

MORAY FIRTH PARTNERSHIP

TOPIC PAPER

GEOMORPHOLOGY AND COASTAL DEFENCE

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1. **Executive Summary** - A brief description of the contents of the remaining sections of this paper.

Map and Area of Interest

Figure 1 gives a map of the area covered by this paper. It includes the whole of the maritime area and land up to the 5 m contour. This section also summarises the content of the paper which has not been repeated here.

Vision

The vision of the Group is to seek to improve the quality of Management of the coast of the Moray Firth by improving the quality of information available to the decision makers and ensuring that they acted within a co-ordinated strategy.

Review of Information

The Moray Firth is set in context with Geological time scales and the 861 km length of coast is set in the context of the rest of Scotland's coast.

Gaps in the information about the way the coast is used is highlighted by means of Table 1.

The powers and limitations of the Coast Protection Authorities is described - along with an explanation of how they function within the context of the requirements of Central Government and current legislation. Particular attention is drawn to the fact that there are several agencies responsible for coast protection structures. In particular - Central Government acting as M.O.D., NOSWA, Forest Enterprise and Trunk Road Authority; Local Government acting as Coast Protection Authority, Planning Authority and Regional Roads Authority; Private Land Owners; Commerce including Railway companies and Harbour Authorities/Trusts.

Legislation is reviewed and listed.. The consultations required by the most recent legislation is noted.

Types of coast protection structures and the available information on routine dredging and the coast protection structures around the Firth has been given in the appendices.

Reference is made to the difficulties which arise as a result of the weaknesses in Planning legislation and the failure of the democratically elected members to consistently follow their own policies.

The paper describes how the difficulties in taking a holistic approach to managing the coast have been resolved in England and Wales by all the agencies joining together to produce Shoreline Management Plans. The paper further describes how The Scottish Office have resisted this approach and how even with a Shoreline Management Plan being completed the current arrangements in Scotland make it difficult to monitor the behaviour of the vulnerable lengths of coast.

Key Reports and Plans, Sources of Existing Data Key Organisation.

The group have identified that whereas the Planning Guidance Note (NPPG13) Coastal Planning proposes that risk from coastal erosion and flooding be assessed, there is a problem because of a lack of fundamental information which will make risk assessment difficult or unreliable. In particular there is no detailed information of the movement of beaches nor information or history on the frequency of wave heights, directions.

The current situation for Bathymetry and Hydrography are briefly included because the information, or rather the gap in detailed information, and knowledge contained within these sciences is relevant to our understanding of coastal processes.

Climate, in so far as it affects winds, waves and sea level, has been discussed at length, concluding that the frequency of storms is increasing and that this coupled with rising sea levels will place the coastline at greater risk of damage.

The importance of historical information on winds and waves is described. The serious gaps which already exist and the worsening situation are described. Particularly for the collection of wind speeds and duration and waves and currents where the gap will make it more difficult to predict what will be the local affect of climate change.

Geomorphology

Moray Firth contains sites which are important for the study of geomorphological processes.

These sites which have mobile boundaries may in time interfere with the life of the adjacent communities and their commerce as a result of accretion or may in time cause the loss of amenity and archaeological heritage as a result of erosion.

Dredging of the sea bed and dumping on the sea bed are also briefly covered.

Geology

The current situation is reviewed including reference to the fact that a lot of the SSSI's along the coast are to protect rock exposures between MHWS and MLWS

Review of Issues and Opportunities

The two main issues are global warming or climate change and Legislation.

The climate changes means that the coast will be at greater risk but the serious gaps in our information make the risk more difficult to quantify. Several gaps and the problems associated with them have been identified.

The issue of Legislation is its diversity, complexity and inconsistency. Coupled with the large number of Agencies involved in protecting the coast or their assets situated along the coast. Despite the amount of legislation it is not adequate to properly control development with some lobby groups having a disproportionate amount of power or influence. The paper calls for a holistic approach with a single agency capable of managing the conflicting issues and taking responsibility for the sea bed below MLWS. There is a need to educate planners on the possibility of long term damage from inappropriate development

How these issues affect various interests and there relationship to coast protection is then considered. The interests being :-

The New Councils	Climate (Winds and Waves)
Education	Geomorphology & Geology
Coast Protection	Natural Heritage
Harbours The Scottish Office	Recreation and Amenity
Bathymetry & Hydrography	Planning and development

2. Map and Area of Interest

A map of the Area is given in Fig. 1

This Topic Paper covers geology, geomorphology and Coastal Defence within the Moray Firth. Where appropriate the following boundaries have been adopted.

- (1) The whole of the marine area of the Moray Firth as defined in Fig 1 of the Moray Firth Review, 1993.
- (2) For all practical purposes the landward boundary would be the Ordnance Survey 5.0 m contour except where the coastal margin was very steep. In these cases where properties or developments may be at risk the immediate, vulnerable, hinterland would be included. Generally this would not be expected to exceed 1 Km.
- (3) The North West limit is Duncansby Head, Caithness.
- (4) The South West limit includes the Beaully and Cromarty Firths.
- (5) The South East limit is Cairnbulg Point, Aberdeenshire.
- (6) In determining the length of coastline within the above limits, the edge of the land (coastal edge) is that defined by the Macaulay Land Use Research Institute - Land Cover for Scotland, 1988.

(Note:- Duncansby Head to Cairnbulg Point is littoral cell 3, HR Wallingford; Coastal Cells in Scotland)

In its Review of information the Topic Group has considered: -

Sea bed sediments including if and how they are moving.

Coastal Sites of Special Scientific Interest, differentiating between Biological, Mixed and Geological

Existing coast defence structures.

The changing coastline, its effect on man and vice versa.

The gaps in knowledge of physical processes such as isostatic tilt, water levels, wave heights, currents, tides, littoral drift.

Current dredging and dumping practice.

Current Monitoring of the changing coastline.

The effect river born sediments have on coastal processes and its effect on man and vice versa.

Climate change and its effect on coastal margins.

3. Vision

Strategies and operations which relate to the management and land use of the Moray Firths varied coast line will value the coasts natural function and sediment dynamics.

Improve our understanding of the physical processes taking place in the Moray Firth in order that the Managers and decision makers can act on the best information available and be confident that the predicted outcomes are based on good science.

To achieve this measuring stations would be located at strategic point in the Firth. The stations would record continuous information on wind speeds and direction, surface and sub-marine currents and direction, wave heights, period and direction, water temperature and quality as well as other information that benefits all those who use or have an interest in the Firth.

Tidy up legislation so that there are no ambiguities and there are clearly established principles over who is responsible for what. This will enable industry, public officials and the voluntary sector to work together to achieve a holistic and sustainable approach to maintain the assets of the Moray Firth.

Coast Protection and the Management of the Coastline would be the responsibility of a single Authority, possibly The Scottish Office, who will have delegated certain management functions to local areas but is able to take an overview of every development and/or maintenance work prior to its being undertaken.

4. Review of Information

4.1.0 Current Situation

The Moray Firth area is part of a continental plate which for 90% of geological time has been covered by ice. Currently, within the context of a geological time scale, there is a gap in the ice cover over the Moray Firth.

The coastline from Duncansby Head to Cairnbulg Point is a length of 861 km. which is 20 - 22% of the coast of mainland Scotland. Highland, Moray and Aberdeenshire, are the relevant Coast Protection Authorities under the Coast Protection Act 1949 for this length of coastline.

The Cromarty Firth is within the domain of the Moray Firth Partnership, the coastal boundary of the Cromarty Firth contains a mix of Heritage, Residential, Recreational and Industrial use. A Cromarty Firth Liaison Group was established in 1992 and has prepared a Management Strategy and Action Plan. None of the Objectives of the Moray Firth Management Strategy are likely to be in conflict with the substance of the stated objectives of the Cromarty Firth Liaison Group. The Topic Group endorses and supports these objectives and would wish to see them extended to the Moray Firth as a whole.

Table 1 gives a breakdown of the coastline by local authority and by land use. Where the information is not readily available but is considered by the authors as useful to planners and decision makers it has been noted as a gap.

Table 1

	Highland		Moray		Aberdeenshir		Partnership (Total)	
	km	%	km	%	km	%	km	%
Total Length	529.3	73	120	17	77.3	10	860.7¹	100
Hard coastline								
Soft coastline								
Length Developed								
Population < 50	Gap		Gap		Gap		Gap	
Population 51 to 200	Gap		Gap		Gap		Gap	
Population 201 to 1000	Gap		Gap		Gap		Gap	
Population 1001 to 2000	Gap		Gap		Gap		Gap	
Population 2001 to 6000	Gap		Gap		Gap		Gap	
Population 6001 to 9000	Gap		Gap		Gap		Gap	
Population > 40000	Gap		Gap		Gap		Gap	
Agricultural/Estate	Gap		Gap		Gap		Gap	
Recreational	Gap		Gap		Gap		Gap	
Forestry	Gap		Gap		Gap		Gap	
Industrial Estates	Gap		Gap		Gap		Gap	
Transport Infrastructure	Gap		Gap		Gap		Gap	
MOD	Gap		Gap		Gap		Gap	
SINS								
all	0		48	40%			48	7%
Geological/Geomorphological								
SSSI								
all	408.9	77.3/56	52.2	44/7	77.3	100/11	538.6¹	63
Geological/Geomorphological								
Coastal Defence Structures	Gap		Gap		Gap		Gap	
all categories but see Appendices G & H								

Note: “Gap” indicates that the information is not readily accessible. Overlap occurs within all the categories.

1 - Figures supplied by SNH

4.1.1 Coast Protection Authorities and their powers.

It should be noted that not all of the coastline is under the jurisdiction of the Coast Protection Authority. Much of it will fall to other parties such as the various Roads Authorities, Railways, Ministry of Defence, Harbour Authorities, Water Authorities, Forest Enterprise, Private Land Owners. It has not been possible to obtain the statistics necessary to apportion this breakdown of these responsibilities. In some instances liability for maintenance costs may be disputed.

The Coast Protection Act 1949 gives powers to the Coast Protection Authority which enable the authority to protect land and property. The decision as to whether or not to carry out a protection scheme does not rest entirely with the Coast Protection Authority in that if the authority wishes to receive a grant towards the cost of the scheme then it must first obtain the approval of the European, Environment and Engineering Unit of The Scottish Office, that the proposal forms an appropriate basis for a Coast Protection Scheme. Recently the Scottish Office have required a Cost Benefit Analysis to be undertaken before a scheme will be approved for grant purposes.

The Coast Protection Act 1949 also requires “any person who carries out any coast protection work other than work of maintenance or repair” to obtain the consent of the Coast Protection authority in writing. There are certain important exceptions to this rule which may be relevant to the proper functioning of the Moray Firth Partnership.

The exceptions are: -

- a) by a coast protection authority;
- b) by any body or person upon whom any powers or duties relating to the protection of land have been conferred or imposed by or under any enactment other than this Act;
- c) by a [¹highway] authority for the protection of a highway;
- d) by the British Transport Commission, or an Executive established by or under section five of the Transport Act 1947, for the protection of a railway; or
- e) by a harbour authority.

exception (b)- includes the Ministry of Defence who are wont to act without any consultation.

exception (c)-Local Authorities are usually the highway authority but since the re-organisation of local government the Trunk Roads are no longer are within the jurisdiction of the Local Authorities. The new Trunk Road Authority has also shown it is capable of acting without prior consultation.

exception (d)-includes British Rail. - The Government has yet to clarify whether the recently privatised Railways will have stand alone powers with regard to protecting the rail transport network.

