Environmentally Friendly Coastal Protection
The ECOPRO Project

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Abstract

In the battle to preserve land against the ravages of the sea man has created many inappropriate protection structures on the coast. Often the coastline which is being protected is, inherently, in dis-equilibrium with nature. When combined with the increased recreational usage of the coastal zone, the rise in sea level and the increased incidence of storms, accelerated erosion rates are often the result. The Environmentally Friendly Coastal Protection project, or ECOPRO for short, developed a coastal erosion assessment method for the non-specialist. It devised a system for optimising erosion monitoring and developed a guide to select of an appropriate coastal protection response. The project results are contained in the ECOPRO Code of Practice. This 320-page guide explains the steps involved in assessing and monitoring coastal erosion problems, planning protective actions and evaluating their environmental impact. Prepared by the Offshore & Coastal Engineering Unit of Enterprise Ireland, it is the result of four years of work which was supported under the EU LIFE Programme and drew on expertise from Ireland, Northern Ireland and Denmark. This paper presents details of the project and the development of the Code.

1. Introduction

In recent years it has become accepted that the coastline is a valuable natural resource which needs careful and sensitive management. This is especially so in the case of small island countries where the coastal zone has a direct and major influence on the economic welfare of the country. Coastal erosion has always been seen as one of the main threats to this resource and for centuries man has been fighting what was perceived as the ravages of the sea.

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In the Republic of Ireland, following destructive storms in the late 1980's which caused severe damage and accelerated erosion rates, there was a perceived need to seriously address the question of coastal erosion. A National Coastal Erosion Committee, formed under the auspices of the County and City Engineers Association, produced a report in 1992 which concluded that a Coastal Management policy rather than a purely Coastal Erosion policy was needed. This report also recommended that 'A code of practice for coastal protection should be drawn up to ensure the uniformity and appropriateness of all works'.

Following an initiative by Enterprise Ireland, the late Professor Bill Carter of the University of Ulster and The Department of the Marine, a proposal was developed for a coastal protection and management demonstration project and was successful in obtaining funding under the E.U. Life Programme. Managed by Enterprise Ireland, the project team consisted of the Department of the Marine and a number of local authorities in the Republic of Ireland, the Department of the Environment and the National Trust in Northern Ireland, Coastwatch Europe, and the Danish Coastal Authority (Kystinspektoratet). Inputs were also be sought from Universities in the Republic and Northern Ireland and from private firms with particular expertise in this field.

The project aims were to develop a method for the assessment of coastal erosion, to devise a system for monitoring erosion and to optimise the selection of an appropriate response. The project was titled Environmentally Friendly Coastal Protection and as this suggests the emphasis was on using environmentally friendly coastal protection techniques (i.e. soft engineering) wherever possible so as to mitigate the impact of coastal protection measures on the environment. These techniques, such as marram grass planting, dune ridge re-contouring, sand trap fencing, beach nourishment, etc., attempt to emulate the natural coastal processes rather than directly oppose them.

The final product of ECOPRO is the Code of Practice on environmentally friendly coastal protection. The principle behind the Code is the need to maintain as far as possible the protection afforded by the natural features of the coast. A beach is natures response to erosion and is extremely effective in dissipating the energy of the sea. Therefore the objective should be to keep beaches in place. The sand dunes backing beaches are an integral part of the system and must be allowed to fulfil their natural function of acting as a buffer zone between land and sea.

This Code of Practice should be of considerable use as a guide to current best practice on coastal protection and management. It is hoped that it will avoid the instant palliative response to storm damage and also ensure that those involved in coastal protection first look at the soft engineering techniques. It was not intended that the code would attempt to supplant the technical manuals on the subject of coastal protection as it is not aimed at the coastal engineer. It is instead, to be used by the non-expert and, it is hoped, will help them to avoid making mistakes in their response to coastal erosion. The code also attempts to make the non-expert more aware of the fragility of the coastal environment and how complex and interrelated is the problem of coastal erosion.

