JOINT NATURE CONSERVATION COMMITTEE

Classification of benthic marine biotopes of the north-east Atlantic.

Proceedings of a BioMar-Life workshop held in Cambridge.

16-18 November 1994.

Edited by Keith Hiscock

Joint Nature Conservation Committee, Monkstone House, Peterborough PE1 1 JY, UK

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The project is led by the National Parks and Wildlife Service, Dublin, Ireland. Partners in the project are: Trinity College, Dublin, Ireland; Joint Nature Conservation Committee, UK; University of Newcastle-upon-Tyne, UK; AIDEnvironment, Netherlands.

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Classification of benthic marine biotopes of the north-east Atlantic.

University Arms Hotel, Cambridge, 16-18 November 1994

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Preface

Conservation science has developed mainly in relation to the conspicuous pressures and extensive habitat loss on land. Only in comparatively recent years have we in Britain seen the need to conserve wildlife in the marine environment. As a nation with so much sea and such varied marine habitats, it was appropriate to establish a dedicated team reviewing our marine wildlife resource. The Marine Nature Conservation Review was initiated in 1987 after several years of marine conservation surveys under the Nature Conservancy Council. As a part of the re-organisation of the statutory nature conservation agencies in Great Britain in 1991, the MNCR was placed in the support unit of the Joint Nature Conservation Committee - the forum through which the nature conservation agencies in Great Britain together with representation from Northern Ireland ensure the maintenance of common standards as well as dealing with issues relevant to Great Britain as a whole or internationally.

In such a position, the MNCR were well-placed to work with colleagues in Europe and to match their own work against new activities which could be funded by the European Union LIFE Fund. The BioMar project was awarded funding in 1992 to develop methods and collect information which would underpin marine conservation particularly in Great Britain and Ireland. Their partners in undertaking this work are the National Parks and Wildlife Service in Dublin, Trinity College Dublin, the University of Newcastle-upon-Tyne and AIDEnvironment in the Netherlands.

Of central importance to underpinning nature conservation on land is information on the types of habitats present, where they occur, which are the best examples and what activities most threaten them. Such information requires structure and simplification and this is undertaken through systems of classification. Management and conservation in the marine environment requires a similar basis from which to work and this meeting will build on the pioneering studies being undertaken by the Marine Nature Conservation Review to pursue the development, with your help, of a system which will work throughout the north-east Atlantic.

Why do we need a specifically marine classification? Looking at existing classifications, it is clear that, although we can use terrestrial classification systems as models, they have been based on plant cover and - of the many differences between land and sea - plant cover exists only in shallow depths in the sea and, even on the shore, the assemblages of species present are often dominated by animals. Indeed, the most thoroughly and quantitatively documented marine communities are the animals which live in sediments. It is also important that the structuring forces which lead to the development of different assemblages of marine species are different to those of the land. Although a provisional marine classification exists in the European Union CORINE (Co-ORdination of INformation on the Environment) project, it has many gaps. However, a way forward to develop a more fitting classification still linked to CORINE was agreed at a BioMar workshop held at Monks Wood in May 1993.

Many contributors to this meeting have been involved in some way in the identification of candidate 'Special Areas of Conservation' under the European Commission Directive on the conservation of natural habitats and of wild flora and fauna (the 'Habitats Directive'). The marine habitat types listed in the Directive have caused great interpretational difficulties and it is to be hoped that European marine biologists can, through exercises such as this, provide a more meaningful support for future Directives or other activities centred on the work of the Commission.

The workshop is being held at a time when the European Environment Agency is being established and, at such an early stage in the development of the agency, it has not been possible to obtain representation at this meeting. Conveying the results of this workshop to them and ensuring full collaboration over the development of a classification to link with their initiatives will be a high priority for the Marine Nature Conservation Review.

The meeting will aim to obtain an agreed framework to take forward the development of a classification. There are bound to be problems - from the philosophical to the practical - in developing such a classification but the aim of the meeting includes finding answers to those problems. Participants have primarily been invited as experienced benthic marine biologists and it is important that they take the outcome of this meeting back to colleagues in their country and ensure that, in an eventual classification, no habitat of key importance from each country is missed.

Apart from contributing to the development of a classification, the meeting should be the start of a process which will involve participants and others in setting standards which will underpin marine nature conservation in the waters of the north-east Atlantic. The process will involve a communications network and a further workshop in September 1995.

Based on the opening address by the Earl of Selborne KBE FRS

The BioMar (Life) project: developing a system for the collection, storage and dissemination of marine data for coastal management

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Introduction

The concentration of human activities in the coastal zone, and the often divided responsibilities of authorities for the sea and land elements of the coast, has resulted in a demand for an integrated approach to coastal zone management. The basis of such management is the availability of environmental information in an accessible and structured framework. Computerised databases and Geographical Information Systems (GIS) can store information collected from maps, literature, and field surveys, but they are only accessible to specialists. It is therefore essential that information can be extracted from such databases and published in an electronic form accessible to a wide range of people (e.g. authorities, the public, scientists).

In conservation management, areas are prioritised for protection on the basis of information on the species present. The occurrence of habitats and communities (together called biotopes) is used to indicate a suite of areas which are likely to cover the range of species known to occur in the region. From within a group of comparable biotopes, it is often desirable to identify areas of high biodiversity so that these may be awarded greater protection from human disturbance. To ensure comparability between biotopes, methods of field survey and data analysis must be standardised as much as possible. A classification of biotopes is also required for this comparison, and a terrestrial classification has been developed for Europe within the European Union Co-ordination of information on the environment (CORINE) programme (Devillers *et al.* 1991). From this classification, biotopes were selected for inclusion in the EU Habitats Directive which legally requires member states to protect representative examples of these biotopes occurring within their territory. However, CORINE did not develop a classification of marine biotopes, and current marine areas are limited to some physiographic features (e.g. cliffs and rocky shores, mudflats and sandflats, sea inlets) and plant habitats (e.g. *Posidonia* beds) which were primarily selected for importance to birds or plants. In addition to facilitating comparisons between biotopes, a classification permits biotope mapping and the identification of rare biotopes. A classification of marine biotopes is therefore required as a tool in the mapping and conservation of marine ecosystems.

The BioMar project is developing a system for the collection, storage, analysis, classification, and dissemination of marine ecological and environmental data for coastal management (Figure 1). This system is being demonstrated with data collected in Britain and Ireland (Costello 1993, Sides *et al.* 1995), and it is intended that it will be applicable to other European countries. Although the immediate aim of the BioMar system is to assist management in the identification of marine areas of conservation value (e.g. high biodiversity), it is envisaged that the results will also have relevance for the management of other coastal resources.

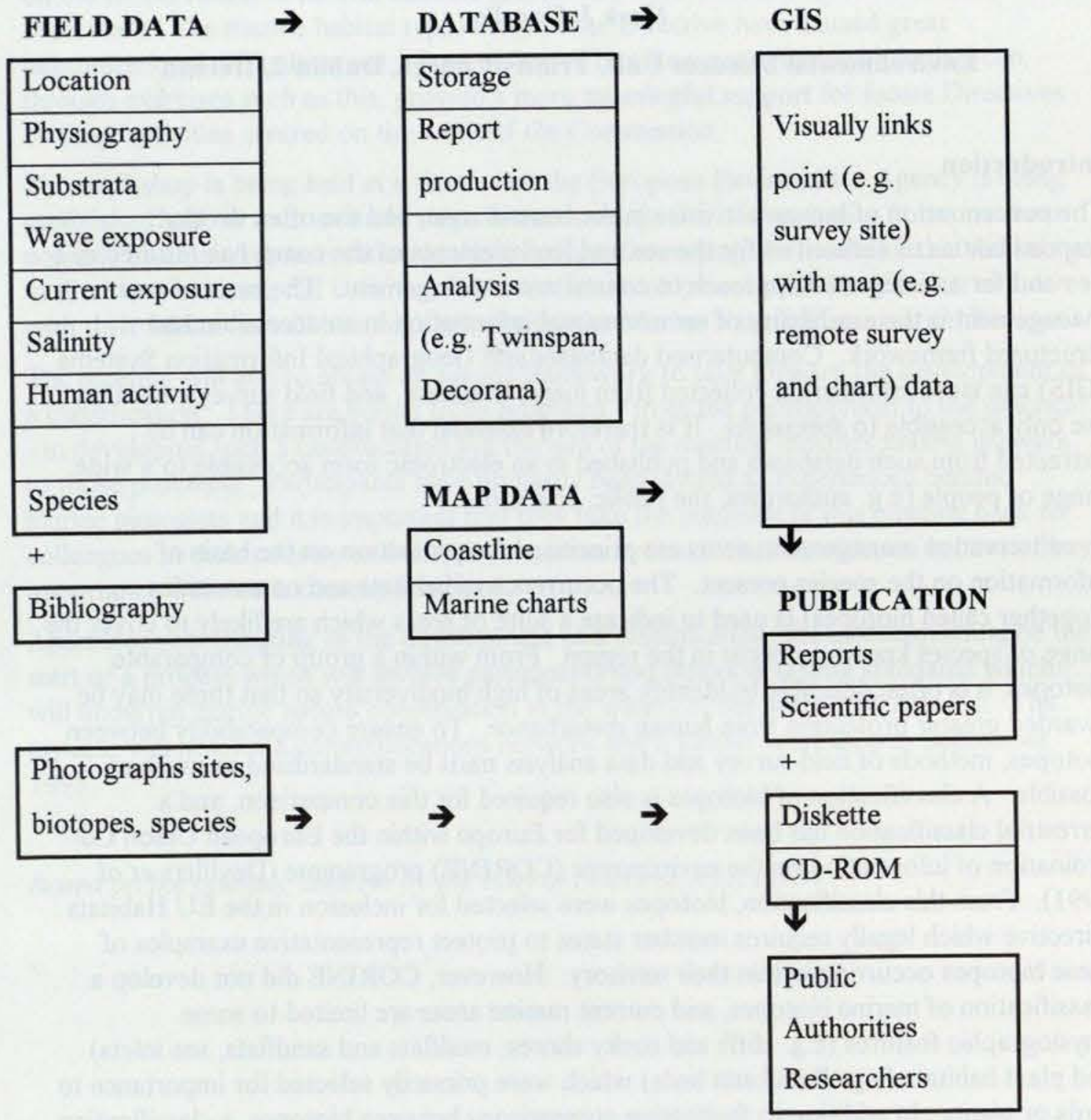

Figure 1. Schematic outline of the BioMar system for collection of field and other data, data storage and analysis (including development of classification of marine biotopes), and dissemination through publication on paper and electronic media.