A further important provision of the 1949 Act is that to protect the Safety of Navigation no work is allowed to take place “on, under or over any part of the seashore lying below high water mark of ordinary spring tides” without the prior consent of the Department of Transport.

Over time (since 1894) a considerable amount of legislation has been passed which relates in some way to our coasts. In the recent past a significant amount of new legislation has been introduced which relates to Coastal Issues.

The most important of these are listed in Table 2, with the most important being highlighted in bold type.

Table 2

Merchant Shipping Act 1894
Public Health Act 1936
Coast Protection Act 1949 <i>NB subsequent amendments are indicate by ‘ * ’</i>
(Land Drainage (Scotland) Act 1958)
(Flood Prevention (Scotland) Act 1961)
Crown Estate Act 1961
Town & Country Planning Act 1972 as amended????
Local Government (Scotland) Act 1973
Health and Safety at Work etc. Act 1974
[Control of Pollution Act 1974]
Offshore Petroleum Development Act 1975
Inner Sound of Raasay Sea Designation Order 1975
Wildlife and Countryside Act 1981
Civic Government (Scotland) Act 1982
Food and Environment Protection Act 1985
(EC Directive on Environmental Impact Assessment 1985) implementation marked ‘**’
* Coast Protection (Notices) (Scotland) Regulations 1988
** Environment Assessment (Scotland) Regulations 1988
Merchant Shipping Act 1988
Control of Pollution Act 1974 as amended by Schedule 23 of the Water Act 1989
Environmental Protection Act 1990
Food and Environment Protection Act as amended 1990
Natural Heritage (Scotland) Act 1991
Construction (Design and Management) Regulations 1994
* Coast Protection (Notices) (Scotland) Amendment Regulations 1996

The Food and Environment Protection Act 1985 is particularly relevant in that Part II covers Deposits in the sea. If a coast protection scheme is “on, under or over any part of the seashore lying below high water mark of ordinary spring tides” then before work can commence a licence is required from the Marine Laboratory of the Fisheries Research Services, Environment Section.

Before it is able to issue a licence the issuing authority has a statutory duty to consult with agencies such as SEPA, SNH, Crown Estate Commissioners, Scottish Fishery Protection Agency (SFPA), Department of Environment, Transport and the Regions (DETR) and Inspectorate of Salmon & Freshwater Fisheries. A similar licence is also required for removal of deposits from the sea bed (dredging). Dumping of dredged material would be covered by the previously mentioned section of the act and in these cases it is customary for the licensing authority to require the licensee to demonstrate that the material is not contaminated. Heavy metals from anti fouling paint being a particular problem.

The routine dredging and dumping within the Moray Firth is listed in Appendix E of this report. Where this information is available, Appendix F lists, and categorises, the existing Coast Protection structures which are maintained by the three Coast Protection Authorities.

Appendix G lists and categorises the existing Coast Protection Structures known by the authors of this report but maintained by other agencies. N.B. This list can not be comprehensive due to the limitations of time and State Secrecy!

Since the introduction of the “Coast Protection (Notices) (Scotland) Amendment Regulations 1996” the Coast Protection Authorities have had a Statutory obligation to serve notice upon SNH and SEPA when they propose coast protection work under Part 1 of the Coast Protection Act 1949.

Before the Local Authorities promote a scheme, but depending upon the size of the scheme, best practice is to commission a study of the immediate coastline. The reports from these studies are usually available from archives although a lot of useful material was lost when local government was re-organised in 1975.

Before a scheme can begin it must also be approved by the Planning Authority. In the past the need for Planning consent has not prevented inappropriate development along the coast. As a rule the officials try and ensure that the developer is responsible for providing and maintaining any coast defences but this does not guarantee that if ownership changes the responsibility does not lapse, particularly if some time has elapsed since the original development. In these circumstances the local authority may have changed and the persons involved in the negotiations will certainly have moved on, possibly to a different local authority.

A further difficulty is that the elected members do not always accept the advice of the officials. Even where the elected members do support the Planning Officials in recommending refusal, it is possible that the threat (i.e. cost) of a challenge through a Court Action or Public Enquiry will persuade them to back down on the basis that, in the short term, there are more urgent needs for public money than providing work for Lawyers and Barristers.

Later in this report reference is made to a “Shoreline Management Plan”. In England and Wales MAFF refuse to approve a coast defence scheme unless it is within the context of a Shoreline Management Plan. As a result the whole of the English and Welsh coast has a Shoreline Management plan in place or about to be completed. It is true to state that the problems in England and Wales are different to those in Scotland. MAFF, NRA and English Nature provided the bulk of the funding for the preparation of these plans, the balance being provided by the Coast Protection Authorities. In most cases several Authorities contributed since the plans overlapped the Authority boundaries, this being the need for the plans. In Scotland funding from central government is not available but the lack of alternative funding could mean the cost of preparing shoreline or integrated management plans for the Moray Firth coastline will be prohibitively expensive to the three local authorities. In addition to this problem, by their very purpose, Shoreline Management Plans recommend that regular monitoring of the coastline is undertaken; a long term commitment of resources which the three local authorities are unlikely to be able to support. This is certainly the case for the one SMP that is already in place. Although the initial surveys recommended in the existing SMP were completed, no record drawings were made and no further monitoring has been undertaken other than responding to, and noting, damage reported by members of the public. In this respect it would be helpful if future shoreline management plans included a **minimum standard** of monitoring the coast based upon a “standard methodology.

A Shoreline Management Plan does not necessarily resolve all the problems. The various agencies referred to in the first paragraph of this section may have assets, actual or at risk, within the length of coast covered by a plan but it does not follow that they will participate in the preparation of a plan. There may be constraints upon their management brief which preclude their being involved or there may be other factors. For instance the MOD did and has

not shown any interest in the Shoreline Plan which included Fort George; a site which is causing Historic Scotland some concern due to the loss of ground and archaeological heritage.

Types of hard and soft engineered structures and their effect upon the environment are listed in Appendix D.

.It is customary to base designs upon the previous 20 years of wind history and allow for a high tide with a surge to obtain the water level. Wave heights and run up can then be calculated and a stone size determined. For larger schemes the cost of a study using a computer model can be justified by the savings that can accrue and the improved level of confidence in the adequacy of the design.

4.1.2 .Key Reports and Plans.

The Scottish Office, Agriculture Environment and Fisheries Department and Historic Scotland commissioned HR (Wallingford) to identify the coastal cells in Scotland. This was published in 1995. The coast of Moray Firth has been identified as Cell 3 in this document. Seven sub-cells have been identified and these are shown in Fig. 1.

NPPG 13 “Coastal Planning” was issued during 1997 and it could form a key part in improving the way the coast is managed.

A Shoreline Management Plan has been prepare which covers the coast from Sutors Gap, Cromarty to Burghead excluding the Beaully Firth. The general philosophy of this plan is that where there is not an existing structure protecting the coast these areas should remain unprotected. However many of the existing structures are beyond their useful life. The Shoreline Management Plan recognises that these must be maintained and eventually replaced.

A Cromarty Firth Liaison Group has been established and has produced a Management Strategy and Action Plan

The Local Authority Strategic and Local Plans.

4.1.3 .Sources of existing Data

The Coast Protection Authorities have “in house” information on existing structures, including reports. The information is usually available if the structure is less than 40 years old but due to the frequent changes to organisational structure, both in local government and to other agencies, the details can be quite difficult to trace.

The Scottish Office ,

Fisheries Research Services, Marine Laboratory, Aberdeen

Agriculture, Environment and Fisheries Department, Victoria Quay, Edinburgh

SNH

Natural Environment Research Council, Proudman Oceanographic Laboratory

University of Aberdeen

University of Hull, (Institute of Estuarine Studies

University of Glasgow

University of Highlands and Islands

University of Strathclyde

Hydraulics Research (Wallingford) Ltd.

4.1.4.Key Organisations and individuals.

Local Authorities; Planning consents and Coast Protection Authorities:

The Highland Council,

Planning and Building Control Services,

Caithness,

Market Square, Wick

Te 01955 607757 Fax. 01955 606814

Mr Stephen Bell,

Area Planning and Building Control Manager

(AP&BCM)

Sutherland,

The Meadows, Dornoch

Te 01862 810491 Fax. 01862 811146

Mr David Polson, AP&BCM

Roads and Transport Services,

Caithness,

Market Square, Wick

Te 01955 607760 Fax. 01955 607761

Mr Richard Guest,

Area Roads and Transport Manager (ARTM)

Sutherland,

Victoria Road, Brora

Te 01408 621733 Fax. 01408 621118

Mr Colin Mackenzie ARTM

Ross & Cromarty,

Achany Road, Dingwall

Te 01349 864991 Fax. 01349 863510

Mr Jim Farquar AP&BCM

Ross & Cromarty,

Council Buildings, Dingwall

Te 01349 865260 Fax. 01349 865260

Mr Bill Robins ARTM

continued

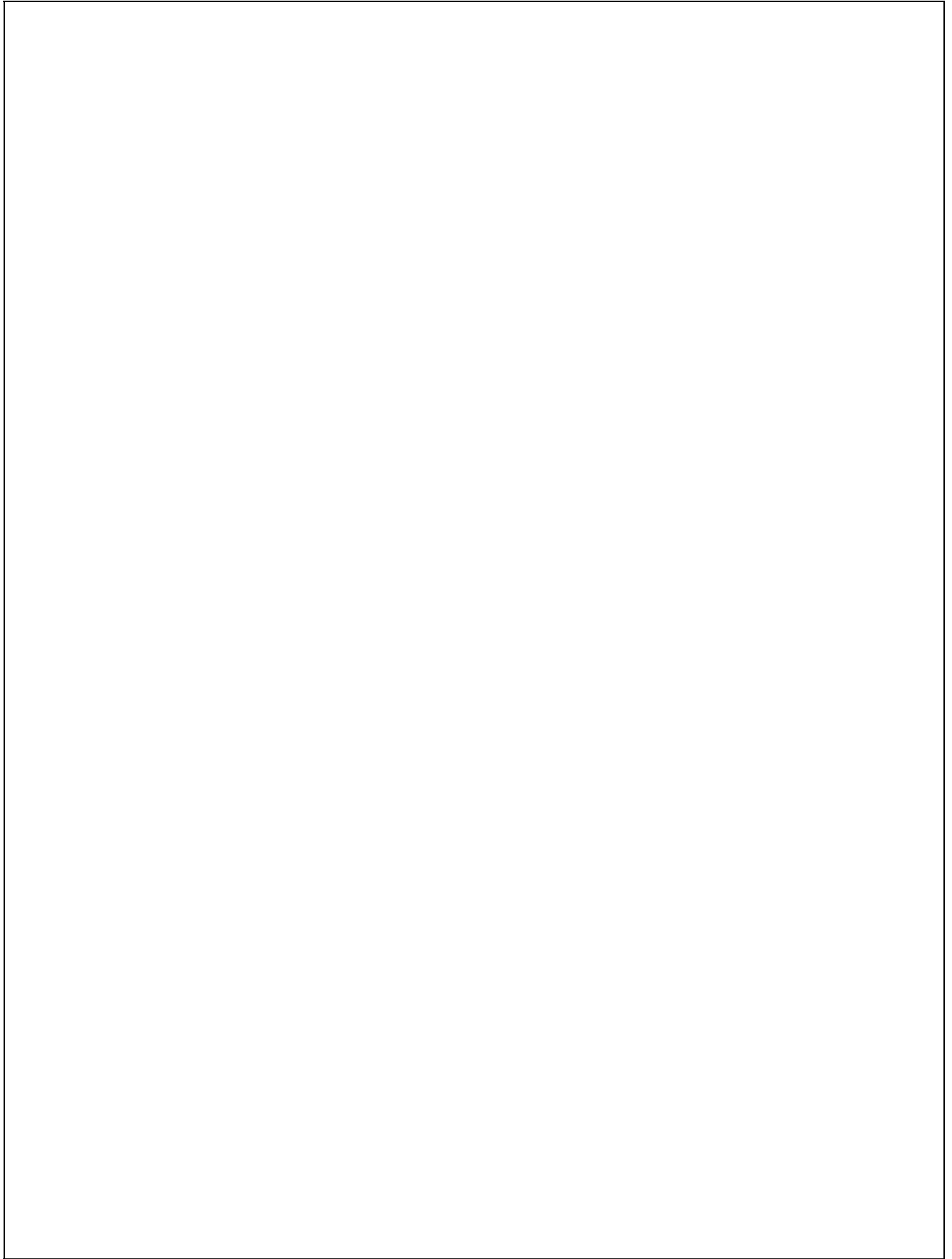


Fig. 1 COASTAL CELL 3: - Duncansby Head to Cairnbulg Point.