2. Project Objectives

The specific objectives of 'ECOPRO' were:

1. To develop coastline monitoring methods which will be adaptable to various types of coastline.

2. To develop a Sensitivity Index by which a coastline's susceptibility to erosion is graded.

3. To present an assessment of performance of shoreline protection/management methods.

4. To present a report on the design, construction and success of two types of protection methods at selected sites.

5. To present all of the above as a 'Code of Practice'.

These five objectives form the five main tasks of the project. Each is dealt with in the Code of Practice with the exception of the Sensitivity Index. While a lot of work was carried out on this, particularly by the University of Ulster, the Danish Coastal Authority and a private company Natural Environment Consultants Ltd., the conclusion was that at the present time it was not possible to develop a practical index which would be usable by non-experts. The work carried out in this area has been reported on separately (Dollard, B., *et al*, 1996).

The overall aim of the project was to promote the use of soft engineering coastal protection techniques by firstly promoting a methodology which will allow the non-expert to assess the erosion problem and identify the likely causes. Secondly, it aimed to provide information on suitable coastal protection and management solutions with particular emphasis on environmental impact. Finally, the project intended to supply reference information on coastal processes and identify useful environmental and historical data sources.

3. Project Management

The project organisational structure is shown in Fig. 1. Enterprise Ireland was the overall Project Manager and was responsible for the day to day running of the project. The project was directed by the Steering Committee which was chaired by the Department of the Marine. The Technical Group provides the Committee with technical analysis of its proposals and drew up specifications for project work. It also drafted the progress and interim reports of work in hand.

The collaboration between the Universities, Government and local authority personnel and public volunteers was excellent and the multi-disciplined mixture of scientists, engineers and environmentalists ensured that most viewpoints were aired. The international dimension between the North and South of Ireland and Denmark helped to broaden our perspective. A successful visit to Denmark by the ECOPRO members, where a number of soft engineering coastal protection methods were viewed, was also very beneficial.

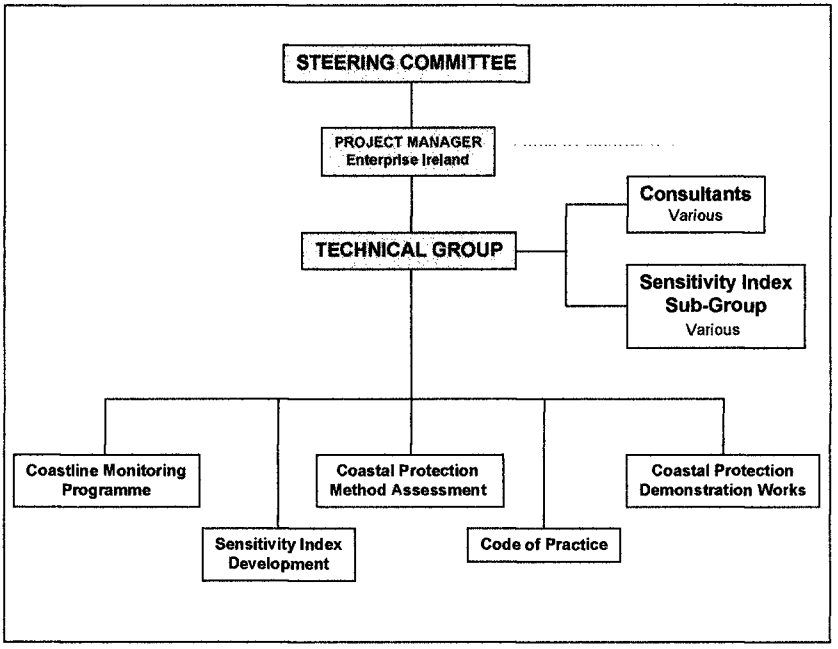

Fig. 1 Organisational structure of ECOPRO

4. Project Tasks Undertaken

4.1 Coastline monitoring

Project objective:

The objective of this work was to devise and test various coastline monitoring methods in order to optimise the time and money spent in obtaining data on coastline and beach level fluctuations. The resultant techniques were to be detailed in the ECOPRO Code of Practice.

Seven sites were chosen for detailed study and are shown in Fig.2. Each has a distinct soft coast and suffer from differing types of erosion. The extent of erosion also varies from place to place.

Coastline monitoring is a very important tool in assessing the sensitivity of the coast to erosion. There are two stages to monitoring the coast. Firstly, it was necessary to fix the present position of the coastline so that historical changes could be compared. This we termed the baseline survey. Secondly, regular monitoring of beach levels when compared with accurate environmental data gave an insight into the overall response of the beach to external forces. The results of these exercises were used in the assessment of the nature and cause(s) of the erosion problem.