BioMar originated from discussions between Dr Keith Hiscock (Joint Nature Conservation Committee, UK) and Dr Mark J. Costello (Trinity College Dublin, Ireland) concerning the need for field data and a biotope classification system to facilitate marine conservation management in Britain and Ireland. These discussions were promoted by reviews of current classification systems and how they may be developed by Hiscock (1991) and Hiscock and Connor (1991). The name BioMar arose from the focus of the project on marine biotopes. In conjunction with Dr Bob Foster-Smith (University of Newcastle-upon-Tyne, UK) and representatives of the National Parks and Wildlife

Service (Ireland) an application was prepared and submitted to the European Union (EU) for part-funding under the NORSPA (NORthern Seas Protection Action) programme. This programme was subsequently incorporated into LIFE, an EU programme within Directorate General XI (Environment) which funds measures contributing to environmental management. On the request of the EU, a fifth partner, AIDEnvironment (The Netherlands), joined BioMar. Within LIFE, and in comparison with EU marine science contracts, BioMar is a large project. It has a total budget of about 5 mECU, and runs for over four years (began in late 1992, final report mid-1997).

Tasks and results

The National Parks and Wildlife Service are the Administrative Co-ordinator of BioMar and conduct all liaison with the EU. Scientific Co-ordination is by Dr Mark J. Costello of Trinity College Dublin, and each partner leads certain tasks in BioMar. The main scientific tasks (and the partner with primary responsibility) are to:

- Develop a marine biotopes classification (JNCC);
- Survey maritime biotopes in Ireland (NPWS);
- Survey marine biotopes in Ireland (TCD);
- Assess remote survey methods (Newcastle);
- Develop computerised data storage, analysis, and dissemination systems (TCD with JNCC);
- Review marine protected areas in Europe (AID Environment).

By field surveys in inshore waters (usually < 5 km from shore and < 50 m deep), information is collected on inter-tidal and sub-tidal marine biotopes from Britain and Ireland. The field surveys methods are based on direct observation by ecologists, using SCUBA where necessary, but include photography and sediment sampling for infauna and granulometric analysis. The survey methods build on the experience of the completed marine subtidal (Erwin *et al.* 1990) and intertidal (Fuller *et al.* 1991) surveys of Northern Ireland, and surveys of Britain which have been in progress since the establishment of the Marine Nature Conservation Review (now within JNCC) in 1987 (Hiscock 1990). To date, 22 marine areas in Britain and 9 areas in Ireland have been surveyed by JNCC and TCD (respectively) as part of BioMar (e.g. Hill *et al.* 1993, Mills *et al.* 1993, Brazier & Murray 1994, Connor 1994a, Davies 1994, Davies & Connor 1994, Holt 1994, Howson *et al.* 1994). Surveys within the BioMar programme will be completed in September 1996.

The field information is used to

a. develop and demonstrate methods for data collection

b develop a classification of marine biotopes which will be applicable to inshore areas of the north-east Atlantic (but not the Baltic and Mediterranean Seas)

c. identify areas of marine conservation importance (e.g. Costello 1993). Through the concurrent survey of maritime (i.e. land by the sea) areas of conservation importance in Ireland, the feasibility and value of linking maritime and marine areas within the same conservation area will be explored. The survey of maritime areas in Ireland has been completed.

The classification of benthic marine biotopes will form the basis for describing, mapping and comparing the conservation value of inshore marine areas (Connor 1994b) and builds on earlier reviews of marine classifications (Hiscock 1991, Hiscock and Connor 1991). To ensure the classification will have wide application in the north-east Atlantic, its development is communicated through publication and presentations at meetings (e.g. Laffoley & Hiscock 1993, Pearson *et al.* 1994, Connor *et al.* in press). As part of BioMar, several meetings and workshops have been held with European specialists in marine ecology and management in which the background, design, and preliminary results of the developing classification were discussed, and modified as necessary. In 1993, such meetings were held with:

a. CORINE;

b. ZNIEFF-Mer (a marine fauna and flora inventory and zoning system being developed in France);

c. with scientists from 11 European countries at the European Marine Biological Symposium (Appendix 1).

The meeting with CORINE divided the existing marine related CORINE biotope codes into two types:

i. Physiographic, and

ii. Biotope

and agreed that BioMar would develop the latter. The BioMar and ZNIEFF (Dauvin 1993, 1994) marine classifications were agreed to be very similar, with the differences mainly arising from the different range of biotopes in each region. The first special European workshop on the classification was held in Cambridge in October 1994 and the second in conjunction with the Estuarine and Coastal Sciences Association symposium in Dublin in September 1995. A third workshop may be held in 1996.

Because of the difficulties in personnel surveying every part of the coast, the use of remote survey methods for both inter-tidal and sub-tidal areas is being developed (Foster-Smith and Davies in press). These remote survey techniques (e.g. acoustic, video) allow point source data to be linked to larger coastal areas. To date, the 16 remote sensing surveys conducted have covered a range of sea areas in Britain and Ireland, used different research vessels and equipment, and involved collaboration with different groups (BioMar partners and various government authorities). The comparability of the maps produced from the surveys demonstrates the wide application of the methods (e.g. Foster-Smith *et al.* 1994). From the experience in BioMar, it will be possible to recommend methods for the collection of marine data which may be used in other countries.

A database has been established for data storage and analysis (Mills 1991, Mills 1994), and can now be linked with computer mapping systems (GIS). The database software platform is Advanced Revelation, and the GIS platform is ArcInfo, but a range of other software tools are also utilised as necessary. The database now stores environmental information on almost 20,000 habitats surveyed in over 9,500 sites. The database also includes the list of over 8,600 species of marine fauna and flora recorded around Britain and Ireland (Howson 1987) which has recently been revised (Picton *et al.* in press) in conjunction with BioMar. Patterns within the data are being analysed, not only to develop a classification of marine biotopes, but also to determine temporal patterns both

Due to the large size and complexity of the main database, the production of more user friendly electronic publications (on diskettes and CD-ROM) from the database and GIS is being demonstrated. An electronic directory to marine biological survey data around Britain has been produced by the MNCR as a contribution to the United Kingdom Digital Marine Atlas Project (UKDMAP) (Mills *et al.* 1993; Barnes *et al.* 1995), and a 'stand-alone' bibliographic product will be available from Trinity College Dublin in late 1995 (Kelly *et al.* in press). The data and technical requirements for a more elaborate CD-ROM based product have been agreed and this is under development.

In addition to its use in dissemination of data, the use of GIS in predicting the occurrence of marine habitats from widely available coastal data (e.g. coastline, bathymetry, wind direction and force) is being explored (Costello & Mills in press). A wave exposure index (Thomas 1986) has been automated within the GIS so that the exposure for any piece of shoreline can be predicted (Crean *et al.* in press). These predictions are now being tested with field data and the flexibility of the model for use with other data sets is being examined.

As a background to marine conservation management in Europe, a desk study of marine protected areas has been completed. Reports on this study, and internal reports on field surveys, have been submitted to the European Commission. There has been considerable effort in disseminating information about BioMar. The partners have made 31 presentations on the project at 10 international and 14 national meetings. In addition, there are 18 publications and 8 accepted for publication, arising from BioMar.

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Appendix 1

Classification of marine biotopes: report on a discussion at the 28th European Marine Biology Symposium, Crete 1993.

Following considerable audience interest in a paper presented by Mr D. Connor on a proposed system for classifying marine biotopes in the north-east Atlantic, a one hour discussion was arranged. Forty six scientists from Austria (1), Belgium (2), France (3), Germany (7), Greece (8), Ireland (2), Italy (5), Mexico (1), Norway (1), Spain(2), Sweden (6), and the United Kingdom (8), were present.

Dr M.J. Costello opened the meeting by stating that the proposed classification was part of a four year (1992-1996) project called BioMar which is part funded by the Commission of the European Communities under the LIFE programme. As Scientific Co-ordinator of BioMar, he wished to know the initial response of European Marine biologists to the classification. The classification may form part of the CEC CORINE (Co-ordination of Information on the Environment) biotopes classification from which biotopes for protection in EU member states would be selected. It was thus necessary that the classification would be acceptable in all European countries for the purpose of identifying and selecting marine biotopes for conservation. Additionally, Dr K. Hiscock hoped that it would find a wider use in marine research, and be acceptable to both scientists and regulatory organisations.

The audience were first asked as to what more they wished to know about the proposed classification, and what concerned them about it. Connor and Hiscock replied that;

(a) it included estuarine, brackish and lagoon habitats;

(b) it did rely on conspicuous species to identify biotopes and assumed that their protection would result in the conservation of other (often unidentified) species;

(c) both species and habitats were used in describing biotopes, and it recognised that the presence of a species was more variable than a habitat;

(d) it included both epibiota observed *in situ* and infauna identified from sediment samples examined in the laboratory;

(e) it would include disturbed (by pollution or natural events) biotopes;

(f) it was intended to be sufficiently flexible to incorporate temporal variation in species composition.

(g) the level of detail in species composition and community dynamics would vary from very well studied to poorly studied biotopes.