Inverness,
1-3 Church Street, Inverness.
Te 01463 724273 Fax. 01463 711332
Mr George Boyd AP&BCM
Nairn,

Te 01667 452757 Fax. 01667 452936
Mr Robert Cameron AP&BCM

Inverness,
Diriebught Road, Inverness.
Te 01463 703101 Fax. 01463 703112
Mr Angus MacInnes ARTM
Nairn,

Te 01408 621733 Fax. 01408 621118
Mr Calum MacDonald ARTM

The Moray Council

Economic Development & Planning,
Highfield House, South Street, Elgin. IV30 1NF
Te 01343 541202 Fax. 01343 545628
Mr Alexander Ritchie, Chief Roads Officer.

The Aberdeenshire Council

Transportation and Roads,
Carlton House, Arduthie Road, Stonehaven.
AB39 2DP
Te 01569 766266 Fax. 01569 765616
Mr Hugh Jamieson,
Head of Transportation and Roads (South)

4.1.5. Review of existing Data

The existing Coast Protection Structures and monitoring have been listed in Appendices G and H. There has not been sufficient time to review or collate this information.

4.1.6. Relevant Key Statistics

Where they have been available the key Statistics have been listed in Table 1. The figures were obtained from several sources and it should be noted that they did not/do not always agree.

4.1.7. Identification of key data gaps and research, survey and monitoring needs.

NPPG 13 proposes that risk from coastal erosion and flooding should be assessed. In order to make a proper assessment detailed historical records are needed, particularly of the movement

of beaches and sand spits. To date there has not been a co-ordinated, long term approach, to survey the movement of beaches and other lengths of soft coastline.

In the long term this has caused a gap in our knowledge. The problems that may accrue as a result of this gap are best illustrated by considering a foreshore which has been accreting for 20 to 30 years. This build up will be imperceptible over this period of time but if, as a result of the wave climate changing, the foreshore suffers a period of rapid erosion the casual observer is likely to become alarmed at what the observer perceives as rapid loss of ground. The reality may be that the coastal edge has not yet moved back to its 'original' line. Without regular and accessible records, the information that the coast is no worse than it was 30 years ago will not be available to the decision makers. Such information can be crucial in re assuring the public and in helping to avoid spending large sums of money on unnecessary schemes.

In the short term this gap will make it very difficult for a proper and realistic Risk Assessments to be undertaken.

See also the need to set up proper monitoring to enable the affects, if any, of climate change; section 4.4.7.

4.2.0 Bathymetry

4.2.1 Current Situation

The bathymetry is quite well documented in Admiralty Charts and British Geological Survey (BGS) maps (1:250k published, 1:100k unpublished), although close inshore is probably not mapped in detail other than navigation routes and harbours. Modern swath bathymetry techniques would however produce much higher quality data.

The Admiralty (U K Hydrographic Office) now produce a digital chart service for use with Global Positioning Systems. This is updated every week but the water depths in parts of the Moray Firth were last surveyed by lead line only, 1840 - 1935; other parts have been Fully surveyed by echo sounder and modern sonar. See Fig 2

4.2.2 Key reports and plans

BGS UK Offshore Regional Report "The Geology of the Moray Firth"; BGS 1:250000 maps; Admiralty Charts and Hydrographic Office (HO) unpublished maps.

The Admiralty has also transferred its charts on to CD Rom which is now available for use with Global Positioning Systems and GIS.

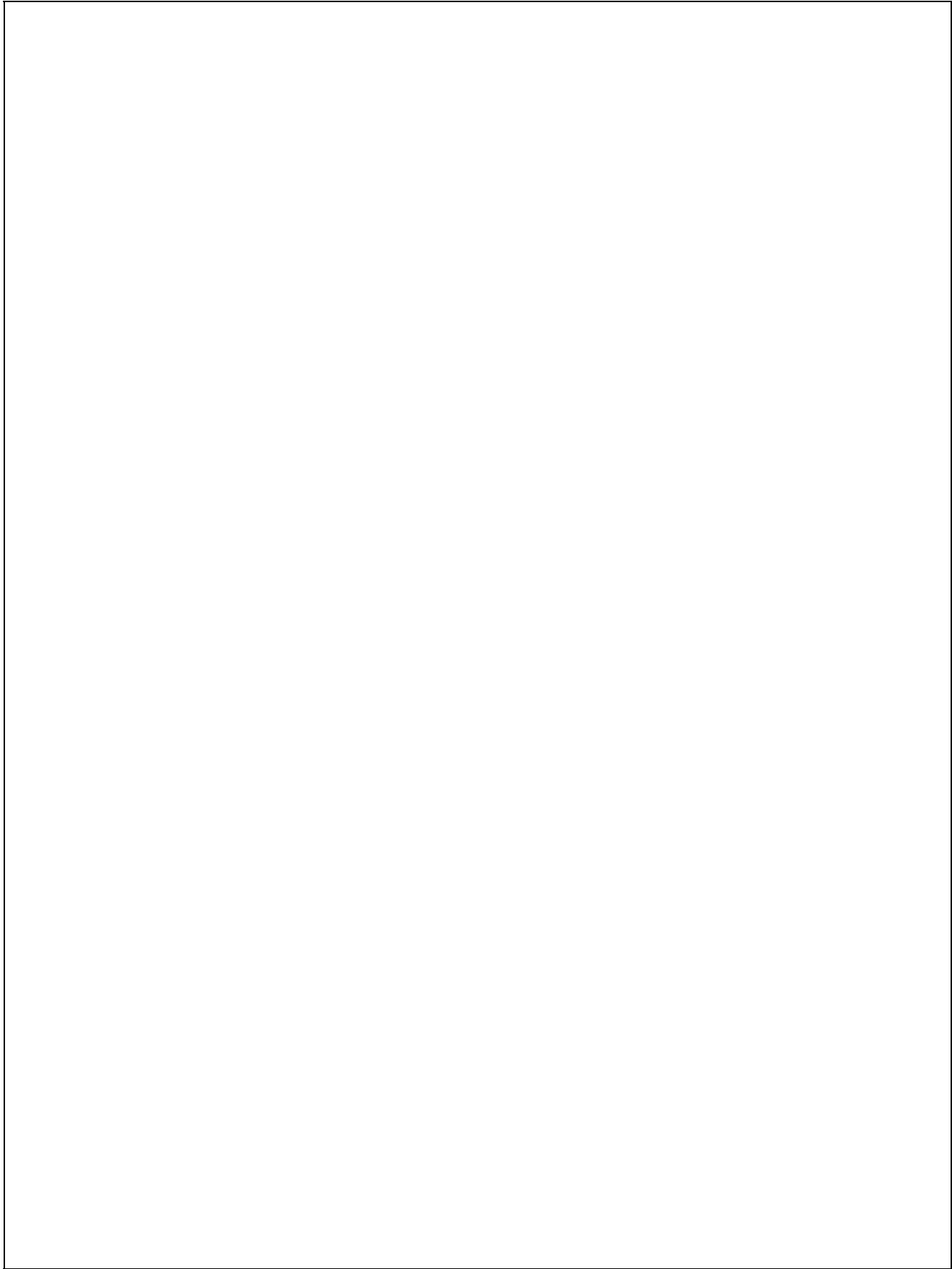


Fig. 2 ADMIRALTY SURVEYS including contract surveys to Admiralty specifications up to March 1997

4.2.3 Sources of existing Data

HO, BGS, oil companies (especially Beatrice and Pipeline), harbour authorities.

4.3.0 Hydrography

4.3.1 .Current Situation

So far as the authors of this report are aware very little work has been done on water circulation in the Firth. The Fisheries Research organisations may have done some work since the latest papers in the MFR are McManus (1992) & Turrel (1992).

Tidal data on Admiralty Charts and in North Sea Pilot, Tidal Atlas of Sager and Samler (1968).

4.3.3 .Sources of existing Data

British Oceanographic Centre will hold data..

4.4.0 .Climate (Winds, Waves and Sea Level)

4.4.1 .Current Situation

The Public are very aware of the possibility of the climate changing, the popular press refer to this as “Global Warming”. Historically the climate has always changed. It has been recognised for a long time that there are two astronomical cycles which modify our climate. One acts over a cyclic period of 11 years, the other over a cyclic period of 19 years.

The main source of energy for the earth is the Sun and over a period of 11 years the energy from sun spots gradually changes from a period of intense activity to a period of reduced activity. During a period of intense activity the number of storms (on earth) increases.

The second cycle which influences our weather is the alignment of the planets, particularly the planes of orbit of the earth around the sun and the moon around the earth. This cycle is approximately 19 years and has been taken into account by those who prepare the Tide Tables for a long time. These periods are not in phase so that it may be expected that when a period of intense sun spot activity coincides with a period of extreme high/low tides the coastline will be changed.

Climate can also suffer comparatively short term change due to major events such as when a volcanic eruption places dust into the upper atmosphere.

The speed of change in climate that are a consequence of the forgoing cycles can vary, records over the short term, particularly around the coast of the UK, are not sufficient to enable observers to detect, or differentiate between, natural effects and any underlying changes that may be a consequence of the hole in the ozone layer and/or the increase in “greenhouse gasses”.

Whatever the causes and trends there are strong indicators that recently the climate has been changing very quickly. Between 1920 and 1945 the global average surface temperature has risen and nine of the hottest years since 1850 have been recorded between 1980 and 1997.

Coastline can be, and is being, dramatically changed because of a small change in the wave climate. Beaches which protect settlements can disappear over a matter of days, conversely beaches can build up and close harbours over a matter of days. Recently this has happened at Montrose and at several locations along the South coast of England. There is no reason why

this should not occur around the coast of the Moray Firth. Unfortunately there is no basic information available which would enable the scientists to attempt to explain what is happening let alone predict what is likely to happen in the future.

There is an extreme sparsity of information on wave climate around the coastal waters of the UK and the Moray Firth is no exception. Some information was gathered during the period 1960 to 1970 since when no information has been collected unless it has been by the oil companies when the information is not in the public domain.