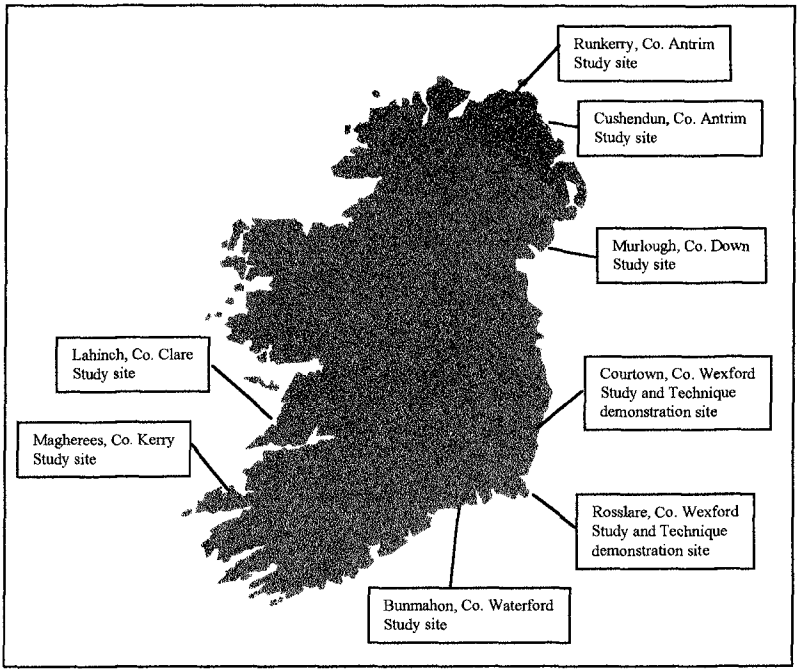

Fig. 2 - Location of ECOPRO study and technique demonstration sites

Baseline survey

This involved the association and comparing of the present day topography for the chosen embayment with the historical data. Under ECOPRO a number of methods were examined to try to fix the present position of the coastline at our seven sites as economically as possible. These were;

- Aerial video
- Aerial photography
- Satellite imagery
- Aerial digital CIR photography

ECOPRO commissioned an aerial video recording, of the entire coastline of the four ECOPRO counties in the Republic of Ireland and this was very useful as a source of information on land use and vegetation classification. Satellite imagery of the sites was also examined but the resolution from satellite imagery was not suitable for accurate erosion measurement.

Aerial photography was the most successful, although expensive. The colour, stereoscopic images, allowed the vegetation line to be easily identified and a height contour map, (0.5m contour interval) was prepared for one of the sites.

ECOPRO fixed the vegetation line for three of the ECOPRO study sites from commissioned aerial photographs. These were then compared with the position of the dune

toe line as given by the Ordnance Survey maps from 1841. A historical data search was conducted for four study sites and a list of sources along with practical information on the techniques are covered in the Code of Practice.

Aerial digital photography using an infrared filter was found to be the most economic technique for mapping large coastal areas. The imagery was easily stored on, and retrievable from, digital tapes or CD's and the infrared filters highlight the vegetation line and indicate the condition of the vegetation.

The methodologies involved in all of these methods are included in the Code of Practice

Beach level monitoring

Beach level monitoring is the measurement of vertical and horizontal erosion/accretion of beaches and nearshore bathymetry and the analysis of sediment. As with the baseline study, a number of different methods were employed to monitor the changes in beach levels. These were;

- Standard surveying techniques
- Cut-down monitors
- Measurements from fixed points (erosion questionnaire)
- Hydrographic surveys
- Sediment sampling

All seven study sites were monitored using either standard levelling or total station techniques and details are given in the Code of Practice. In order to facilitate the identification of which storm or event caused specific beach changes, ECOPRO initiated a programme of regular beach cut-down measurements. Measurements were taken every two weeks at each of the 16 monitor posts. This gave both the lowest beach level achieved and the amount of sand subsequently deposited on the beach. The Code of Practice includes details of this method and comments on its suitability.

Measurements from fixed points e.g. rocks, piers, etc. were also carried out at a number of sites as part of the Coastwatch Europe erosion questionnaire.