Points made from the audience included that:

(i) habitats must be the focus of protection rather than individual species;

(ii) both rare and common cosmopolitan species, and communities, needed protection;

(iii) use of conspicuous species as descriptors of a biotope was satisfactory;

(iv) it was important to recognise variation in knowledge of different species groups and communities;

(v) most European countries had very limited knowledge of what marine biotopes and species they had;

(vi) biotopes must not be treated as "super-species" as this would result in a plethora of studies describing "new" biotopes and imply that transitional biotopes were somehow imperfect;

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(vii) a classification should not become part of science dogma and its limitations should be clearly stated;

(viii) each country may wish to develop the classification in further detail than that adopted at a European level.

Unresolved questions related to at what level a biotope would be identified for protection, and how areas with communities transitional (in space or time) between biotopes could be dealt with. Furthermore, predicting the composition of disturbed and inter-tidal communities was considerably easier than for subtidal rocky communities.

In general, the audience were in favour of the attempt to classify marine biotopes. It was notable how few present were aware of Augiers (1982) classification of Mediterranean marine biotopes which BioMar had been asked to integrate with its classification. Only four (9%) of the audience were aware of the CEC CORINE biotope classification.

Concern centred on how the classification would be used in conservation in relation to other methods of protecting marine species and their habitats. The role of a marine biotope classification in CEC conservation policy warranted clarification.

In closing the discussion, Dr Costello stated that there would be further opportunities to comment and criticise the BioMar classification, by either writing to him, Mr Connor or Dr Hiscock, or attending a workshop proposed for 1994. Such comments could include suggestions concerning the use of Augiers classification of Mediterranean marine biotopes.

Objectives and application of a classification of marine benthic biotopes.
Objectives of the workshop

Keith Hiscock

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Introduction

There are already several existing classification systems for marine benthic biotopes in Europe and in the world. For Great Britain, the MNCR team has for some time been working the systematic collection of information (through field survey and review of relevant literature) to develop of a classification structure. Our current working classification (Connor 1994) was circulated to workshop participants before the meeting.

The first day of the workshop is aimed at ensuring that you are all aware of the 'starting point' we have reached and that relevant facts are clear. Also, we want to be sure that participants are aware of anything relevant to the development of a classification either in terms of existing systems or in terms of ecological, taxonomic or other factors we should take into account including, some would say most importantly, practicality and use in environmental decision making.

Objectives of the BioMar classification

Our objective in relation to the biotopes classification in the BioMar programme is to:

> Develop a classification of benthic marine and brackish water biotopes for the British Isles and applicable to the north-east Atlantic which will underpin management and conservation of coastal ecosystems within a a scientific framework.

This workshop is a step towards that objective and, over the next two years, the process of achieving that aim will be fulfilled.

The classification will support:

- studies of biodiversity;
- assessment of nature conservation importance;
- sensitivity mapping, and
- wider management in the marine environment.

Managing marine ecosystems to conserve their diversity of content requires five main areas of information:

- resource data;
- information on the physical and chemical environment;
- information on the structure of marine communities and on the key elements in their functioning;
- information on natural variability;
- information on effects of human activities.

This information will require a structured approach to its application to conservation and management through:

- classification systems for resource data;
- criteria to ensure identification of a comprehensive series of marine protected areas.

Important information for decision making in environmental protection includes:

- identification of rare habitats and associated communities;
- identification of vulnerable (threatened) habitats and associated communities;
- identification of rare species;
- identification of vulnerable species, and
- identification of human activities which may change marine ecosystems.

In nature conservation and environmental management today scientists have to answer many difficult questions about very complex ecosystems. We need therefore to find ways of making this complex system more simple so that we can structure our work and ensure that our conclusions can be understood and built into political actions. If we, the marine scientists, do not do that, political decisions about environmental protection will be made anyway and we cannot expect them to accurately reflect ecosystem structure or function or to be comprehensive.

A classification of benthic marine biotopes is one area we should be able to tackle reasonably easily. It broadly follows from another system of classification intended to bring structure into chaos - the Linnaen binomial taxonomic system. And, just as that has a hierarchy which enables use at coarser or finer levels of differentiation, so we would hope that hierarchical approach might be incorporated into a classification of habitats and communities - which together are our biotopes.

We can use a well-structured classification to:

- assess and compare species richness between similar biotopes;
- identify areas with a wide variety of biotopes;
- ensure that the full range of the biotopes present in a biogeographical area or state is included in marine protected areas;
- identify and map sensitive (vulnerable) habitats in relation to different human activities, and
- indicate those biotopes likely to contain rare species.

Application of the classification is pursued further in the presentation by Tim Hill.

Example of use - the Habitats Directive

I will give you a current example of political action which would have benefited from application of a well-structured and meaningful classification of benthic marine biotopes. The European Commission Directive on the conservation of natural habitats and of wild flora and fauna (Council of the European Communities 1992) was issued in May 1993. Identifying and listing the habitats to be protected on land clearly benefited from good knowledge of floristic composition and a structured approach to classifying terrestrial systems.

Thus, looking at a very distinctive and thoroughly classified habitat type - sandunes - the following types are identified in the Directive as requiring protection in Europe:

Sea dunes of the Atlantic, North Sea and Baltic coasts	
16.211	Embryonic shifting dunes
16.212	Shifting dunes along the shoreline with *Ammophila arenaria* (white dunes)
16.221 to 16.227	*Fixed dunes with herbaceous vegetation (grey dunes):
16.221	*Galio-Koelerion albescentis*
16.222	*Euphorbio-Helichrysion*
16.223	*Crucianellion maritimae*
16.224	*Euphorbia terracina*
16.225	*Mesobromion*
16.226	*Trifolio-Gerantietea sanguinei, Galio maritimi-Geranion sanguinei*
16.227	*Thero-Airion, Botrychio-Polgaletum, Tuberarion guttatae*
16.23	*Decalcified fixed dunes with *Empetrum nigrum*
16.24	*Eu-atlantic decalcified fixed dunes (*Calluno-Ulicetea)*
16.25	Dunes with *Hyppophae rhamnoides*
16.26	Dunes with *Salix arenaria*
16.29	Wooded dunes of the Atlantic coast
16.31 to 16.35	Humid dune slacks
1.A	Machairs (*in Ireland)
(* = a priority habitat under the terms of the Directive)	

For the marine environment, the list is much coarser, interpretation is open to differences between states and not all key habitats are included:

- 11.25 Sandbanks which are slightly covered by seawater at all times.
- 13.2 Estuaries.
- 14 Mudflats and sandflats not covered by seawater at low tide.
- 21 Lagoons (a priority habitat*).
- Large shallow inlets and bays.
- Reefs.
- Submerged or partly submerged sea caves.

(Code numbers are from the CORINE (Co-ORdination of INformation on the Environment) classification).

Our best efforts to define the habitats (particularly those not in the CORINE classification; listed above without codes) in a way which meets both the letter and the spirit of the Directive may be called into question by what might be scientifically valid but completely different definitions of the types. It would be much better to be able to support such initiatives with a set of biotopes agreed and defined by European marine biologists as valid and practical.

The list of marine habitats in the Directive partially uses the 1989 version of the EC CORINE classification of communities (the published version, with minor differences is Devillers *et al.* 1991). To my knowledge, marine scientists had no input into the marine part of the classification although the Council of Europe publication by on Mediterranean biocenoses (Augier 1982) appears in parts. The major problem with the CORINE classification is the confusing mixture of physiographic features and their component habitats both of which are incomplete and poorly structured. At a successful workshop held in May 1993 (Appendix 1), we determined with Pierre Devillers, the main developer of the CORINE classification, a way forward to develop a broadly new and comprehensive spur to the CORINE classification. Conclusions at that workshop have been incorporated into a Council of Europe publication *A classification of palaearctic habitats* (Devillers & Devillers-Terschuren 1993) and the marine classification is illustrated in the next paper by David Connor. The further development of the CORINE programme is 'on hold' until the new European Union Environment Agency is staffed and running.

Under the BioMar programme, we are charged with developing a benthic marine classification for the European Commission Directorate General XI. Whatever framework we develop, it should be capable of accommodation within the CORINE structure and coding system. However, it must also have a hierarchy and a coding which we are comfortable with.

The successful development of a classification of benthic marine biotopes can support other initiatives. For instance, it can provide a more consistent and comparable basis for description and assessment in Quality Status Reports - required under the 1992 Paris Convention. It can be used to support schedules of rare and threatened biotopes which could greatly help decision-making in fora such as the North Sea Ministerial meetings - the next of which is in June 1995.

Objectives of this meeting

The aims of this workshop are to:

> Obtain consensus from representatives of the European marine biologist community for the structure to a classification and their commitment to develop the classification further.

It is to be practical that we apply these aims to the north-east Atlantic - in biogeographical terms, the boreal and part of the Lusitanean provinces with elements of the Arctic in the north. It is ambitious to expect agreement from so many scientists with different traditions. But, it will greatly help future environmental protection if we can agree.

By the end of this meeting, I propose that we will have agreed:

1. a framework for the classification;
2. the minimum information requirements to identify biotopes;*
3. a hierarchy which is scientifically based but practical to apply;
4. selection criteria for characterising species;
5. a *pro forma* for biotope descriptions;
6. arrangements for further development of the classification.

*Additional aim identified during the discussion.

I also hope that, in bringing the scientists here together, we will have renewed many old friendships and made new ones which will make future communication, and often compromise, easier.

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Appendix 1

Report of the biotopes classification workshop held at Monks Wood, Cambridgeshire, UK on 10-11 May 1993.

Attendees:

Joint Nature Conservation Committee: Keith Hiscock, David Connor, David Mills.

Trinity College Dublin: Mark Costello, Bernard Picton.

Wildlife Service, Dublin: Muiris de Buitléir, Colmán Ó'Críordáin, Eddie Wymer.

University of Newcastle: Bob Foster-Smith, Jon Davies.