Fortunately wave height can be related to wind speed, although there is a record of wave heights at Sevenstones light vessel increasing in height without a matching record of increased wind speeds so that other external forces, possibly distant storms, do affect the height of offshore waves. If, as is expected, the frequency of storms increases, then it may no longer be possible to relate wave heights to wind speed with any confidence.

Waves are generated by wind acting upon the surface of the water across the expanse of the oceans. Such waves are usually referred to as **offshore waves**. In offshore areas the wind speeds are much greater than over land but by using historical information on wind speeds and direction it is possible to build a mathematical computer model of a wave climate. Without actual data to check the assumptions made to produce the model there will always be an element of doubt regarding the reliability of such an approach.

Historical information on wind speeds, direction etc. is available from the Meteorological Office. Although the information pre dates 1970 this is the usual cut off date on account of the earlier data not being readily accessible to electronic processing. The land based stations are shown on the map, Figure 3.

The facility to relate offshore wave heights to wind speeds has proved extremely useful to designers of marine structures. In the past the numerous stations, harbours and airports scattered around the coastline have kept and made available good meteorological records of the local conditions. This made it possible for the designer to be confident that the wind speeds used to design the structure had an adequate factor of safety without having to make it too strong.

Information on wind speeds around the landward perimeter is currently available but it is an issue of concern that the availability of contemporary records is not likely to continue. The present trend is to ensure that public bodies fully account for the money they spend and as a consequence of this many functions which were historically undertaken to assist other public bodies are being reviewed and discontinued unless the benefitting body is able/prepared to fund the work involved. The philosophy that it is for the Public's benefit is no longer accepted. A serious casualty of this is the collecting of local weather information. In the recent past Dalcross has ceased to keep records and as the meteorological forecasters develop satellite systems they will have less and less need for the collection and keeping of local records to enable them to make short term predictions.

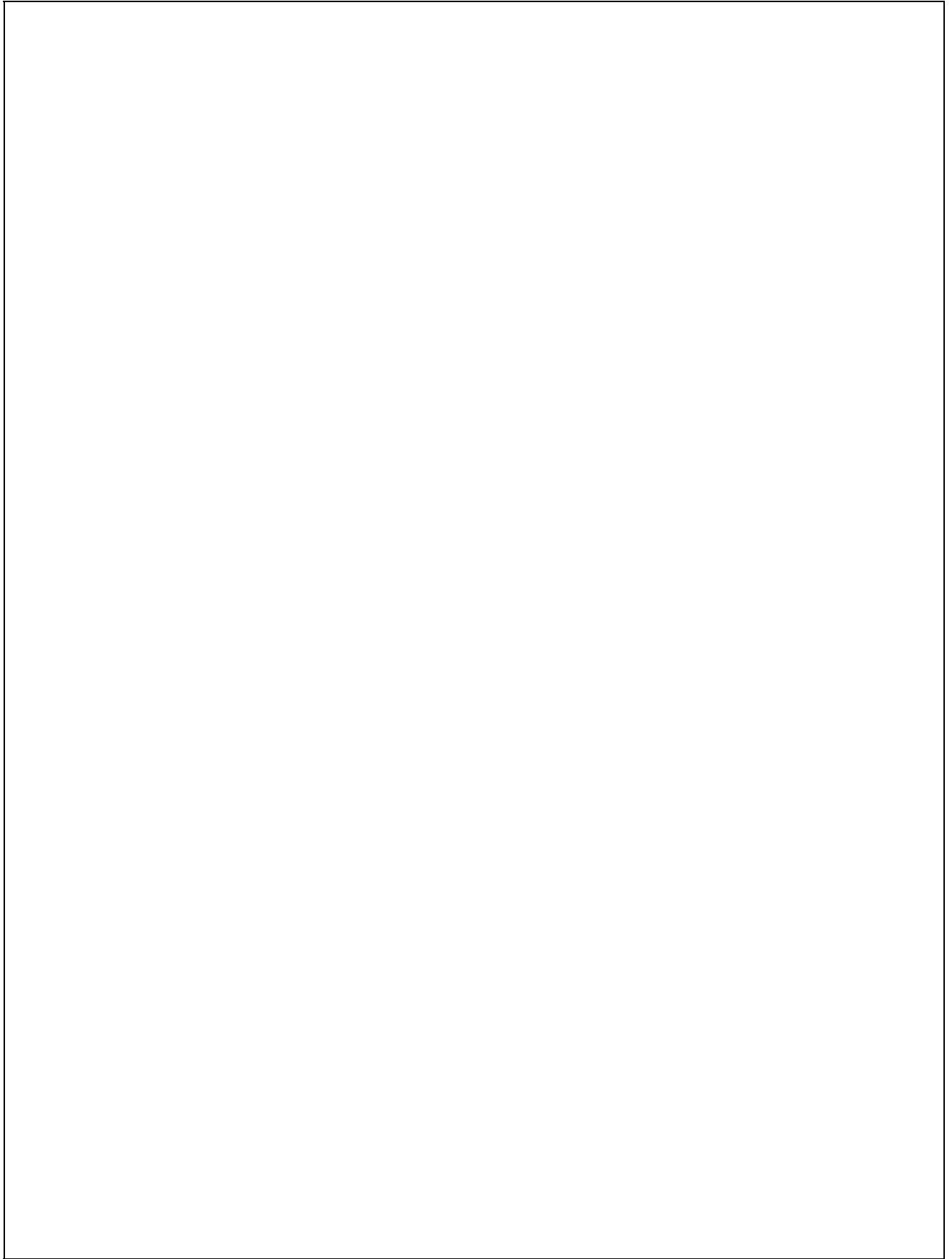


Fig. 3 Meteorological Stations, Past and Present

4.4.2. Key Reports and Plans

Proudman Oceanographic Laboratory have recently published two reports on extreme sea levels at UK, Class A sites, the latter report confining itself to the East coast. These reports are a statistical analysis of water levels over the past 20 years and there is some debate within the scientific community over the validity of their findings. Chapter 13 of Internal Document No.72 shows the sea level changes since 1990 to be as Table 3. for the Moray Firth.

Table 3 Sea level changes since 1990

Number	Long.	Lat.	MSL in 1990 OD	Trend (rise) (mm per yr.)
1	-3.083	58.433	0.334	3.220
2	-3.199	58.318	0.334	3.097
3	-3.469	58.208	0.334	2.967
4	-3.718	58.080	0.333	2.827
5	-3.984	57.968	0.333	2.651
6	-4.272	57.869	0.331	2.445
7.	-3.937	57.839	0.328	2.219
8	-4.158	57.688	0.323	2.082
9	-4.428	57.580	0.318	2.061
10	-4.123	57.660	0.313	2.087
11	-4.287	57.503	0.307	1.968
12	-4.002	57.599	0.301	1.728
13	-3.685	57.660	0.295	1.448
14	3.367	57.721	0.290	1.217
15	-3.043	57.667	0.286	1.044
16	-2.709	57.690	0.283	0.902
17	-2.370	57.675	0.282	0.797
18	-2.033	57.694	0.282	0.721
19	-1.808	57.561	0.282	0.665
20	-1.869	57.384	0.282	0.630

[The three decimal places indicated in the 'Trend' is a result of the statistical analysis. It does not reflect the level of accuracy of the prediction]

The location of these points is shown on Figure 4.

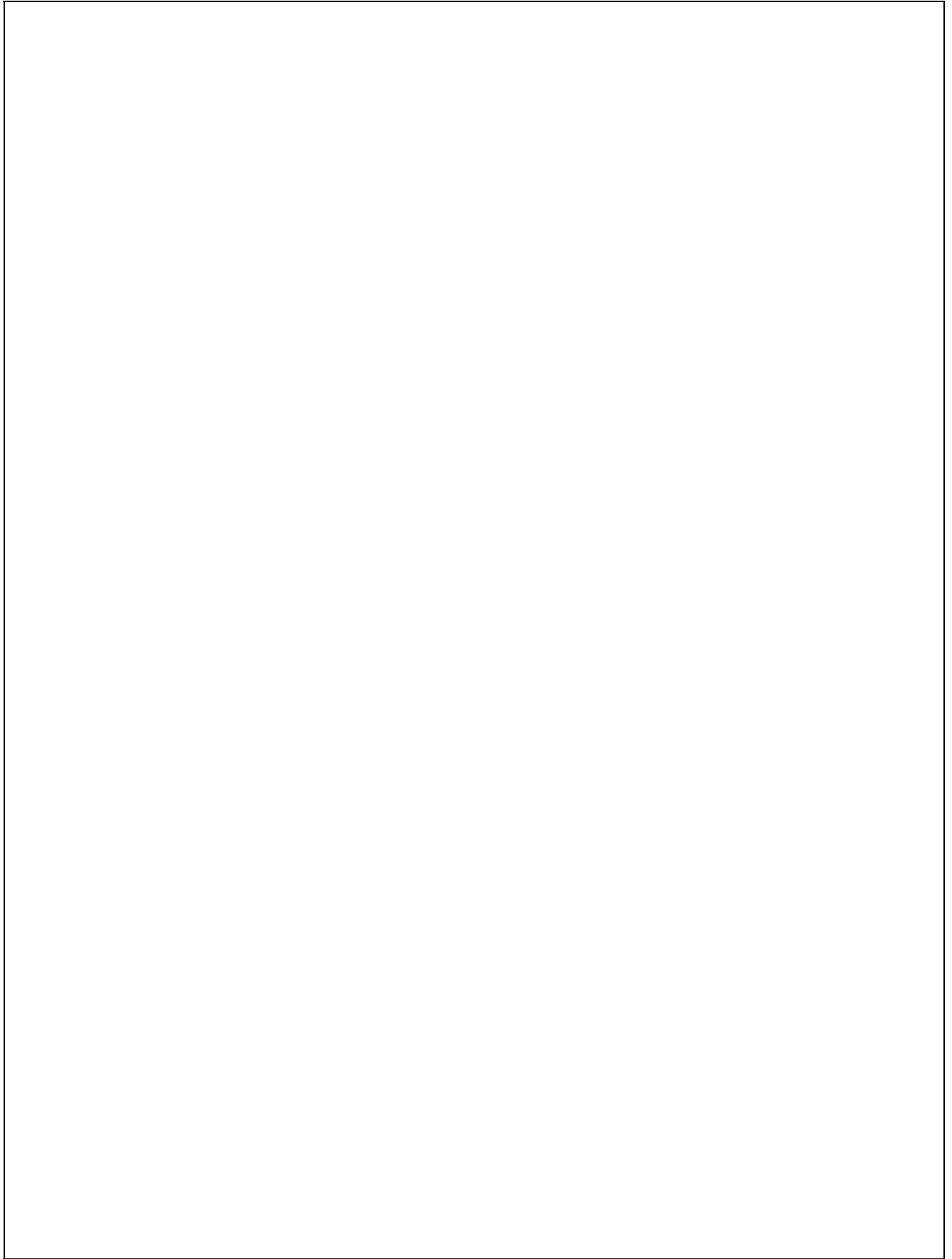


Figure 4 : Moray Firth. □ and the numeric labels indicate sites on the 20 km grid used by Proudman Oceanographic Laboratories, *see Table 3 and POL Internal Document 72.*

4.4.3 Sources of existing data and their scope

The Moray Firth Review identifies wind and waves as critical energy input sources. There are several land based weather stations which have good records of wind speeds and directions. There is very little information available on offshore winds at sea level. There is a similar gap in information on offshore wave heights/periods and direction. For a short period during the 1970's the Institute of Oceanographic Sciences recorded waves off Kinniards Head.