Hydrographic surveys

Hydrographic surveys were made at four sites. The bathymetry at a fifth site was measured on a regular basis to aid with the Sensitivity Index computer studies. Sediment sampling was carried out at the four Republic of Ireland sites. One of the Northern Ireland sites was regularly sampled, again as part of the Sensitivity Index work.

Data storage

ECOPRO opted for a custom built coastal data storage and display system SANDS (Shoreline and Nearshore Data System). Three packages were initially installed in the Department of the Marine, Enterprise Ireland and the Department of the Environment, Northern Ireland and later one copy was transferred to a Local authority, in order to determine its suitability for local data storage and analysis.

Wind and wave data

Offshore wind and wave data for 4 representative points around the island of Ireland was purchased from the UK Meteorological Office Wave Hindcast Model. This data covered a two year period. Storm data was obtained from the Irish weather service Met Éireann.

4.2 The Sensitivity Index

Project objective:

Gather together as much information on the factors that influence coastal erosion and 'weight' them accordingly. Based on these 'values' deduce the overall sensitivity of the coastline to erosion.

The background to this work was a paper written by V. Gornitz (Gornitz, V, 1990) who developed a simple scoring system which could be used to determine the vulnerability of coast to erosion. It was intended to be used on a large scale for isolated areas where it was not feasible or economical to collect accurate data. However, the ECOPRO group decided that for this method to be useful as an assessment tool and for its results to be used in the selection of protection methods it must be user friendly, accurate and on a scale that is practical. In addition the index should identify the causative factors of erosion as this will allow suitable protection to be prescribed. Fig. 3 lists the variables typically involved in coastal erosion.

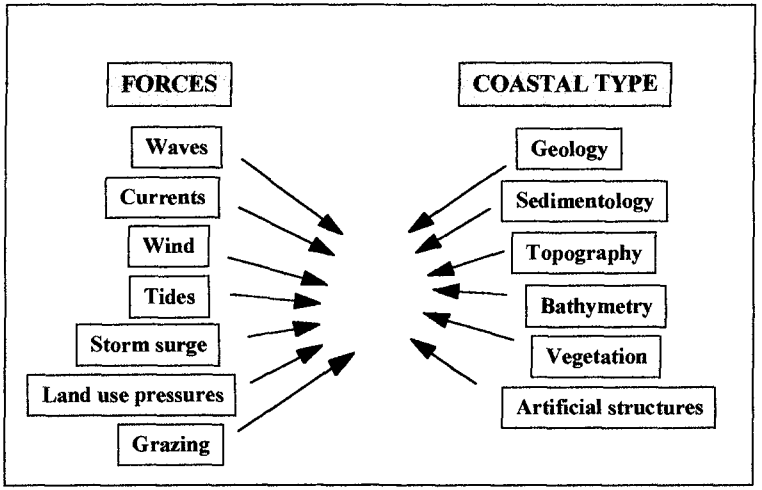

Fig. 3 Variables involved in coastal erosion

The ECOPRO group entrusted the Danish Coastal Authority (D.C.A.) (Kystinspektoratet) with the task of further developing Sensitivity Index method. The Environmental Studies Department of the University of Ulster was commissioned to examine the level of accuracy required of nearshore wave data for analysis of wave/sediment interaction. A private company, 'Natural Environment Consultants Ltd', who are specialists in coastal environment habitats, was also employed to carry out work on the dune vegetation condition aspect of the index. These three form a sub-group which reported on progress to the ECOPRO Technical group.

The ECOPRO group decided to tackle this work in two complementary stages. Firstly a method to calculate a general indicator of sensitivity needed to be devised. This was essentially an extension of the V. Gornitz work and would be useful as a first step assessment method by, for example, a local authority on the entire coast under its jurisdiction. The second stage was a refinement of the method based on the most accurate information available and on computed wave/sediment interaction data. This involved computer models, beach monitoring, vegetation classification, beach sediment analysis, wave and current measurement (or hindcasting). This method was used on short lengths of coast (typically 100m).

The prediction of sensitivity was correlated against historical and short term erosion trends and, thus, the index was fine tuned. Erosion rates usually vary across a coastal cell mainly due to the different levels of exposure of parts of the coastline to wave action. Modelling these processes using computers gives an indication of the sensitivity of the coast to erosion and when combined with other factors such as wind, geology and topography of the coastline, strength and regenerative ability of dune vegetation, beach sediment size, etc., an overall sensitivity grade was assigned. This was checked against historical records such as maps and aerial photographs and more recent beach level measurements.