EC Environment Agency Task Force (DGXI) (representing): Pierre Devillers, Dorian Moss.

Apologies:

Hugh Nijkamp, AIDEnvironment, Netherlands

Introduction

Presentations were made at the meeting to describe the approaches being adopted by the MNCR to classifying marine benthic communities (including pre-meeting circulation of backing papers), of the methods planned for work to be undertaken from Newcastle University on rapid mapping of the seafloor and of the role of CORINE in underpinning nature conservation in the EC.

This note outlines the main conclusions of the meeting.

BioMar classification

We agreed the following vision:

We are developing a classification of marine and brackish water biotopes which will under-pin management and conservation of coastal ecosystems within a scientific framework.

We agreed that the classification would be for marine benthic habitats only including, estuaries/brackish water habitats in connection with the sea, would be completed for the British Isles only but could be expanded to the north-east Atlantic, and would extend over the whole continental shelf to 200m depth.

We agreed that the BioMar classification would:

- structure the collection and interpretation of survey results;
- provide a shorthand method for describing and mapping the biological character of the marine environment using a common language;
- provide an indication of the extent and spatial arrangement of the 'resource';
- provide an indication of the diversity of species assemblages in an area;
- provide a basis for comparing 'like with like' to assess species diversity and abundance in the same biotope.
- provide a basis for predicting, from physical and chemical information, what biotopes are likely to be present in an area;
- provide a structure for coastal management;
- by conserving regional representative examples, provide a method for conserving biodiversity [except that some species level conservation (eg cetaceans) will remain];
- set protected species into the context of the community in which they occur to aid management;
- provide a broad structure to which regional classifications can be attached.

Proposed structure of a marine classification

There was general approval for the structure proposed by the MNCR, basing upper divisions on different substrata and zonation and lower divisions on communities recognised at a variety (two or three) levels dependent on species composition and ease of identification. MNCR would develop for BioMar the 'end units' of the classification which would form the basis of a north-east Atlantic classification for inclusion in the CORINE classification.

We agreed the following relationship with the CORINE classification:

- part 11 of the CORINE classification will be developed as a habitat-based classification in accordance with the suggestions made by Pierre Devillers [and expanded following the workshop];
- large-scale coastal features would be expanded and a structure was suggested.

We agreed that the structure of the BioMar classification had to be:

Practical	=	easily expandable avoids repetition widely acceptable (and therefore accepted)
Hierarchical	=	logical similar weighting to end units broad scale to fine scale
Scaled	=	appropriate to end users

We agreed the following definition of terms:

Habitat: The particular type of local environment in which an organism lives.

Community: A group of organisms occurring in a particular habitat, presumably interacting with each other and with the environment, and separable by means of ecological survey from other groups.

Biotope: Combines habitat and community into the smallest physically defined unit supporting a move or less homogeneous assemblage of species.

The definition of 'biotope' and of a 'biotope unit' was discussed in detail. Initially, a minimum area for a 'biotope limit' of 25m^2 or 25% of a larger area was suggested. The use of a fixed minimum size was not considered appropriate by most participants and the suggested area was too large and many distinctive physically defined units supporting more or less homogeneous assemblages would be smaller than this.

It was also accepted that by defining the habitat units at different levels we need to record separately from those habitat units. A phrase such as "recording will generally be from biotopes defined up to level 2 in the classification except where they fall below a minimum size of [to be determined] m^2" would be appropriate.

European workshop

We agreed the following aims for the workshop:

- to establish the systems of classification currently being used and the communities identified;
- to develop one structured classification and agreed catalogue applicable to the NE Atlantic and Baltic which will accommodate existing types (including Mediterranean and Macronesian) as an expansion of the CORINE classification;

It was agreed that we should make contact with Council of Europe representatives with a view to holding the workshop in Strasbourg.

The following draft timetable of activities was agreed:

May 1993	Steering Group workshops (Monks Wood, 10-11 May 1993)
Summer 1993	Consultation stage
August/September 1993	Invitations
January/February 1993	European workshops Delegated development tasks (BioMar papers)
Summer 1994	Presentation(s) of classification

The consultation stage was planned to consolidate workshop aims, participation and venue including briefing contributors where appropriate.

Database co-ordination

Introduction

This part of the meeting was being undertaken to:

- inform;
- exchange ideas;
- improve liaison and working relations between data specialists;

Entry of BioMar data to the CORINE database

It was agreed that both Britain and Ireland should select marine sites for inclusion in the CORINE site database.

Mechanisms need to be identified to indicate the most important sites in a region (there are 11 regions in GB and they are politically based).

The criteria for site selection are being developed by MNCR. Further discussion with CORINE would be required to establish criteria for inclusion of sites to the CORINE database.

Once sites are identified, they should be entered to the CORINE database.

The GB sites currently listed under marine sections of CORINE are from an exercise in the early 1980s and mainly based on ornithological interest.

SACs (once agreed) would be entered to the CORINE database, amongst others.

As MNCR develops, we need to ensure CORINE terminology is being used (reference the first page of the CORINE manual).

Dissemination products from biotopes classification

It was agreed that these would include:

1. updated CORINE biotopes manual;
2. paper version of the classification;
3. electronic products on 'multimedia'.

For the biotopes classification, it was suggested that the multi-media electronic publication could include:

- a description of each biotope;
- photographs;
- a key to identify biotopes;
- software to match survey results to biotopes;
- information on sources of data;
- distribution maps;
- ?a video.

This type of approach was considered fully feasible. The technological support is widely available and Paul Mills had developed a 'BioMar viewer' - rather like an Estuaries Review inventory multi media product. However, these were first thoughts and eventual products would be influenced by the activities of other partners. Close working of partners would be needed and GIS was identified especially needed collaboration.

Discussion following the papers by Mark Costello and Keith Hiscock

Introductory remarks

The Chairman encouraged the meeting to take this opportunity to achieve a consensus and by the end of the meeting to have fulfilled all five [later, six] aims. He invited participants to indicate what they would particularly like addressed and 'challenged' them to agree, disagree or adjust the aims specified in the previous presentation.

Habitats Directive types and biotopes (relationship of biotopes to physiographic features)

Clarification was sought with regard to the apparent incompatibilities between the draft biotopes classification for Great Britain circulated before the meeting and the types specified in the Habitats Directive. It also seemed that the sand dune example was a very fine level of detailed based on species present whereas the marine types in the Directive were very coarse. It seemed to Keith Hiscock that the physiographic-basis of the types specified in the Directive was not entirely compatible with what we were proposing as individual biotopes would not uniquely occur in a particular feature. However, physiographic features were important as they often came as close as any unit in the marine environment to a functional unit.

There is no conflict between the development of the classification and the implementation of the Directive - we in Great Britain are working with the list in the Directive and not suggesting an alternative. It is too late to introduce a new classification which will affect the selection of sites occurring now under the Directive but we can affect the process in the future via CORINE.

(Later in the discussion) concern was expressed by Denise Bellan-Santini over the development of the CORINE classification and its application to the Directive where it seemed that an adequate classification of marine biotopes had not been used to compile the Directive. It was also observed that very few marine species were listed in the Directive and it seemed that marine biologists had been little involved in developing the Directive. A further point, of particular concern in Germany, was the dominance of vegetation types in defining the CORINE classification system. Keith Hiscock felt that, although we could help interpret the Directive by indicating the marine biotopes which would occur within each Annex I habitat listed, this was likely to be of little immediate use since national lists of candidate sites for protection under the Directive have to be submitted by 5 June 1995 and most countries should have their lists ready by now. Nevertheless, there was currently an exercise being undertaken to reach agreed definitions of non-priority habitat types in the Directive Habitats Working Group and that group would meet in early December. The greatest opportunity for revision of Annex I marine habitats lay with the input from new member states.

Howard Platt pointed out that certain habitat types (rocky shores, for instance) were listed in the CORINE classification but had not been selected for inclusion in the Directive. Strict definition of habitats listed in the Directive may result in losing some key habitats from selection.

Flexibility (revision of a classification)

Tom Pearson was concerned to understand how flexible the biotopes classification system would be - once established, would it be immutable? The following points were made in discussion:

1. there must be flexibility including to expand the classification and to take-out obsolete types but this must be underpinned by a system of synonymy. However, at present, the classification is still being developed and is not yet ready to be published;
2. we do need a classification system now but it must be capable of amendment in the future.
3. there must be a continuing review process;
4. the CORINE system did not allow for change of codes although did allow for addition of types and this was particularly undertaken by subdivision within a country with a particularly large example of a certain habitat;
5. not all European countries use the CORINE system for their terrestrial habitats - with marine habitats we had the opportunity to develop a consistency which was lacking for terrestrial systems;
6. at this meeting, we need agreement on major divisions and categories and identifying gaps in coverage; specifics will come at a later stage.
7. the classification presented to CORINE need not be as finely divided as is used in practice - this is particularly important if, in two years time, we are not sure of the accuracy of the 'finer' levels of a classification.

The question of a review mechanism was of particular concern. The system adopted for review needed to be agreed within the EU Environment Agency and the International Council of the Exploration of the Seas was suggested as a possible organisation to provide the forum for such a review through one of its committees or working groups. It was agreed that we needed to address now what will happen to the classification especially in relation to review once the BioMar programme was finished at the end of 1996.

Ratify or revise the existing classification?

Jon Davies asked for clarification of the aims of the meeting in relation to the existing classification - was it the intention of the organisers to obtain ratification or was complete revision an option? Keith Hiscock indicated that, having presented and discussed the major aims of the exercise and the outline structure to a classification at several European meetings in the past eighteen months, we would be very disappointed if this meeting found serious flaws. We are now seeking the help of the Atlantic-European community of benthic ecologists in building the system and establishing whether the structure will accommodate biotopes which we are not familiar with. We are certainly here to make changes but hope that we have not done badly up to now.