4.4.4 Identification of key data gaps and research, survey and monitoring needs

There has not been a co-ordinated long term approach to collecting information on waves and currents within the Moray Firth. This gap in our knowledge means that it may be impossible to assess the local affects of any global climate change.

4.5.0 Geomorphology

4.5.1 .Current Situation

The Moray Firth contains some particularly important sites which are ideal for the study of geomorphological processes. The most important of these are Morrich More, Culbin Sands and Spey Bay. Given the abundance of suitable sites for advanced studies there are numerous papers and thesis on this and related topics.

A significant proportion (65%) of the Moray Firth Coastline is protected by virtue of its SSSI status. There are not any particularly key individual reports which warrant particular attention but it is important to note that the boundary of a geomorphological site is mobile. For instance - the sand spits at Culbin and Findhorn are growing to the West and already interfere with the navigation channels of Findhorn and Nairn harbours. Complete closure of these harbours would have a dramatic affect on the quality of life of these communities.

In the long term rising sea levels may force these and similar communities to abandon all or part of their shoreline properties but during the intervening period some form of compromise over the management of the maintenance of all the navigable channels within the Moray Firth is necessary.

4.5.3.Sources of existing Data and their scope.

The Royal Commission on the Ancient and Historical Monuments of Scotland have a library of photographs, including aerial photographs, which should provide a useful source of information upon how the coast and its infrastructure have changed since the collection was started.

The Scottish Office Marine Laboratory have records of past and proposed dredging and dumping of sands and aggregates. This includes information on areas which have previously been identified as suitable for commercial dredging. The quality of the information that was used to decide these areas, and whether they would be considered suitable by today's standards is not known to the authors of this paper.

4.6.0 Geology

4.6.1 .Current Situation

Most of the rock cliffs and rock exposures along the beaches have been protected as sites of interest to science.

BGS have carried out a regional survey of the Moray Firth, collecting shallow seismic profiles and gravity and magnetic data, sea bed samples in the form of grabs, gravity cores and vibro cores, and shallow drilling boreholes. The results of these studies has been published as 1:250000 maps of:

- Solid Geology (including a Special Sheet of the Moray Firth, 1995)

- Sea bed sediments and Quaternary geology (including bathymetry)

- Gravity anomalies

- Magnetic anomalies

BGS has also produced the Moray Firth Regional Report that summarises the geology of the region. Further information, particularly for sections, is held by oil companies.

4.6.2.Key Reports and Plans

The Geology of the Moray Firth. UK Offshore Regional Report. 1990 and as above.

4.6.3.Sources of existing Data and there scope.

Chapter 2 of UK Coastal Directory- Region 3 gives a very brief but comprehensive review of the current understanding of the geology of the coast and sea bed.

BGS, oil companies (may be willing to release old data or data on shallow geology not related to exploration). BGS is now adding offshore information to coastal 1:50000 maps, including, in advanced preparation, the Banff and Portsoy sheets.

4.6.4.Key organisations and individuals involved

BGS

5. Review of Issues and Opportunities

5.1. Introduction

The whole of the coast is eroding.

There are two key issues which are likely to affect all aspects of the Moray Firth Partnership, particularly the coastal margin. They are Global Warming or Climate Change and Legislation and its effectiveness.

They have been considered separately and then how they affect all the diverse interests and parties who have an involvement or interest in the Moray Firth coast.

GLOBAL WARMING AND CLIMATE CHANGE

Increase in extreme events is likely to place vulnerable coasts at greater risk.

Sea level change will affect coastal margins.

The Topic Group have identified that there is a lack of basic information to enable decision makers to formulate policy. The financial pressure on local authorities, coupled with the ever changing political climate, means that it is extremely unlikely that a commitment can, and will, be made to fund the necessarily long term research that will be required to gather real information which can be used to test a computer model which is used to predict possible outcomes. The following topics have been identified as needing more information. It should be noted that time has precluded a thorough investigation on the nature or severity of this need.

	Comment	Opportunity
a) wave climate	A detailed and continuous data base of wave heights and directions would provide a useful indicator of any changes that are occurring. Once the core of data is established it may give sufficient time for vulnerable coasts to be re assessed and appropriate measures agreed.	The resolution of all the issues is an opportunity to improve the understanding of natural processes.
b) long term current patterns, particularly at various depths	Current patterns are useful to establish the movement of sediments, or manage emergency situations - for instance the movement of oil slicks may change direction as they oxidise and sink.	Improve our management of the coast to protect and sustain its diversity.
c) long term sedimentation patterns	The best (most effective and sustainable) protection for the coast is a beach. The stability of a beach must be affected by the offshore sediment levels, a greater understanding of sediments and the littoral drift will improve the quality of management decisions.	
d) littoral drift can result in the need to adjust boundaries.		
e) isostatic adjustment	To date the rise in sea level has been offset by rising land levels. Some scientists believe that the restoration of equilibrium has been reached and that as a consequence the land is rising at a much slower rate. If this is true a rapid rise in sea level would be much more damaging. There is a need to verify or re evaluate the change in land levels.	
f) Information on the coast to enable lengths where there is a risk from erosion or flooding to be identified is not readily available.	In the past the local authorities bordering the Moray Firth have had a reactive policy over dealing with erosion and flooding by overtopping. i.e. the high cost of coast defence schemes is such that before the councillors will agree to fund a scheme there has to be a strong demand. At present none of the local authorities are formally maintaining records or monitoring existing schemes.	Opportunity to provide a scientific basis for zoning areas; either for non development or development.
g) Closure of meteorological stations.	Despite the shortage of information a lot of information gathering stations, such as meteorology station, are being closed. This will make matters worse.	Educate and inform the decision makers to make them aware that the short term benefit of closing a station is likely to have a long term consequence.

There is an opportunity to provide a central registry/library of all the information available on the topics covered by all the topic groups of the Moray Firth Partnership.

LEGISLATION.

	Comment	Opportunity	
a)	Although some agencies have a Statutory Duty to consult widely, other agencies do not	Government at all levels is going through a period of rapid change. Technical and clerical officers are experiencing the same change so that a wealth of experience at dealing with the multiplicity of Legislation has been lost. The complexity of the existing Legislation is such that given the time and budget constraints there is a risk that important aspect will be overlooked.	Sort out the inconsistencies and tidy up the Legislation or at the very least produce a handbook/reference guide to help users to understand and follow the steps that have to be taken.
b)	Littoral drift sub cells overlap local authority boundaries. In Highland the cells overlap the five Area boundaries and at present there is no formally established co-ordinated approach to ensure that work done by one Area or Council does not adversely affect the adjacent Area or Council.	Shoreline management plans are needed but this will have to be coupled to a long term commitment to incorporate the recommendations into the Structural and Local Plans as well as a long term commitment to carry out the likely monitoring that such plans recommend.	Shoreline Management Plans to be prepared for the whole coast although there was debate in the group over the merit of this approach in terms of value for money.
c)	There is a lack of clarity over responsibility, particularly the seaward side of MLWS.		Extend Planning Regulations and Conservation beyond MLWS (<i>a mobile boundary!</i>).
d)	Coast protection schemes have reduced the supply of sediments for littoral drift, as a consequence the supply of sediment being fed into the sea from rivers has become a more important source but development along river banks is reducing the amount available and this will have a long term affect on the coastline.	Planners and decision makers must be made aware that often a simple development can have wider long term affects upon the environment.	
e)	There are no real powers to prevent development on areas of coast.	It is often cheaper for a local authority to permit development so as to avoid defending its decision in an expensive court action.	No legislation in place to enable the sea bed to be protected
f)	Very powerful lobby groups can have an undue influence on development proposals.	Dredging of a harbour, or dumping of dredged material, or the like, can be prevented by such organisations as Crown Estates (Mussel Fishing) or Salmon Fishing <u>without any public discussion.</u>	

THE ISSUES AS THEY EFFECT THE DIFFERENT INTERESTS:-

The New Councils

The need to restrain expenditure is having a marked effect upon how the recently elected Councillors allocate resources. The pressures are such that they are forced to respond to short term or the public perception of need without regard to any long term strategy. There is an opportunity for the Partnership to encourage and support the Local Authorities in educating the public on the need for and the production of long term strategic plans with regard to the coast of the Moray Firth.

Education

Among the public at large there is widespread ignorance about how the coastal process is one of continual change, particularly how this change may be affected by climate change. This is an opportunity for the educational bodies, particularly the Local Universities, to become involved with the communities and decision makers by keeping them informed on the latest research and how it is likely to affect their environment.

Coast Protection

In the past coast protection schemes have been very local in nature with little regard to the effects they are likely to have on the adjacent coastal landforms. In some instances the defences themselves have not been appropriate in that they damage the foreshore as well as protect the land behind. Many of these structures are reaching the end of their useful life.

Rising sea levels and increased storms will accelerate the deterioration of these structures and increase the damage to unprotected lengths of coast. Flooding by overtopping will become more frequent. Dealing with this damage as “emergency” or “urgently necessary” works will perpetuate the problems, represent a lost opportunity and be a waste of valuable resources.

There is an opportunity to improve the monitoring of the coastline, particularly the existing structures and the sections which are known to be vulnerable to change. Monitoring should be to an agreed minimum standard determined from the Shoreline Management Plans.

By taking a structured and long term approach to monitoring a more cost effective use of limited resources should be possible.

In the long term a holistic approach is essential with coastal defences being sustainable and flexible. There is little point to protecting the sea frontage of a links golf course, settlement or amenity area if rising sea levels and increased storms are going to cause the nearby dunes to be breached so that the whole area becomes flooded or in the extreme a tidal mud flat. The holistic approach must be all inclusive. In this respect the providers around the Moray Firth are at an advantage in that good quality rock for rock armour is available and rock armour provides good flexibility. It can be removed and re located, or added to or repaired without much difficulty.

Funding for coastal mapping is available from PESCA and possibly ERDF which provides an opportunity to obtain a detailed record of the coast if an appropriate source of matching funds can be identified.

Harbours

One of the many assets of the Moray Firth Coastline is the mix of commercial, fishing and leisure harbours. Some of these are the responsibility of the Local Authority, as Harbour Authority; other are run by a local Harbour Trust. These should be recognised as a local resource. Harbours and their management have a significant impact on the protection of the coast and its geomorphology but the Harbour Authorities are only required to obtain the approval of the Secretary of State, or his successor, without any requirement to consult with and obtain the agreement of other parties nor to take into account the sediment supply. The opportunities for bringing this and the management of the coastline are discussed in the next issue, viz. The Scottish Office.

The Scottish Office (SO)

At present the funding of coast protection schemes mitigates against a holistic and sustainable approach. Funds are not being made available for Shoreline Management Plans except where a plan recommends a hard scheme, in this situation the SO has indicated that the element of the cost of the plan which relates to the proposed hard scheme can be recovered as part of the main grant towards the cost of the scheme. In these circumstances where a Shoreline Management Plan is being prepared there is a risk that at the local authority will be influenced by the need for at least one hard scheme in order that part of the cost of the Plan can be recovered through a grant.

Although the erosion problems along the Moray Firth coastline are not as severe as those being experienced in England and Wales, a significant proportion of the Moray Firth coast has been identified as of National importance to science. These areas are sensitive and make it important that the management and maintenance of the existing and new defences pay due regard to any impact beyond the confines of that particular locus.

