	10-12 Dec '98
24	Brussels	Final meeting Thematic Experts	22 January '99