The Linnaen analogy

Jack Matthews asked if the Linnaen hierarchical classification analogy could extend as far as CORINE: we seemed to be seeking broad agreement at the coarser level and major categories needed to be developed *pro tem.*

How far out and how deep?

Torleiv Brattegard asked for clarification of this point especially drawing attention to the great depth of some Norwegian fjords. There was general agreement that the classification should refer to the benthic habitats out to the edge of the continental shelf with no reference to depth. Although needing to give some indication of limits, the framework being developed should be widely applicable. "Marine" habitats seemed to satisfy everyone.

How salty?

The group was challenged (by Roger Bamber) to define "marine". The terms used in the initial objectives were "marine and brackish". There was general agreement to the suggestion that the classification should refer to saline habitats - the sea and waters influenced by seawater infiltration down to a salinity of 0.5‰ but not the tidal parts of rivers and not saltwater systems inland.

Had all agendas been included in the listed objectives?

Further discussion was encouraged to ensure that everyones objectives could be taken into account.

The classification framework

Michel Glémarec drew specific attention to objective 1 and to the question of scale of observation which could be from a large feature such as the Bay of Biscay to a much smaller one such as a small estuary. In France, habitats are identified in a large framework with associated communities. From Morocco to the Faroes and Norway, the same 'habitats' based on edaphic and climatic conditions occurred but, in the same habitat, there are different associated communities which could occur. This produced real difficulties in applying the 'biotope' concept. With habitats clearly identified in a large framework there are associated communities but 'biotopes' were not clear. Linking habitat to community (the 'biotope') could create problems especially because of emergence and submergence: the habitat could be the same but the community different.

Emergence/submergence perspectives

Some communities occur in deep water in southern latitudes and in much shallower water in northern latitudes. The difference of habitat with apparently the same community needed to be taken into account. The classification clearly had to take account of biogeography and the association of communities remains strongly linked to the physical habitat. Each of the working group needed to take account of scale and resolution of observation.

From a practical point of view, Bob Foster-Smith suggested we need to agree to a common denominator - what is the lowest acceptable common denominator. Keith Hiscock suggested that the minimum we should go away with is a framework, indeed, one member of the group suggested the minimum should be "an agreement".

Conclusion There seemed no further comment and no alterations proposed to the objectives.

The development of a biotope classification in Great Britain and Ireland - principals and structure of the classification

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Introduction

This paper aims to provide a background to the MNCR's involvement in the development of a classification and to illustrate the range of biotopes to be encompassed within the classification. It explains the structure and approach adopted by the MNCR to development of a classification, further details of which are given in Connor *et al.* (in press) (with appropriate extracts here) and Connor (1994).

The Marine Nature Conservation Review

The MNCR has been undertaking a major field survey programme around Great Britain since 1987, covering an exceptionally wide range of rock and sediment habitats in both the littoral and nearshore sublittoral zones on the open coast, in estuaries and other marine inlets and in brackish lagoons. To date the MNCR holds detailed survey information for over 10,000 sites. This survey programme is now complimented by a similar survey of the Republic of Ireland's marine habitats through the BioMar project.

Figure 1 Location of 10x10 km squares with survey data (as at August 1995). Each symbol represents one or more survey sites, but not necessarily comprehensive survey coverage within the area.

MNCR field surveys are restricted, for logistical and resource reasons, to coastal waters (generally out to about 5 km from the shore). However this is a zone of enormous habitat complexity compared with offshore areas and hence requires detailed study to understand, describe and map the communities present. For offshore areas, there is a great deal of published information from major offshore survey programmes (predominantly of sediment habitats).

The extensive field survey programme has given the MNCR a great deal of experience in the factors which contribute to community structure and determine why particular groups of species occur at any one site. Many, such as the nature of the shore or seabed (i.e. whether it is rock, sand or mud) are quite obvious to any marine ecologist, but others are more subtle. In a highly complex ecosystem, we constantly see patterns emerging, that is the same communities occurring in similar physical conditions in widely separated locations. The development of a classification system, to structure the data held and aid its interpretation for management and conservation, is an essential stage in the MNCR programme. The development of the classification, through BioMar, is important in establishing a common approach which can be applied throughout the north-east Atlantic.

The nature of marine communities

In the marine environment there is a strong relationship between the physical nature of the habitat and the biological composition of its associated community. Most communities appear to occur within a recognisable suite of physical conditions, although some occur within a more tightly defined physical habitat than do others. Community structure is additionally modified by biological factors such as recruitment, predation and inter-species competition.

The following environmental and biological factors make a major contribution to community structure:

ENVIRONMENTAL FACTORS:	Substratum Height or depth (desiccation/light penetration/wave disturbance/thermal stability) Exposure to wave action Strength of tidal currents Salinity Temperature (biogeography) Geomorphology Geology Pollution Oxygenation Wave surge Scour/turbidity/siltation
BIOLOGICAL FACTORS:	Grazing Predation Competition Recruitment

The range and extremes of the factors given above were illustrated to workshop participants through a series of colour slides from British coastal habitats and indicate the variety of habitats which needed to be encompassed within a classification system. The illustrations covered the following topics:

Factor	Range / variation illustrated by:
Substratum	Communities on rock, mixed rock and sediment, sand and mud
Zonation	On rock: Supralittoral lichens, eulittoral fucoids, infralittoral kelps, circalittoral animals, deep water communities. On sediment: muddy shore, very shallow mud with synaptid holothurians, shallow mud with *Virgularia mirabilis* and *Philine aperta*, deeper mud with *Nephrops norvegicus* and *Funiculina quadrangularis*, deep water mud communities; shallow algal dominated sediments.
Wave exposure	Extreme exposure with *Fucus distichus* on shores and infralittoral *Alaria esculenta* forests (latter on Rockall); exposed coasts with *Laminaria hyperborea* forests; very sheltered coasts with *Ascophyllum nodosum* var. *mackaii* beds on shore, *Laminaria saccharina* forests and the anemone *Protanthea simplex* in the circalittoral.
Currents	Intertidal rapids with waterfalls. Best illustrated in the circalittoral: sponge and anemone communities in very strong currents; *Alcyonium digitatum* communities in strong currents; *Modiolus modiolus* beds, brittle star beds and maerl beds in lesser currents.
Salinity	Reduced salinity rocky sublittoral communities with *Lithothamnion glaciale* and *Psammechinus miliaris*. Brackish water habitats with *Ruppia* spp. in lagoons.
Biogeography	Warm Lusitanean species: *Leptopsammia pruvoti*. Cold water boreal species: *Cucumaria frondosa*, *Bolocera tuediae*.
Geomorphology	Vertical rocky shores with barnacles, but covered by fucoids in extreme shelter. Surge gullies with surge tolerant fauna of sponges and anemones.
Geology	Algal communities on chalk shores.
Oxygenation	*Beggiatoa* in deoxygenated habitats.
Scour & siltation	e.g. *Flustra foliacea* dominated habitats.
Temporal variation	e.g. appearance of holothurians such as *Thyonidium commune* and *Psolus phantopus* at sediment surface in summer months.
Grazing	Rich algal communities compared with intensely grazed kelp forests.

The classification thus has to take account of many variables and the many potential combinations of these variables which may lead to distinct communities. In a wider geographical perspective the deep fjords of Scandinavia and the warmer coasts of France

and Spain offer further habitat variation to consider for a north-east Atlantic classification.

Considerations in establishing a structure for the classification

In addition to taking account of the nature of marine habitats and communities as outlined above, for the classification to be both widely applicable and widely acceptable it needed to accommodate:

- *the variation in scale of physical and biological features* (from large physiographic units such as estuaries down to the more detailed narrow zones recognisable on a single rocky shore);
- *different levels of detail in available data* (littoral communities are well studied whilst some areas such as deep rocky habitats remain poorly known);
- *different skill levels of future surveyors*;
- *the variety of intended applications* (such as habitat mapping, scientific study, conservation management);

and to:

- *be practical in format and operation* (including presentation of the classification in new ways to illustrate the complex relationship of marine communities to each other and to their environment);
- *be presented within a logical structure* (to ensure that similar biotopes are placed near to each other and at appropriate hierarchical levels within the classification).

Other marine classification systems

In establishing a suitable structure for the classification a series of other classification systems were examined (Hiscock & Connor 1991):

Classification	Comments
CORINE (1991)	Very poorly developed for marine habitats; currently includes a series of physiographic features and broad scale habitat types.
Mediterranean (Augier 1982) Washington, USA (Dethier 1992) France ZNIEFF (Dauvin *et al.* 1994)	Comprehensive classifications with structure and level of detail comparable to that currently being developed for BioMar. [French participants at the workshop considered the classification of Pérès & Picard (1964) to be the authoritative classification and rated that of Augier (1982) poorly] Each of these three classifications arranges its biotopes in a slightly different manner, placing varying emphases on factors such as salinity and zonation to establish its structure.
Clare Island, Ireland (Southern 1915) Offshore sediments (Jones 1950) Algae, Netherlands (den Hartog 1959) Sediment shores, GB (Bishop & Holme 1980)	Examples of classifications of limited habitat or geographical coverage, but which are useful for description of particular habitats.

CORINE

As the MNCR BioMar classification will be submitted to the European Commission's *Life* programme for incorporation into the CORINE classification, the structure adopted by CORINE was considered in the development of the present classification. The relationship between the proposed BioMar classification and CORINE was established at a BioMar workshop at Monkswood, Cambridgeshire in May 1993 (see Appendix 1 to the earlier paper by Keith Hiscock for a report of the workshop). This included modification to the existing CORINE (1991) classification, particularly to ensure that all marine habitats were located in the same part of the classification (11.2) and that additional categories were provided to better represent the range of physiographic features present on the coast (under 12, 13, 19 and 21).