At present there is little or no dialogue between the agencies involved in protecting their own lengths of coast. In the absence of the Legislation being tidied up to ensure that these agencies do not undertake a scheme without the wide consultation expected of other agencies, the production of Shoreline Management Plans would ensure a limited amount of consultation. This is not entirely satisfactory unless organisations such as the MOD are persuaded to participate.

Ideally there is an opportunity to introduce Legislation which ensures that all those with an interest in the coastal zone are required to work within the strategic and local plans prepared by the Local Authorities for the coastal zones. This legislation would have to include a requirement that neighbouring Local Authorities produced plans which were compatible across their boundaries.

Bathymetry and Hydrography

It is widely accepted that the globally averaged surface temperatures are rising and that on a global scale sea levels and storm frequencies are rising. There is a serious gap in our understanding of how these changes will affect localities such as the Moray Firth and its surrounding landforms.

There is an urgent need to begin collecting information on how the mass of water in the Moray Firth behaves. This mass of water must have a local affect on the climate but it will not be possible to relate temperatures, currents and waves to weather conditions until a sufficient amount of information is available.

An opportunity exists to set up monitoring stations which would build up information on how the conditions in the Firth were changing and possibly how this related to the global changes. Not only would this be of direct benefit to the communities around the Firth but here would also be an indirect benefit as the work was made available to a wider public with a consequent increase in visitors.

Climate - (Winds and Waves)

The issue with regard to Climate is fundamentally the same as that for Bathymetry and Topography. If information is to be of value to designers, planners and decision makers it must be based upon long term records, 20 years should be considered the minimum period in order to eliminate (include) the known astronomic changes (cycles).

No long term information is available on Winds and Waves within the Moray Firth maritime area.

If, as is likely, it is not possible to establish monitoring stations to obtain a record and up to date information on wave climate and the off shore (local) wind conditions then it is essential that designers have historical information on the local coastal wind environment. Without this the design may be unrealistically conservative and therefore expensive or it may be under designed when it may fail causing loss of life and widespread damage. Furthermore if both or either average wind speeds are increasing and water levels rising then both previous and contemporary designs may become unsafe because the design is inadequate. Prudence suggests that it would be better to be aware of this danger as the record is being collated rather than during a post-mortem following a failure

If it is not possible to act on the opportunity for monitoring stations as outlined in the previous section then, if we are to be confident that future generations will have the information they need to enable their schemes to be based upon reliable information, we must not lose the opportunity to maintain an unbroken record of wind information from the land based weather stations .

At present the major tidal currents bypass the mouth of the Moray Firth and pass down the North Sea where the surge in water level can build up to be 3 m above its predicted level. This has allowed the Moray Firth coast to escape the worst effects of recent storm surges. It is possible that changes in the ocean currents brought about by changing water temperatures could slightly alter the direction of the currents entering the North Sea. If this swings them further to the North the storm surge may be partly deflected into the Moray Firth where it is likely to be particularly damaging to soft coastlines such as those at Morrich More and Culbin.

This is highly speculative and due to the protection afforded by the Shetland and Orkney Islands is extremely unlikely.

The possibility has been referred to at this stage in order to emphasise the need to monitor the way currents are changing. If this is not done it is likely that our first intimation of a change will be an extreme event, where the damage is likely to be much greater than would be the case if the service providers had been aware of the possibility of such an event.

Geomorphology and Geology

The updating of records and information is sourced through universities and the like so that the collection and collation of information is not an issue for this Topic Group . However a significant proportion of the coast has been identified as of National importance to science. Much of this is

confined to the strip of foreshore between MHWS & MLWS so that what happens to the land above MHWS is an issue in that it may impact on the SSSI..

In the extremely long term the whole coastline is eroding but within the sensible time scale that is the remit of this Topic Group local effects can be quite significant.

The position of MHWS & MLWS is not absolute, the boundary moves according to whether the foreshore is suffering accretion or erosion. This was not recognised when the boundaries of the SSSI's were being prepared or there were no facilities for dealing with this issue in the Wildlife and Countryside Act 1981. SNH now have a Legal opinion on this matter and there is an opportunity to ensure that a conflict does not arise by carrying out a review of the boundaries of the SSSI's with due regard paid to a boundary's mobility where this is applicable.

Natural Heritage

Nearly two thirds of the coastline of the Moray Firth has been identified as of importance to science. Several of these are of sufficient importance to warrant them being classed as Special Protection Areas (SPA) or Special Areas of Conservation (SAC). As an operation likely to damage features of special interest all these areas require SNH to be consulted for the "erection of sea defences or coast protection works" and the "extraction of minerals including shingle, sands, subsoil and topsoil". The exact wording varies according to the sites location.

For some of the sites, such as Longman Bay and Spey Bay, coast protection works are already in place. For the remainder it would be reasonable to assume that, unless there are exceptional circumstances, SNH would resist any proposals to carry out coast protection works or extract minerals.

Bearing in mind that the Coast Protection Act 1949 is an enabling act, the identification of two thirds of the coastline of the Moray Firth as being of National importance to science has given SNH an important role in protecting this valuable heritage resource.

Coastal Processes do not respect artificial boundaries. Work carried out updrift of a SSSI may affect the SSSI and other down drift sites. Local communities perceive that SSSI status inhibits development and prevents inward growth. With such a large proportion of the coast having special status coupled with the prospect that development of the remaining lengths will almost inevitably have some effect on an adjacent SSSI is, of itself, an issue.

Historic Heritage

The coastline of the Moray Firth contains a rich heritage of mans impact on the coast. This heritage dates back from the present day to mans first visits to the Highlands and South Moray Coast.

The built heritage is a none renewable resource, if a site is lost, its archaeological and historical information is also lost. The tourist and education potential of the site is also lost. No overall strategy exists for the recording on preservation of the Historical Heritage which is at risk from erosion and/or rising sea levels.

Historic Scotland are currently surveying from Caithness to Nairn but the report of their findings will not be available until the end of 1999.

Erosion at Dunrobin Castle and Fort George are of immediate concern but there is a paucity of funding for archaeological excavation or protection of sites subject to erosion.

This is of particular concern because generally there is a lack of awareness of historical and archaeological issues. Traces of settlement and its agriculture may be difficult for a non specialist to recognise or alternatively a twentieth century structure may not yet be recognised as of historic importance. There is a need for greater awareness of the built and archaeological heritage when planning and prioritising coastal defences. Most people would accept that it is desirable to preserve important sites and buildings but the economic justification for this is difficult to assess. It is unlikely that local authorities would consider that they could justify spending large sums of money on the preservation of an ancient site. Even if they did they would find it extremely difficult to show a benefit through a cost benefit analysis in order to persuade the SO that a scheme met its requirement and qualified for grant aid.

The public at large perceive the need to preserve our heritage but the decision makers need some guidance and a standard measure on the value of preserving a specific site. Until this guidance is available it will not be possible to prioritise the protection of heritage sites.

Again time has precluded giving statistical information on the Historical and archaeological sites within 50 m of the coast. There are also many wrecks which will contain much information on our past.

As previously stated most of the foreshore has been designated as Nationally important. For this reason there are likely to be sound scientific reasons for allowing the coast to erode. i.e., to let the natural processes prevail.

Where there is a heritage site at risk a balance will have to be reached between the need to preserve the natural heritage and the need to preserve the built heritage.

Recreation and Amenity

One of the major assets of the Moray Firth Coastline is the “natural” wild landscape. This should be recognised as a local resource.

Amenity beaches and links golf courses are also important recreational resources which provide many communities with a vital source of income. Some of these areas, such as Dornoch Golf Course and beach surfing at Fraserburgh Bay, are of international importance. Some formal footpaths exist but much of the coastline is also used informally for coastal walks, bird watching, wild fowling and horse riding.

As a rule the location of MHWS is dictated by assets on the landward side. For an amenity beach this is likely to be the community or caravan park where the visitor rests. For a coastal path it is likely to be fenced agricultural land.

Rising sea levels will result in MLWS moving inshore so that the amenity area is squeezed into a smaller space.

The degree of protection and management of these recreation and amenity areas tends to vary according to the policies and priorities of the different local authorities.

In the past, in response to strong public pressure, Highland Regional Council has undertaken the protection of golf courses. In these cases the club has been asked to contribute towards the costs. Grampian Regional Council has contributed towards the costs of coast protection schemes promoted by a Cullen and Cruden Bay Golf Club.

Similar strong public pressure can be generated by the disruption of a well used and popular footpath as a result of erosion. There is often a lot of pressure to reinstate and save the access but such measures would not be sustainable.

The local authorities are providing Countryside Rangers to manage and encourage the sensible use of amenity and recreation areas. The employment of these Rangers provides an opportunity for informal monitoring of the coastline such as keeping a regular photographic record and reporting in general terms the movement of beach levels. There is also an opportunity to improve the management of the dune structures by making them aware of best practice and training them in the skills needed to carry out beach management illustrated in the SNH Information Plants Series 5.

Soft Coasts are used by off road vehicles, this can be two, three and four or more wheeled transport. This type of use should be discouraged as it is very obtrusive to other users as well as damaging the natural environment. If they are being heavily used such coasts can also be damaged by trampling and children at play. To avoid and manage this problem there is an opportunity to work with the Tourist Industry to improve and control access to coastal areas.

Planning and Development

The Scottish Office has recently issued the long awaited Planning Policy Guidance on Coastal Planning (NPPG 13). This requires Local Authorities to have a strategic planning policy context for the coast. Based upon the principal that “in the long term, erosion of the coast is an inevitable natural process” the ideal Planning Policy should be to prevent or at the very least severely restrict further development along the coast. In the short term it is unrealistic for this generation to expect future generations to respect the zoning of areas to prohibit development. Most politicians find that the argument that “people must have some where to live” is very persuasive. Yesterdays green belt is today’s ideal site for a new town. This is a matter of population control and beyond the remit of this topic paper.

What is important is that, because of the possibility of sea level rise, the Strategic and Local Plans should identify the lengths of “hard” and “soft” coast, identify those areas at risk, particularly in the event of a sea level rise, and ensure that where development is permitted it will be the developers responsibility to provide the measures that are necessary to protect the investment. Any management strategy for the Moray Firth should include a requirement or pointer to ensure that at the time such decisions are made the long term implications of the proposals are taken into account.

Continued.....

It is recommended that the general principles with respect to development should be

1. Development which does not need a coastal location should not normally be permitted.
2. Developments which require a coastal location should generally be accommodated within the developed coast.
3. Brownfield sites should be reused instead of developing greenfield sites.
4. New development should be located to minimise its environmental impact.
5. Conservation and enhancement of the natural environment of the coast should be encouraged and the opportunities for this should be identified.
6. No decision should be made without proper consideration of its affect upon natural processes.

7. Developers must protect their own investment against erosion and flooding, preferably before the development is commissioned.
8. Where there is uncertainty about the environmental impact of a development on the natural processes the precautionary approach should be taken.