Although the work on the index did not reach a stage where it was appropriate for inclusion in the Code of Practice, the exercise did provide some interesting results which could provide the basis for more extensive studies.

In order to satisfy the objective of this part of the project and to provide the users of the Code of Practice with an erosion assessment method it was decided to develop a technique using Field and Historical Survey decision support flowcharts. The result was a user friendly and practical approach to a complex problem and trials conducted by non-experts using the flowcharts have helped the ECOPRO team to refine the technique. Initial results are very encouraging but it is only when the method is more widely used will its full potential be realised.

4.3 Evaluation of coastal protection/management options

Project objective:

To examine current coastal protection measures being used and to evaluate their success. Each technique is to be summarised and included in the Code of Practice.

Once the nature of the erosion problem has been assessed, the method of protecting the coast needs to be decided. ECOPRO advocates the use of soft engineering options wherever possible. These attempts to work with the natural processes rather than oppose them. This approach often means that the shore zone is used as a buffer and must be wider than would be envisaged under conventional hard engineering schemes. An environmentally friendly scheme must often consider a certain amount of erosion as being beneficial, providing sediment interchange along the coast.

The ECOPRO Code of Practice identifies which type of erosion problems can be tackled with soft engineering and what particular method should be employed. 27 different coastal protection and management techniques are detailed in the Appendix of the Code.

In practice, the most commonly used protection methods are located in the lower and upper shore regions where most of the wave energy is absorbed. Lower shore techniques attempt to dissipate the incoming wave energy whereas upper shore techniques try to strengthen the existing natural structure. The supra shore or backshore and hinterland techniques assign land to act as a buffer against the sea. The most common form of these techniques is the use of set-back lines and this usually forms part of an overall Coastal Zone Management policy adopted by the relevant local authority. This involves the drawing of lines on maps by the local planning authority, seaward of which no new developments will be allowed and, more controversially, no attempt will be made to protect the existing land or buildings. This has two obvious advantages. Firstly, it almost eliminates the cost of coastal protection and secondly, it will reduce the demands for protection in the future. It does, however, raise the question of compensation to and also the longer term question of what to do when the buffer zone has been exhausted.

Many of these soft engineering techniques are not suited to exposed 'high energy' coastal areas where large waves impinge on the coast. Here, if protection is absolutely required, hard structures are necessary. General information on these and their likely impact on the environment is given in the Code of Practice.

The suitability of each technique is based on published literature and the results of a questionnaire survey of the Irish and Danish local authorities. Details of each technique are included in the Code of Practice and the experiences of the local authorities with the various methods is outlined.

4.4 Case histories of protection techniques

Project objective:

To give practical information on the design, implementation and monitoring of two different types of environmentally friendly coastal protection techniques.

One of the projects covered was a beach nourishment scheme in Rosslare Co. Wexford. Here 160,000m^3 of sand, dredged from offshore bars, was placed on the beach. This is the largest beach nourishment scheme carried out in Ireland to date.

The second was a small scale scheme involving the re-contouring of a sand dune ridge, marram grass planting and dune toe protection in Courtown Co. Wexford.

These two techniques are possibly the most popular soft engineering methods employed in Europe today. Practical information on both is included in the Code of Practice.

4.5 The ECOPRO Code of Practice

Project Objective:

To provide the non-expert with practical advice on how to identify the possible causes of marine erosion, select an appropriate response and how to evaluate its likely impact on the environment. Advice should also be given on coastal processes, data sources, monitoring techniques, legal implications and funding opportunities.

The layout of the code structure is shown in Fig. 4.