The current elements of the CORINE classification relevant to BioMar are given below (from Devillers & Devillers-Terschuren (1993):

CORINE - marine habitat divisions

11.2			BENTHIC COMMUNITIES
	11.21		Deep sea floor (with sub-divisions)
	11.22		Sublittoral soft seabeds
	11.23		Sublittoral pebbly seabeds
	11.24		Sublittoral rocky seabeds and kelp forests
	11.25		Sublittoral organogenic concretions
		11.251	Corallogenic concretions
		11.252	Encrusting algae pavements
		11.253	Gastropod and polychaete ledges
		11.254	Mussel beds
		11.255	Gas vent communities
		11.256	Coral reefs
	11.26		Sublittoral cave communities
	11.27		Soft sediment littoral communities
	11.28		Pebbly shore littoral communities
	11.29		Rocky shore littoral communities
		11.291	Mediolittoral fringe rocks
		11.292	Lower mediolittoral rocks
		11.293	Upper mediolittoral rocks
		11.294	Mediolittoral cave and overhang communities
		11.295	Mediolittoral rock pools
		11.296	Supralittoral rocks
		11.297	Supralittoral rock pools
	11.2A		Littoral communities of organogenic concretions
11.3			SEA-GRASS MEADOWS
	11.31-11.3A		(eelgrass *Zostera, Posidonia, Cymodocea,* etc.)
11.4			BRACKISH SEA VASCULAR VEGETATION
	11.41-11.43		(tasselweed, spike-rush, crowfoot communities)

CORINE - physiographic feature divisions

12			SEA INLETS AND COASTAL FEATURES
	12.1		Open linear coasts
	12.2		Semi-enclosed coasts
	12.3		Sounds and straits
	12.4		Enclosed embayments
	12.5		Fiords, fiards, sea lochs
		12.51	Fiords, fiordic lochs
		12.52	Fiards, fiardic lochs
		12.53	Open sea lochs
	12.6		Rias, voes, abers
	12.7		Sea-caves
		12.71	Submerged sea-caves
		12.72	Complex sea-caves
13			ESTUARIES AND TIDAL RIVERS
	13.1		Tidal rivers
	13.2		Estuaries
		13.21	Coastal plain estuaries
		13.22	Bar built estuaries
		13.23	Complex estuaries, firths
14			MUD FLATS AND SAND FLATS
15			SALTMARSHES, SALT STEPPES, SALT SCRUBS, SALT FORESTS (with sub-divisions)
16			COASTAL SAND-DUNES & SAND BEACHES (with sub-divisions)
17			SHINGLE BEACHES (with sub-divisions)
18			SEA-CLIFFS AND ROCKY SHORES (with sub-divisions)
19			ISLETS, ROCK STACKS, REEFS, BANKS, SHOALS
	19.1		Lithogenic rock stacks and islets
	19.2		Surface and underwater rocks
	19.3		Barrier islands, spits
	19.4		Banks and shoals
	19.5		Coral reefs
	19.6		Seamounts and guyots
21			COASTAL LAGOONS
	21.1		Sea-connected lagoons
	21.2		Isolated lagoons
	21.3		Percolation pools
	21.4		Silled or sluiced ponds

The two-tier approach within the CORINE classification with its separate, but linked, divisions of physiographic types and habitat types enables the development of a classification system at varying scales. For instance, whereas the category 'estuary' is useful at a conservation management level, it is not appropriate as a field recording unit as the estuary clearly comprises a series of distinct habitats (saltmarsh, sediment flats, rocky shores, subtidal habitats). The link of habitat units to larger physiographic features within CORINE is illustrated in the table below.

BioMar biotope classification and the CORINE physiographic features

Examples to illustrate relationship

Sub-stratum	Zone	Biotope	CORINE types: 12.1 Open linear coast	12.7 Sea-caves	14 Mud flats & sand flats	12.5 Fiords, fiards, sea lochs	13.2 Estuaries	21 Lagoons
Rock	Supra-littoral	Yellow & grey lichens	•			•	•	•
	Eulittoral	*Mytilus* & barnacles (very exposed)	•					
		Ascophyllum nodosum (very sheltered)	•			•	•	•
Mixed rock & sediment	Eulittoral	*Fucus ceranoides* (low salinity/ freshwater runoff)				•	•	•
Mud	Littoral	*Hediste diversicolor-Scrobicularia plana*			•	•	•	
Rock	Infralittoral	Sponges, anemones, *Mytilus edulis*, hydroids & colonial ascidians (in wave surge)	•	•		•		
Sand	Shallow sublittoral	*Zostera marina*	•			•	•	•

Structure of the MNCR BioMar classification

Whilst the divisions of a classification need to be biologically led (because the classification is ultimately used for species conservation) the dynamic nature of certain communities means it is essential to identify the habitat within which potentially a variety of communities may occur over time. Also the nature of marine communities, with different taxa and life forms associated in a variety of ways, ensures there is no meaningful way to structure a classification based on its biology alone. Hence physical habitat attributes are used to provide a structure for the classification which is both logical and easy to use. In this way much more significant use of the habitat is made than for terrestrial systems, where vegetation alone is often the prime determinant of the classification's structure.

The physical attributes which appear to most strongly influence community composition are substratum, the vertical gradients of exposure to air and desiccation on the shore and attenuation of light or change in temperature and wave disturbance with depth in the sublittoral, wave exposure, tidal stream strength, salinity, temperature, and oxygenation (further discussed in Hiscock & Connor 1991). Each of these can be considered as an environmental gradient which form axes within a multi-dimensional matrix. Each community develops within a suite of physical conditions which lie within the multi-dimensional matrix. Although the degree of importance of each physical attribute varies for differing communities the first two, namely substratum and vertical gradient or zonation, appear to play a highly significant role in all communities. They are also the most easily and reliably recorded attributes in the field and are readily mapped. These factors combine to make the two attributes of substratum and zonation the most appropriate for structuring the upper end of the classification.

The classification is presented in such a way as to allow access via either the physical habitat or the biological community.

Presentation through habitat features

Although community composition is the result of a complex series factors, the most important of these can be used, in a two-dimensional matrix, to illustrate the relationship of the communities both to each other and to the factors selected for the two axes. The classification can initially be considered within a primary matrix of substrata versus zonation, placing the biotopes within the appropriate area of the matrix:

	Rock ————————→ **Mud**
Upper shore ↓ **Deep water**	

The wide variety of biotopes present within an entire classification inevitably leads to cluttering of presentation within a single matrix alone; further matrices are required to fully illustrate the range of biotopes present. For instance rocky habitats are best illustrated within a second matrix of wave exposure versus zonation, whilst sediment shore communities could be displayed along a salinity gradient. The current MNCR classification for rocky shores and sediment shores indicates the approach adopted (Appendix 1).

The divisions adopted on each of the physical gradients are those which, through the experience of survey work and data interpretation, appear to be most biologically meaningful (for instance, it is appropriate to distinguish cobbles on the shore which can be highly mobile from more stable boulders but not to distinguish small from large cobbles as the latter has little affect on the community composition but the former does). The divisions of each matrix are not restrictive; biotopes may appear in more than one box in the matrix or the boxes may be merged, as shown, where, for instance, on rocky shores more biotopes are distinguished on the lower shore compared with the upper shore.

Placement of the biological entities within such a physical framework has a number of benefits noted below.

- It helps to display the relationship of each biotope to other closely related types and to clarify the physical factors which contribute to its structure. These relationships are less clear in conventional listings of types.
- It enables the identification of dissimilar communities within apparently similar physical environments. Here, although there may be subtle physical factors which drive such differences in biological composition, other factors such as seasonal change, chance recruitment, grazing pressures or pollution effects may account for the differences and allow such communities to be linked within the classification.
- It provides a structure for undertaking new ecological survey, to ensure that the full range of habitats in an area is identified and sampled.

Particular parts of the coast will provide data for the development of specific sections of the classification. For instance, sheltered rocky habitats are predominant in the sealochs of western Scotland and it is here that the more subtle variations in community composition related to changes in salinity regime or tidal stream strength within sheltered habitats can be elucidated. Conversely the open North Sea coast of England is predominantly moderately exposed to wave action and here changes in structure due to differences in shore topography can been identified.

Presentation through biological features

The classification adopts a hierarchical approach to the differentiation of types, related to the ability to discriminate by various methods of remote and *in situ* sampling and to the ease of recognition by workers of differing skill levels and with the emphasis on conspicuous species. The two prime physical factors of substrata and zonation form the upper tiers in the hierarchy, as outlined above. Below this biotopes are currently distinguished at two levels. Level 1 biotopes are typically distinguished by their differing dominant species or life forms and are likely to be readily recognised by rapid survey or by less experienced workers. Level 2 biotopes are subdivisions of the level 1 type, typically based on less obvious differences in species composition (*e.g.* less conspicuous species), minor geographical variations or more subtle variations in the habitat and will often require greater expertise or survey effort to identify. Whilst such a philosophy of approach from broad scale easily recognisable types to finer detail less readily recognised types is advocated it is recognised that certain biotopes, particularly in sediments, may not conform with this approach and that in some instances it may be appropriate to adopt further levels in the classification. An extract from the current MNCR classification illustrates the approach adopted here (Appendix 2).

The biotopes are listed in the classification following the sequence of substrata and zonation from the primary physical matrix. Subsequent divisions in the classification are based on the level 1 and level 2 types, but these are further ordered according to the other important physical attributes of sub-zones (higher to lower), wave exposure (exposed to sheltered), tidal stream strength (strong to weak) and salinity (full to low) and for sediments their sediment grade (coarse to fine) (terms used for each of these attributes are given later in this workshop report). Thus within the infralittoral bedrock section *Laminaria hyperborea* biotopes, which occur in more wave exposed or tide-swept habitats, are listed before *Laminaria saccharina* biotopes. Listing of biotopes in this way provides a logical sequence to the classification. However, the relative importance of each attribute should not be inferred from such a sequence as each biotope derives its character from a complex of attributes, both physical and biological.