APPENDIX A

LIST OF MEMBERS of GEOMORPHOLOGY AND COASTAL DEFENCE TOPIC GROUP

Mr Peter Christie
 The Highland Council
 Roads and Transport (Structures)
 Glenurquhart Road
 INVERNESS
 IV3 5NX

Mr Shaozhong Shi,
 Environmental Science,
 University of Highlands and Islands
 Midmills Building,
 Crown Circus.
 INVERNESS

Mr Adam Craigmile
 Aberdeenshire Council
 Roads Department
 Carlton House, Arduthie Road
 STONEHAVEN
 AB39 2DP

Ms S Warbrick
 Scottish Natural Heritage
 32 Reidhaven Street
 ELGIN
 IV30 1QH

Mr Keith Stratton
 Moray Council
 Roads Department
 Highfield House, South Street
 ELGIN
 IV30 1NF

Other contributors

Mr R Tabony,
 Metereological Office
 Glasgow

Dr N Fannin and Dr Dan Evans,
 Petroleum and Marine Geological Group,
 British Geological Survey,
 Edinburgh

Appendix B

BIBLIOGRAPHY

This is an extract of the Bibliography from The Moray Firth Review to list titles relevant to Geology, Geomorphology and Coast Protection. Additions to this Bibliography have been indicated thus - ''*

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APPENDIX C

POSSIBLE OVERLAPPING INTERESTS WITH THE GEOMORPHOLOGY AND COASTAL DEFENCE GROUP. LISTED BY TOPIC GROUP.

Information, Research and GIS

There is a need for more information on offshore waves and tidal currents to allow for more accurate assessment of design criteria and a better understanding of how this influences the formation of sand spits etc..

There is a need to establish monitoring of the coastline on a more formal basis.

Land use.

The recently issued Planning Guidance Note NPPG 13 should include the under noted provisions.

Development should not interfere with geomorphological process's.

There should be a presumption against development along the coast but where development on the coast is permitted there should be a buffer zone to allow for any future change in the shape of the coastal margin.

Information on Land use was difficult to obtain. Once the effects of NPPG13 have become established the information will provide pointers for the need to maintain the existing, or provide new, coastal defences.

Economic Development

Those planning for economic development should be aware that the whole of the coast is eroding. Erosion Patterns will have an impact upon the potential for Economic Development along the coastal Margin.

There should be a presumption against development along the coast but where development on the coast is permitted there should be a buffer zone to allow for any future change in the shape of the coastal margin.

Environmental Quality

(Link with Information, Research) Information on currents and tidal streams to enhance the understanding of the affects of sea outfalls. A lot of remote communities used to dump their rubbish on the foreshore hinterland, this, and the continuing problem of illegal tipping, is a potential problem of pollution. Risk and need for Coastal defences should be assessed.

Tourism

There is a demand to protect tourist infrastructure such as golf courses; any development must be sustainable, not interfere with geomorphological process's, and be sympathetic to the landscape vistas.

Education and Interpretation

Education and Interpretation should always include how the landscape was formed and how this has affected Economic Development. This can include the need to protect developed areas from the ravages of coastal storms, tidal surges and rising sea levels.

Natural Heritage

The coast should be allowed to continue to evolve, any development should not interfere with geomorphological process's

Fisheries.

Improved understanding of currents and the movement of sea bed sediments would improve the understanding of the behaviour and conservation of fish.

Development of the Management Strategy.

The Management Strategy should include a strategy for managing the coast line and its defence. This can include existing and proposed Shoreline Management Plans.

Community Involvement

Storm damage is highly emotive for local communities, particularly where there is an influx of peoples who are not familiar with the forces of nature and the damage that can be inflicted. (Link with Education and Interpretation) Any management strategy must necessarily work with and educate local communities so that they fully understand the issues and are able to participate in the decision making.

Sport and Recreation

No real overlap other than the possible impact of Coastal Defences on Sport and Recreation and the possible impact of Sport and Recreation on sensitive areas, particularly the use off mountain bikes, motor bikes and all terrain vehicles. See Tourism.

Built Heritage & Archaeology.

A lot of important Built Heritage and Archaeology sites are on the coast and vulnerable to loss or damage. If these are to be preserved they need to be identified and the need for protection prioritised and funded. Local Authorities are unlikely to be able to undertake responsibility.

APPENDIX D

Types of coast protection structures.

APPENDIX E**ROUTINE DREDGING**

Location	Volume	Frequency
Wick Harbour		1 year
Helmsdale Harbour		
Portmahomack		
Balintore Harbour		
Invergordon Harbour		
Avoch Harbour?		7 years
Inverness Harbour		7 years
BARMAC Channel		2/3 years
Nairn Harbour		2/3 years
Findhorn Harbour		
Burghead Harbour		4/6 months
Hopeman Harbour		1 year
Lossiemouth Harbour		12/24 months
Buckie Harbour		6 months
Findochty Harbour		12/24 months
MacDuff Harbour		1 year
Fraserburgh		

APPENDIX F

Coast protection Structures maintained by coast protection authority.

Area	Location (Place Name)	OS Grid Ref.	Longitude.		Latitude		Length	Type	Description	Monitor frequency	
			°	'	°	'					
Sutherland											
	LOWER BRORA	NC91020360	3	50.48	58	0.85			4	ROCK ARMOUR.	12
	GOLSPIE GOLF COURSE	NH82769952	3	59	57	58.5	900		3	ROCK ARMOUR REVETMENTS.	36
	GOLSPIE PIER & S W	NH82969963	3	58	57	59	0		3	PIER ACTING AS A LARGE GROIN .	12
	BRORA, GEORGE ST.	NC90920388	3	56.61	58	1	0		2	GABION BASKETS .	24
	EMBO	NH81809300	3	59.95	57	54.86	0		3	EROSION OF COASTAL EDGE.	36
	HELMSDALE	ND03701543	3	38.65	58	6.91	230		3	BUILDERS WASTE	60
	PORTGOWER	ND01331365	3	40.66	58	5.97	0		3		6
	DUNROBIN CASTLE - N	NC85790095	3	56.51	57	58.81	710		3	ANCIENT SEA WALL	36
	DUNROBIN CASTLE - S	NC85180064	3	56.51	57	58.81	310		3	ANCIENT SEA WALL	36
	FOOTPATH - DUNROBIN	NC84940045	3	57	57	58.59	0		3		0
	GOLSPIE TOWN	NH83969999	3	58	57	58.48	0		3	ROCK ARMOUR + CONC. SEA WALL	12
	LITTLEFERRY	NH80609568	1	56.09	57	56.09	0		3	BOULDERS LIFTED FROM SHORE	84
	MOUND C'WAY, (A9).	NH77579822	4	4.27	57	57.47	820		1	ROCK ARMOUR.	36
	SKELBO,	NH80069500	4	1	57	55.92	100		2	ROCK ARMOUR	60
	DORNOCH G COURSE	NH81459185	4	0.7	57	53.47	600		3	ROCK ARMOUR	48
	DORNOCH BR., (A9), N	NH74828637	4	6.53	57	50.84	170		1	ROCK ARMOUR	60
	DORNOCH BR., (A9), S.	NH74838473	4	6.62	57	50.1	1,438.00		1	ROCK ARMOUR .	60
	BONAR BRIDGE - CREICH (A9)	NH63408941	4	18.35	57	52.47	168		2	ROCK ARMOUR	0
	BONAR BRIDGE NORTH	NH61009122	4	20.71	57	53.4	0		5	RIVER WALL	60
	BONAR BRIDGE SOUTH	NH60869147	4	20.86	57	53.46	23		2	ROCK ARMOUR .	72
	MEIKLE FERRY (U1/3)		0	0	0	0	0		2	EROSION OF COASTAL EDGE.	0
	LOCH FLEET - S - (C7)	NH77049700	4	4.78	57	57.03	0		3	ROCK ARMOUR.	0
	BRORA GOLF COURSE	NC91850698	3	50.36	58	1.03	0		3	SLEEPER WALLS	12
	GOLSPIE, CLADDACH	nc84060007	3	57.66	57	58.49	0		3	ROCK ARMOUR	12

APPENDIX F

Coast protection Structures maintained by coast protection authority.

Area	Location (Place Name)	OS Grid Ref.	Longitude.		Latitude		Length	Type	Description	Monitor frequency
			o	'	o	'				
Ross & Cromarty										
1 of 3	POLLO - OLD MILL HOUSE	NH74667188	4	5.86	57	43.49	50	3	ROCK ARMOUR	18
	SHANDWICK BAY	NH86167534	3	54.35	57	45.32	113	5	EROSION OF COASTAL EDGE.	24
	CROMARTY - SHORE STREET	nh78606778	4	2	57	40.5	162	3	ROCK ARMOUR .	36
	FORTROSE.	NH73735622	4	8	57	35	0	3	ANCIENT MASONRY WALLS,	48
	SALTBURN, INVERGORDON	NH73177033	4	7.35	57	42.65	0	3	INTERMITTENT ROCK ARMOUR	24
	INVERGORDON WEST (AMENITY AREA)	NH70156857	4	10.45	57	41.7	0	6	INTERMITTENT ROCK ARMOUR.	60
	FORTROSE & ROSEMARKIE GOLF COURSE	NH74075672	4	37	57	35	1,180.00	3	GABIONS, CONCRETE SLABS, ETC.	12
	CROMARTY - SUTERS FOOTPATH	NH79396729	4	2	57	40.5	0	3	ANCIENT PAVING STONE WALL + GABION WALL	36
	DINGWALL	nh55725903	0	0	0	0	0	3	FLOOD WALL	0
	BALNABRUACH	NH90668405	3	51	57	50	0	3	GABIONS WITH TIMBER FACING .	12
	JEMIMAVILLE	nh71626513	4	8.5	57	40	0	3	EROSION OF LOW GROUND,	24
	MEIKLE FERRY, (U1/3)	NH73238590	0	0	0	0	0	3	EROSION OF LOW EMBANKMENT	90
	TAIN - SEWAGE WORKS AND OLD TIP	NH77778287	0	0	0	0	0	3	EROSION OF LOW COASTAL BANK .	6
	TAIN - PLAIDS	NH78498249	0	0	0	0	800	3	OFFSHORE BREAKWATER .	24
	PORTMAHOMACH	NH91208415	0	0	0	0	0	3	ROCK ARMOUR	48
	ROCKFIELD	NH92408296	0	0	0	0	50	3	ROCK ARMOUR	24
	HILTON OF CADBOLL	NH87537684	3	53	57	46.14	1,300.00	5	ROCK ARMOUR .	24
	BALINTORE	NH86397554	3	54	57	45.43	29	3	PATENT CONCRETE BLOCK PROTECTION	12
	INVER	NH86038246	3	55.67	57	49.2	600	5	ROCK ARMOUR	36
	NIGG ROAD (B9175)	NH795-715-	0	0	0	0	0	2	EROSION	0
	BARBARAVILLE, (U1/55)	NH75647259	4	4.91	57	43.86	280	2	EROSION OF COASTAL EDGE.	36

APPENDIX F

Coast protection Structures maintained by coast protection authority.