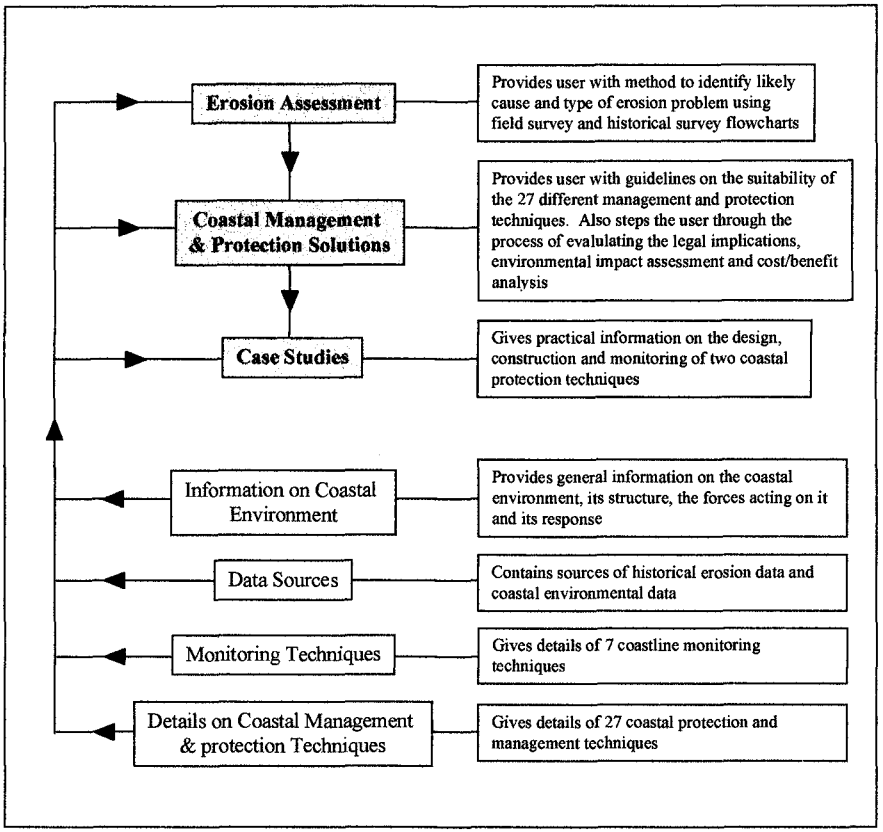

Fig. 4 - Code of Practice Layout

The Code of Practice deals firstly with the assessment of an erosion problem using field and historical erosion surveys. The aim is to try to determine the nature of the problem, whether it is continuous erosion or erosion caused by a single storm event or a sequence of storms. It also aims to identify the causes, whether natural or man induced. This section is structured around the use of decision support flowcharts which guide the user through a series of yes/no questions.

The next section of the Code uses these assessment results to identify suitable solutions. It gives information on the technical suitability of various coastal protection and management options. It also gives advice on assessing their legal and environmental impacts, and provides information on carrying out a cost/benefit analysis.

The following section is devoted to the two case studies. Practical information on their installation is supplied.

Appendix 1 of the Code gives general information on the coastal environment, its structure, the forces acting on it and its response. Appendix 2 contains sources of historical

and environmental data. Appendix 3 details coastline monitoring methods and Appendix 4 gives details of 27 different coastal protection and management options.

5. Project Results

Code of Practice

The Code of Practice is the final product of ECOPRO and whether it achieves its aims of increasing the awareness of the fragility of the coastal environment and preventing mistakes being made with coastal protection measures, will be the true result of the project. Initial indications in this respect are good. A workshop held in September in Cork was attended by engineers from most of the maritime counties in the Republic of Ireland and each were presented with copies of the Code of Practice. By general consent it was agreed that the code answered most of their queries on coastal erosion. Encouragingly the section on monitoring the coast was considered very useful. This bodes well for the future as once coastal monitoring begins, an awareness of the dynamic nature of the coastal zone is sure to follow.

The Code of Practice is essentially generic and can be used in all situations. The techniques are clearly and fully described using user friendly flowcharts wherever possible. The sections of the Code covering legislation and data sources are, through necessity, specific to the island of Ireland, but their format is such that they could be easily rewritten to suit other countries.

The Code of Practice follows a logical step-by-step path guiding the user through the assessment and solution of an erosion problem. General information on the coastal environment, contained in the appendix, is applicable, not only to North Atlantic coasts, but to most European Community waters. This section is also written in a clear style aimed at the non-expert. Formulae are only included where necessary and are usually backed up with graphic illustration.