Single biotopes may cover many tens of square kilometres in the case of offshore uniform sediments or only a few square metres for distinctive features (e.g. rockpools) on rocky shores. For practical purposes there needs to be a lower limit on the scale of units described as biotopes so that the classification avoids being unwieldy. Consequently small features, such as crevices in rock or the biota on kelp stipes, are described as features of the main biotope rather than biotopes in their own right.

Each biotope is described in a standard manner, including a title to highlight the key features of both the habitat and the community, a classification of the main physical attributes of the habitat, an indication of its distribution, an illustration of the biotope, a description of the biotope including any known temporal and spatial variation, and a list of regularly occurring species (Appendix 3).

Each biotope receives a unique code; a alphabetical code system has been developed which reflects the nature of the biotope (e.g. LRK.FSER is a **L**ittoral **R**oc**K** habitat with ***F**ucus **SER**ratus*); it also avoids use of a numbering system which is essential within a developing system to allow changes in the order of presentation of biotopes and additions. The code structure is further explained in Connor (ed.)(1994).

Problems associated with development of the classification

There are inevitably difficulties in trying to place structure, sometimes rather artificially, on what is a highly complex marine environment. The approach adopted takes into account the factors noted below.

- *Temporal variation* (by placing emphasis on the habitat in which distinct communities may occur and associating the different communities to the same habitat).
- *Continua* (many boundaries between biotopes are not distinct, with change along a gradient being only gradual. Practical considerations in where to place divisions between types are adopted to achieve a workable classification in what is recognised as an ecosystem lacking many distinct boundaries).
- *Differing degree of definition throughout classification* (a hierarchical approach allows certain parts of the classification to be developed more thoroughly than others, depending on the degree of definition required and the amount of data available. As far as is practical similar degrees of definition are adopted at any one level in the hierarchy).
- *Separation of types* (a series of criteria are used to help establish the justification for different types - see Connor *ed.* 1994):
    - each biotope will be a recognisable entity in the field;
    - each biotope will recur in similar physical conditions in widely separate geographic locations;
    - the distinction of types is based on:
        - different dominant species;
        - different life forms or functional groups;
        - characteristic arrays of species;
        - presence of highly preferential species.

Conclusion

The range of habitats to be encompassed within a marine classification for the north-east Atlantic is very large. Through considerable experience both in surveying a wide range of habitats and in interpretation (through ordination and clustering techniques) and classification of British marine data the MNCR has established a workable approach on which to base further development at a north-east Atlantic level.

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Appendix 1

Biotope matrices for sediment and rocky shores (from Connor *et al.* 1995)

The main biotopes are given in bold and centred within each box of the matrix whilst more minor biotopes are placed to the bottom left of the box.

Sediment shore biotope matrix

ZONE	Pebble (shingle)	Gravel / coarse sand	Medium sand	Fine sand	Muddy sand (10-30% silt/clay)	Sandy mud (30-80% silt/clay)	Mud (>80% silt/clay)	Mixed sediment (gravel / mud)
EXTREME UPPER SHORE	***Talitrus saltator* (LMXD.TAL)**					**Salt marsh** **Pioneer *Salicornia* salt marsh (LMUD.SAL)**		
UPPER SHORE	**Barren** (LMXD.BAR)	**Barren** (LSND.BAR)	**Amphipods & *Eurydice pulchra* (LSND.AE)**	**Amphipods & *Scolelepis squamata* (LSND.AP.S)**	***Arenicola marina* & bivalves (LMSND.ARB)**	**Variable salinity - *Hediste, Macoma & Cerastoderma* (LMUD.HM.CER)**	**Reduced salinity - *Hediste & Scrobicularia* (LMUD.HS)**	
MID SHORE				Mid-shore clean sand - *Arenicola* (LSND.AP.AR)		**Low salinity - *Hediste, Macoma & Manayunkia* (LMUD.HM.MAN)** Full salinity - *Arenicola* (LMUD.AR)	**Low salinity - *Hediste* & oligochaetes (LMUD.HO)** Upper-mid shore - *Zostera noltii* (LMUD.HS.Z) Full salinity - *Arenicola* (LMUD.AR)	**Low salinity - *Hediste diversicolor* (LMGR.HED)**
LOWER SHORE		**Amphipods & *Eurydice pulchra* (LSND.AE)**	**Amphipods & *Scolelepis squamata*** (LSND.AP.S)	**Amphipods, *Nephtys cirrosa & Angulus* (LSND.AP.ANG)**	**Polychaetes & *Cerastoderma* (LMSND.PC)** Tidal-scour - *Lanice* (LMSND.LAN)	**Variable salinity - *Hediste, Macoma & Cerastoderma* (LMUD.HM.CER)** **Reduced salinity - *Hediste, Macoma & Nephtys hombergii* (LMUD.HM.NEP)**	**Reduced salinity - *Hediste, Macoma & Nephtys hombergii* (LMUD.HM.NEP)** **Low salinity - *Hediste* & oligochaetes (LMUD.HO)**	**Reduced salinity - *Mya arenaria* & polychaetes (LMGR.MYA)**
EXTREME LOWER SHORE				***Echinocardium & Ensis* (LMSND.ECH)** ***Zostera marina / angustifolia* (LMSND.ZOS)**		Full salinity - *Arenicola* (LMUD.AR)	Full salinity - *Arenicola* (LMUD.AR)	Full salinity - *Venerupis senegalensis & Mya truncata* (LMGR.VEN)

Rocky shore biotope matrix

ZONE	VERY EXPOSED	EXPOSED	MODERATELY EXPOSED	SHELTERED	VERY SHELTERED
SUPRA-LITTORAL	**Yellow & grey lichens (YG)** Pools - *Enteromorpha & Cladophora* (CHL) Nitrate enrichment - *Prasiola stipitata* (PRA)				
UPPER LITTORAL FRINGE	***Verrucaria* with *Porphyra umbilicalis* (VER.POR)** ***Verrucaria* with sparse barnacles (VER.B)** ***Verrucaria maura* (VER.VER)**		***Verrucaria maura* (VER.VER)** Pools - *Enteromorpha & Cladophora* (CHL) Freshwater runoff / unstable - *Enteromorpha* (ENT) Nitrate enrichment - *Prasiola stipitata* (PRA) Vertical chalk - Chrysophyceae (CHR) Chalk caves - *Audouinella floridula, Pilinia maritima & Pseudendoclonium submarinum*(APP)		
LOWER LITTORAL FRINGE	Pools - Coralline crusts & *Corallina officinalis* (COR) Vertical / steep - *Lichina pygmaea* (LPYG) Overhang / shaded - *Catenella caespitosa* (CAT) Nitrate enrichment - *Prasiola stipitata* (PRA) Extreme exposure - *Fucus distichus & Fucus spiralis* f. *nana* (FDIS)		***Pelvetia canaliculata* (PEL)** Vertical - *Verrucaria maura* & sparse barnacles (VER.B) Pools - *Enteromorpha & Cladophora* (CHL) Freshwater runoff / unstable - *Enteromorpha* (ENT) Nitrate enrichment - *Prasiola stipitata* (PRA) Vertical chalk - *Ulothrix flacca & Urospora* (UU) or *Blidingia* (BLID)		
UPPER EULITTORAL	***Mytilus edulis* & barnacles (MB)**	**Barnacles & *Patella vulgata* (BP)** Shallow pools - Coralline crusts & *Corallina officinalis* (COR)	***Fucus spiralis* (FSP)** Vertical - Barnacles & *Patella vulgata* (BP) Shallow pools - Coralline crusts & *Corallina officinalis* (COR) Low salinity - *Fucus ceranoides* (FCER)		
MID EULITTORAL	Shallow pools - Coralline crusts & *Corallina officinalis* (COR) Deep pools - Fucoids & kelps (FK.*)	**Barnacles & *Patella vulgata* (BP)** ***Mytilus edulis* & barnacles (MB)** Shallow pools - Coralline crusts & *Corallina officinalis* (COR) Deep pools - Fucoids & kelps (FK.*)	**Barnacles & *Patella vulgata* (BP)** ***Fucus vesiculosus* & barnacle mosaics (FVES.BP)** ***Fucus vesiculosus* (FVES.LIT)** Shallow pools - Coralline crusts & *Corallina officinalis* (COR) Deep pools - Fucoids & kelps (FK.*) Sediment influence - *Mytilus edulis* beds (MYT) Sand-scour - *Porphyra & Enteromorpha* (EPH) Chalk - *Laurencia & Gelidium* (RED.LAU) Clay & peat - Piddocks (PID.*)	***Fucus vesiculosus* (FVES.LIT)** ***Ascophyllum nodosum* (ASC.ASC)** Vertical - Barnacles & *Patella vulgata* (BP) Shallow pools - Coralline crusts & *Corallina officinalis* (COR) Deep pools - Fucoids & kelps (FK.*)	***Ascophyllum nodosum* (ASC.ASC)** Tide-swept - *A. nodosum*, sponges & ascidians (ASC.T) Variable salinity - *A. nodosum & F. vesiculosus* (ASC.VS) Low salinity - *Fucus ceranoides* (FCER)
LOWER EULITTORAL	***Mytilus edulis* & barnacles (MB)** ***Corallina* (RED.COR)** Shallow pools - Coralline crusts & *Corallina officinalis* (COR) Deep pools - Fucoids & kelps (FK.*) Surge gullies - Sponges, anemones & *Mytilus* (SAM)	***Himanthalia elongata* (HIM)** ***Corallina* (RED.COR)** **Red algal turf (RED.*)** Shallow pools - Coralline crusts & *Corallina officinalis* (COR) Deep pools - Fucoids & kelps (FK.*) Overhangs - Red algae & sponges (RSP)	***Himanthalia elongata* (HIM)** **Red algal turf (RED.*)** ***Fucus serratus* & red algal mosaics (FSE.RED)** ***Fucus serratus* (FSE.FSE)** Under-boulders - encrusting bryozoans, serpulid worms & *Porcellana* (BSP) Overhangs - Red algae & sponges (RSP) Shallow pools - Coralline crusts & *Corallina officinalis* (COR) Deep pools - Fucoids & kelps (FK.*) Sediment influence - *Mytilus edulis* beds (MYT) Sand-scour - *Audouinella floridula* (FSE.AUD) Chalk - *F. serratus* & piddocks (FSE.PID) Clay & peat - Piddocks (PID.*)	***Fucus serratus* (FSE.FSE)** U nder-boulders - encrusting bryozoans, serpulid worms & *Porcellana* (BSP) Overhangs - Red algae & sponges (RSP) & Bryozoans, ascidians & sponges (BAS) Shallow pools - Coralline crusts & *Corallina officinalis* (COR) Deep pools - Fucoids & kelps (FK.*)	***Fucus serratus* (FSE.FSE)** O verhangs - Red algae & sponges (RSP) & Bryozoans, ascidians & sponges (BAS) Tide-swept - *F. serratus*, sponges & ascidians (FSE.T) Variable salinity - *F. serratus* & large *Mytilus edulis* (FSE.VS)
SUBLITTORAL FRINGE	***Alaria esculenta & Mytilus edulis* (AL)** Surge gullies - Sponges, anemones & *Mytilus* (SAM)	***Laminaria digitata & Alaria esculenta* (LDIG.AL)** Vertical - *Alaria esculenta* (AL) Surge gullies - Sponges, anemones & *Mytilus* (SAM)	***Laminaria digitata* (LDIG.LDIG)** Under-boulders - encrusting bryozoans, serpulid worms & *Porcellana* (BSP) Vertical - *Laminaria digitata & Alaria esculenta* (LDIG.AL) Disturbed - *Saccorhiza polyschides* (SPOL) Chalk - *L. digitata* & piddocks (LDIG.PID) Surge gullies - Sponges, anemones & *Mytilus* (SAM)	***L. digitata & L. saccharina* (LDIG.LSAC)** Under-boulders - encrusting bryozoans, serpulid worms & *Porcellana* (BSP) Overhangs - Bryozoans, ascidians & sponges (BAS)	***Laminaria saccharina* (LSAC)** Tide-swept - *L. digitata*, ascidians & bryozoans (LDIG.T)