Area	Location (Place Name)	OS Grid Ref.	Longitude.		Latitude		Length	Type	Description	Monitor frequency
			°	'	°	'				
Ross & Cromarty (continued)										
2 of 3	POLLO TO BALINTRAIT, (B817)	NH74467177	4	6.53	57	43.43	594	2	MASONRY SEA WALL.	48
	BALINTRAIT	NH74177119	4	6.32	57	43.12	0	3	OVERTOPPING	36
	BALINTRAIT TO SALT BURN, (B817)	NH73977099	4	6.56	57	43	0	2	MASONRY SEA WALL	0
	INVERGORDON, EAST, (B817)	NH72186933	4	8.4	57	42.11	0	2	ROCK ARMOUR	60
	ROSSKEEN BRIDGE(B817)	NH69606893	0	0	0	0	0	2	ROCK ARMOUR	72
	BELLEPORT (B817)	NH67906897	0	0	0	0	118	2	SEA WALLS	72
	BALCONIE POINT FOOTPATH, ALLT GRAAD	NH62716600	0	0	0	0	0	3	EROSION OF LOW GROUND	0
	EVANTON (A9T)	NH60506450	0	0	0	0	0	1		0
	FOULIS POINT AMENITY AREA (B817)	NH59976370	0	0	0	0	250	9	EROSION OF LOW COASTAL BANK .	0
	ARDULIE POINT TO CHALYBEATE WELLS	NH58836219	0	0	0	0	0	2	INTERMITTENT SEA WALLS .	60
	ST BRIGHS CHAPEL AT WATERLOO BY DIN	NH57796164	0	0	0	0	0	3	EROSION OF LOW GROUND	0
	KINCRAIG BY DINGWALL	NH57036100	4	23.67	57	36.95	0	3	UNDERMINING OF RETAINING WALL	24
	BALLOAN (B9163)	NH58305910	0	0	0	0	0	3		0
	CROMARTY BRIDGE, SOUTH (A9T)	NH59256030	0	0	0	0	0	3	ROCK ARMOUR	0
	BALBLAIR (U3/23)	NH70206710	0	0	0	0	0	3	EROSION OF LOW GROUND	0
	JEMIMAVILLE TO CROMARTY (B9163)	NH71396522	0	0	0	0	0	2	SEA WALLS	0
	CROMARTY, BURNSIDE COTTAGE & CLUNES	NH79186734	4	1.5	0	0	0	3	ANCIENT SLOPING MASONRY SEA WALL	24
	ROSEMARKIE, MARINE TERRACE AND CARA	NH73895809	0	0	0	0	0	2	SEA WALL + GABION WALL	60
	AVOCH TO FORTROSE (A832)	NH71905605	4	10	57	34.25	0	2	MASONRY SEA WALL	0
	AVOCH SEA WALL	NH70425509	0	0	0	0	0	2	CONCRETE SEA WALL	60

APPENDIX F

Coast protection Structures maintained by coast protection authority.

Area	Location (Place Name)	OS Grid Ref.	Longitude.		Latitude		Length	Authority	Description	Monitor frequency
			°	'	°	'				
Inverness										
	ARDERSIER	NH78005500	4	3	57	34.5	0	5	ROCK ARMOUR	12
	BUNCHREW HOUSE H	NH61584600	4	19.07	57	29.17	0	3	EROSION OF LOW COASTAL BANK .	36
	ACCESS ROAD TO EAST LONGMAN,	NH66354693	4	14.3	58	29.68	870	2	ROCK ARMOUR).	0
	A862 - PHOPACHY SEA WALL	NH60134613	4	20	57	29	0	2	DETAILS NOT KNOWN	0
	A862 - SEA WALL (CLACHNAHARRY)	NH63604605	4	18	57	29	0	2	MASONRY SEA WALL	0
	CLACHNAHARRY, LOW STREET	NH64574652	0	0	0	0	0	3	SEA WALL + ROCK ARMOUR .	6
	SOUTH KESSOCK	NH65024650	0	0	0	0	800	8	OLD SEA WALL + ROCK ARMOUR	6
	LONGMAN WASTE DISPOSAL TIP	NH67424716	4	12.71	57	29.74	0	6	ROCK ARMOUR .	0
	MILTON OF CULLODEN (U36)		0	0	0	0	0	0	OLD MASONRY WALL.	0
	ALTURLIE POINT SEA WALLS (U87)		0	0	0	0	0	0	GABION WALLS.	6
	FORT GEORGE		0	0	0	0	0	10	ANCIENT MASONRY WALLS + GABION BASKETS.	0
	BEAULY	NH55004800	4	25	57	30	0	3	FLOOD BANKING	0
Nairn										
	NAIRN GOLF COURSE	NH84755673	3	56.1	57	34.91	0	3	ROCK ARMOUR.	24
	NAIRN WEST BEACH	NH86835692	3	53.5	57	35.35	4,000.00	3	ROCK ARMOUR + GABIONS AND GROINS .	6
	NAIRN EAST BEACH	NH88935728	0	0	0	0	0	3	LARGE SAND DUNE.	6

APPENDIX F

Coast protection Structures maintained by coast protection authority.

Area	Location (Place Name)	OS Grid Ref.	Longitude.		Latitude		Length	Type	Description	Monitor frequency
			°	'	°	'				
Aberdeen'ire										
	SANDEND HARBOUR									
	SANDEND BEACH									
	PORTSOY									
	PORTSOY LINKS									
	WHITEHILLS, WEST									
	WHITEHILL HARBOUR									
	BOYNDIE BAY									
	BANF LINKS									
	BANF HARBOUR									
	BANF SCOTSTOWN									
	MACDUFF									
	MACDUFF, UNION ROAD									
	MACDUFF HIGH SHORE									
	GARDENSTOWN, WEST									
	GARDENSTOWN EAST									
	CROVIE VILLAGE									
	PENNAN VILLAGE									
	PITNULIE VILLAGE									
	SANDHAVEN WEST									
	SANDHAVEN HARBOUR									
	FRASERBURGH									
	FRASERBURGH BAY									
	CAIRNBULG									
	INVERALLOCHY									

APPENDIX G

Coast protection Structures maintained by other agencies.

Area	Location (Place Name)	OS Grid Ref.	Longitude.	Latitude	Length	Type	Description	Monitor frequency
Caithness								
Roads Auth.	See Appendix F							
Trunk R	A9							
NOSWA								
Wick Harbour								
Commercial	Rockwater Ltd, Pipes							
Private	Wick Castle					Monument ?		
MOD								
Sutherland								
Roads Auth'y	See Appendix F							
Trunk R	MOUND C'WAY, (A9).	NH77579822	4 4.27	57 57.47	820	1	ROCK ARMOUR.	36
Trunk R	DORNOCH BR., (A9), N	NH74828637	4 6.53	57 50.84	170	1	ROCK ARMOUR	60
Trunk R	DORNOCH BR., (A9), S.	NH74838473	4 6.62	57 50.1	1,438.00	1	ROCK ARMOUR .	60
NOSWA	BONAR BRIDGE N	NH61009122	4 20.71	57 53.4	0	5	RIVER WALL	60
Railway	BRORA, LOTHBEG							
	Portgower ?							
	Brora, Lothbeg							
	Dornoch Firth							
Commercial	Lower Brora							
Private								
MOD								
Ross & Cromarty								
Trunk R	EVANTON (A9T)	NH60506450	0 0	0 0	0	1		0
NOSWA	SHANDWICK BAY	NH86167534	3 54.35	57 45.32	113	5	EROSION OF COASTAL EDGE.	24
NOSWA	HILTON OF CADBOLL	NH87537684	3 53	57 46.14	1,300.00	5	ROCK ARMOUR .	24
NOSWA	INVER	NH86038246	3 55.67	57 49.2	600	5	ROCK ARMOUR	36
NOSWA	Tain Sewerage works							

APPENDIX G

Coast protection Structures maintained by other agencies.

APPENDIX I

Glossary

Accretion	Build-up of material solely by the action of the forces of nature by the deposition of water- or airborne material.
Alongshore	see longshore .
Armour layer	Protective layer on rubble-mound breakwater composed of armour units.
Artificial nourishment, beach replenishment/recharge, beach feeding	Supplementing the natural supply of beach material to a beach , using imported material.
Bathymetry	The science of sounding the topography of sea/estuary/lake bed.
Beach	By common usage, the zone of beach material that extends landward from the lowest water line to the place beyond the high water line, where there is a marked change in material or physiographic form, or to the line of permanent vegetation.
Coastal defences, coastal works	Collective terms covering protection provided to the coastline. These include coast protection and sea defences .
Coastal processes	Collective term covering the action of natural forces on the coastline and adjoining seabed.
Coastal regime	The overall system resulting from the interaction on the coast and seabed of the various coastal processes .
Coast protection	Works to protect land against erosion or encroachment by the sea.
Deep water	Water so deep that waves are little affected by the bottom. Generally, water deeper than one half the surface wave length is considered to be deep water .
Design storm	Seawalls will often be designed to withstand wave attack by the extreme design storm. The severity of the storm (i.e. return period) is chosen in view of the acceptable level of risk of damage or failure.
Downdrift	The direction of predominant movement of littoral drift along the shore.
Erosion	The wearing away of material by the action of natural forces.
Fetch	Relative to a particular point (on the sea), the area of sea over which the wind can blow to generate waves at the point.
Foreshore	The part of the shore lying between high water mark and low water mark (see tides).
Geomorphology	The science of the form, especially the outer form, of land including that under the sea.

Geology	Science of the earth's crust, its strata and relationships.
Groyne	A structure generally perpendicular to the shoreline built to control the movement of beach material .
Hydrography	The investigation of seas and other bodies of water including charting, sounding, study of tides, currents, etc..
Littoral drift, littoral transport	The movement of beach material in the littoral zone by waves and currents. Includes movement parallel (longshore transport) and perpendicular (onshore-offshore transport) to the shore.
Littoral zone	Beach and surf zone.
Longshore	Along the shore.
Maintenance	Repair or replacement of components of a structure whose life is less than that of the overall structure, or of a localised area which has failed.
Morphology	River/estuary/lake/seabed form and its change with time.
Overtopping	Water passing over the top of the seawall.
Revetment	A revetment is a cladding applied to a sloping surface of an embankment, natural coast or shoreline to stabilise and protect it against erosion by currents and wave action. The cladding can be of stone, dressed stone, in situ concrete, precast concrete units or other material. Rock armour walls and revetment structures are all sloping structures. A rock armour walls will absorb most of the wave energy without the problems associated with the reflection characteristics of vertical walls. It generally consists of an armour layer & an underlayer with a geotextile membrane between the underlayer & the formation. The underlayer should consist of granular material to allow free drainage under the armour layer.
Rip-rap	Wide-graded quarry stone normally used as a protective layer to prevent erosion . No longer considered good practice since the smaller stones become displaced which eventually allows the larger stones to move/ be displaced.
Rock Armour	Usually closely graded (uniformly sized) large stones (>1 te) placed so they lock together.
Sea defences	Works to prevent or alleviate flooding by the sea.
Storm surge	A rise in water ' level in the open coast due to the action of wind stress as well as atmospheric pressure on the sea surface.

Tides

(1) *Highest astronomical tide (HAT), lowest astronomical tide (LAT)*: The highest and lowest levels, respectively, which can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions. These levels will not be reached every year. HAT and LAT are not the extreme levels which can be reached, as storm surges may cause considerably higher and lower levels to occur.

(2) *Mean high water springs (MHWS), mean low water springs (MLWS)*: The height of mean high water springs is the average, throughout a year when the average maximum declination of the moon is $23\frac{1}{2}^{\circ}$ of the heights of two successive high waters during those periods of 24 hours (approximately once a fortnight) when the range of the tide is greatest. The height of mean low water springs is the average height obtained by the two successive low waters during the same periods.

(3) *Mean high water (MHW), mean low water (MLW)*: For the purpose of this manual, mean high water, as shown on Ordnance Survey Maps, is defined as the arithmetic mean of the published values of mean low water springs and mean low water neaps. This ruling applies to England and Wales. In Scotland the tidal levels shown on Ordnance Survey Maps are those of mean high (or low) water springs (MH (or L) WS).