The Sensitivity Index

The overall conclusion on the Sensitivity Index was that the use of such an index requires the availability of specialist knowledge and computer modelling capability. As such, it would not be of practical use to the target audience of the Code of Practice. Although an interesting formula to predict erosion rates from beach slope and wave statistics emerged from one study, it was considered that its application was only valid for micro-tidal, open coastlines. It was decided not to include it in the Code as it might be used inappropriately.

Coastline Monitoring

The data obtained from monitoring the seven pilot sites and the two case study locations have demonstrated the usefulness of the various techniques. The data collected covers:

- 8 sets of 70 beach profiles cross sections taken approximately every two months from October 1993 to March 1996
- 30 sets of 20 beach monitor post data taken approximately every month

- Wave hindcast data for 4 points offshore Ireland covering a two year period (3 hourly readings of wave height, period and direction for wind waves, swell waves and resultant waves)
- Four volumes of historical erosion data covering four of the study sites. Each contains all available maps and aerial photography along with reports from national and local sources
- Bathymetric survey data for four study sites
- Detailed digital ground survey data from commissioned aerial photography for one site
- Digital imagery (full spectrum and infrared) from aerial and video photography for 60 km of soft coast.

The survey methods advocated in the Code of Practice are devised with the premise that the user will have a limited amount of data available. In most European coastal areas there is a lack of coastal environmental data, especially nearshore wave data and water level measurements. Where economically justified, this difficulty can be overcome by specialist using computer models. However, these models are usually not available to the target users of the Code, the non specialist. The survey techniques should, therefore, be re-usable throughout the Community and the Code of Practice itself could provide the format for national guides to environmentally friendly coastal protection throughout Europe.

The analysis of the data collected has provided ECOPRO with the practical knowledge necessary to be able to optimise the choice of monitoring technique for a particular erosion problem. These recommendations are included in the Code of Practice and details of the techniques are given in the Code Appendix. The data was also used by the Sensitivity Group in their work on the Sensitivity Index.

The ECOPRO database has been used in a number of academic studies (to date four final year projects and two post graduate degree thesis). It has also been used to fine tune and validate two sediment transport computer modelling investigations carried out by coastal engineering specialist on behalf of a local authority and the owners of a golf course.

6. Dissemination of Project Results

Since the results of the project are contained in the ECOPRO Code of Practice, dissemination will be primarily through the distribution of the Code. The Code is available from;

Government Publications Sales Office, Molesworth Street, Dublin 2, Ireland.
Tel; +353 1 6613111 Fax; +353 1 4752760

The ECOPRO project promoted the cause of environmentally friendly coastal protection through public exhibitions. In 1994, as part of a exhibition on coastal environment matters in the ENFO centre, Dublin, ECOPRO provided a display stand promoting the projeet and its aims. The exhibition ran for two weeks and was attended by over 5,000 people. Under ECOPRO, Coastwatch Europe organised two national and a number of local workshops on dune dynamics, monitoring and coastal protection measures.

7. Recommendations on Future Work

One of the main findings of ECOPRO's work on the Sensitivity Index was the importance of accurate wave and water level data. This data is not available for the vast majority of European coastal sites. Obtaining this data for a particular site is very expensive and can only be justified where costly coastal protection schemes are being adopted to protect valuable property. In less developed areas this type of data collection is not viable. The alternative is to make decisions based on less accurate but more readily available information. ECOPRO attempts to help the user make these decisions based on best current practice. As technology advances and our knowledge of coastal processes improves, this best current practice will evolve and it is important that ECOPRO evolves alongside. The ECOPRO team have committed themselves to continuously update the Code of Practice and to conduct questionnaire surveys of selected users to ensure that it is achieving its aims.

The structure of the decision support flowcharts and the Code in general, is such that it would lend itself readily to being encoded as a computer program. This is currently being investigated by the ECOPRO team. If possible this would make the Code much more widely available especially if placed on the Internet.

The work on the Sensitivity Index could be progressed so that ultimately a more accurate technique on erosion sensitivity would be available. For this to be usable by non-experts much of the data required, i.e. nearshore wave statistics, water levels, etc., would need to be pre-processed and presented in atlas format for ease of use. Eventually it is envisaged that each local authority or coastal community could, without specialist knowledge, have a technique which would allow them to accurately assess each areas susceptibility to erosion and to identify the cause by using readily available information.

Acknowledgements
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