All codes prefixed by LRK. An * after the code shown indicates several types are described.

Appendix 2

Extract from biotope classification to illustrate hierarchical approach (from Connor *et al.* 1995)

Sublittoral fringe rock (kelp communities)

LRK.AL Very exposed sublittoral fringe bedrock with *Alaria esculenta* and *Mytilus edulis*

LRK.LDIG Exposed to sheltered sublittoral fringe rock with *Laminaria digitata*

LRK.LDIG.AL Exposed sublittoral fringe bedrock with *Laminaria digitata* and *Alaria esculenta*

LRK.LDIG.LDIG Moderately exposed sublittoral fringe rock with *Laminaria digitata*

LRK.LDIG.PID Sublittoral fringe soft rock with *Laminaria digitata* and piddocks

LRK.LDIG.LSAC Sheltered sublittoral fringe rock with *Laminaria digitata* and *Laminaria saccharina*

LRK.LDIG.T Tide-swept sublittoral fringe rock with *Laminaria digitata*, ascidians and bryozoans

LRK.SPOL Disturbed sublittoral fringe rock with *Saccorhiza polyschides*

LRK.LSAC Very sheltered sublittoral fringe rock with *Laminaria saccharina*

Minor habitats

LRK.SAM Surge gullies in the sublittoral fringe with sponges, anemones and *Mytilus edulis.*

Sheltered overhangs - see Eulittoral rock: LRK.BAS

Eulittoral mixed substrata

LMXD.FCER Low salinity eulittoral mixed substrata with *Fucus ceranoides*

LMXD.BLIT Unstable eulittoral mixed substrata with barnacles and *Littorina littorea*

LMXD.EPH Variable salinity or disturbed eulittoral mixed substrata with ephemeral green and red algae

LMXD.SAB Sand-abraded eulittoral mixed substrata with *Sabellaria alveolata* reefs

LMXD.MYT Eulittoral mixed substrata with *Mytilus edulis* beds

LMXD.ASC Full salinity mid eulittoral mixed substrata with *Ascophyllum nodosum*

LMXD.AMAC Extremely sheltered mid eulittoral mixed substrata with *Ascophyllum nodosum* ecad *mackaii* beds

LMXD.FVES Variable salinity mid eulittoral mixed substrata with *Fucus vesiculosus*

LMXD.FSE Lower eulittoral mixed substrata with *Fucus serratus*

LMXD.SAR Tide-swept lower eulittoral mixed substrata with sponges, ascidians and red algae

Minor habitats

LMXD.HYD Shallow pools on mixed substrata with hydroids, ephemeral algae and *Littorina littorea*

Extreme upper shore sediments (including saltmarsh)

LMXD.TAL Decomposing macro-algae on the strand-line with *Talitrus saltator*

LMUD.SAL Extreme upper shore mud with pioneer *Salicornia* spp.

For other salt marsh communities see National Vegetation Classification

Littoral (eulittoral) sediments (communities of amphipods, polychaetes and bivalves)

Shingle/gravel shores

LMXD.BAR Shingle or gravel shores with no apparent macrofauna

Clean sandy shores

LSND.BAR Very exposed coarse sand shores with no apparent macrofauna

LSND.AE Mobile coarse sand shores with burrowing amphipods and *Eurydice pulchra*

LSND.AP Clean sand shores with burrowing amphipods and polychaetes

LSND.AP.S Clean medium to fine sand shores with burrowing amphipods and *Scolelepis squamata*

LSND.AP.AR Mid shore clean sand with burrowing amphipods, *Nephtys cirrosa* and *Arenicola marina*

LSND.AP.ANG Lower shore clean stable sand with burrowing amphipods, *Nephtys cirrosa* and *Angulus tenuis*

Muddy sand shores

LMSND.ARB Mid to lower shore muddy sand with *Arenicola marina* and bivalves

LMSND.PC Lower shore slightly muddy sand with polychaetes and *Cerastoderma edule*

LMSND.LAN Tide-scoured lower shore sand with dense *Lanice conchilega*

Extreme lower shore communities see Shallow sublittoral sediments: LMSND.ECH and LMSND.ZOS

Appendix 3 Example of a biotope description (from Connor *et al.* 1995)

LRK.LDIG.LDIG: Moderately exposed sublittoral fringe rock with *Laminaria digitata*

Description

Moderately exposed to sheltered sublittoral fringe bedrock and boulders are dominated by a dense canopy of *Laminaria digitata* with a wide range of filamentous and foliose red algae beneath. The rocky substratum is usually covered by encrusting coralline red algae, on which occasional limpets *Patella vulgata* and topshells *Gibbula* spp. graze. A wide variety of fauna occurs, including the sponge *Halichondria panicea*, barnacles (*Balanus crenatus* and *Semibalanus balanoides*) and occasional small mussels *Mytilus edulis*. Kelp holdfasts provide a refuge for a varied assemblage of species including sponges (e.g. *Leucosolenia* spp.), anemones (*Urticina felina*), limpets (*Helcion pellucidum*), crustaceans, bryozoans and colonial ascidians. This biotope is usually found beneath the *Fucus serratus* zone (LRK.FSE) and above the truly sublittoral *Laminaria hyperborea* zone. Other canopy-forming algae such as *Alaria esculenta* and *Laminaria saccharina* may occur, although never at high abundance (compare with LRK.LDIG.AL and LRK.LDIG.LSAC respectively). In areas where tidal water movement is increased, a richer *L. digitata*-dominated biotope (LRK.LDIG.T) generally replaces the sheltered shore *Laminaria saccharina* (LRK.LSAC) biotope.

Very common

View of a well developed *Laminaria digitata* zone on a chalk platform (Newhaven, West Sussex; J.D. George)

Classification

Salinity:	Full
Wave exposure:	Moderately exposed - sheltered
Tidal streams:	Weak
Zone/range:	Sublittoral fringe
Substratum:	Bedrock & boulders
Other modifier:	

Encrusting coralline red algae beneath the kelp canopy (St. Margarets Bay, Kent; J.D. George)

The Development of the marine ZNIEFF (*Zones Naturelles d'Intérêt Ecologique, Faunistique et Floristique*) in France

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Introduction

The inventory of sensitive biotopes corresponds to a need that we have for both a better knowledge of the natural heritage and for ensuring their protection, particularly their most remarkable habitats and species. Following an inventory of terrestrial ZNIEFF (*Zones Naturelles d'Intérêt Ecologique, Faunistique et Floristique* - Natural Zones of Ecological, Faunistical and Floristical Interest), the inventory of marine ZNIEFF is being undertaken. The aim is to provide a typology adapted to the marine zone and to produce a synthesis and an inventory of the marine communities present on the French coast. Therefore, it is necessary to base our approach for the marine ZNIEFF on the ZNIEFF program co-ordinated by the *Secrétariat de la Flore et de la Faune* (Secretariat of Fauna and Flora, SFF).

The SFF was created within the National Museum of Natural History to take care of the depository of knowledge gained in the field of natural science (Maurin, in press). Its mission is to assess the heritage of natural environments and the diversity of species in France. The National Museum of Natural History is now under the responsibilities of two ministeries: the Ministry of the University and Research and the Ministry of the Environment and has three fundamental responsibilities:

1. research;
2. heritage conservation of natural and human sciences;
3. diffusion of knowledge and exhibitions.

It participates in the training of students and researchers and houses a doctoral school. For about twenty years, it has also had charge, at the request of the Ministry of the Environment, of the collection, computing and management of the national data on flora and fauna.

The Secretariat of Fauna and Flora

The activities undertaken by the SFF are dedicated to many kinds of objectives. The main ones are noted below.

1. Inventories of areas of the fauna and flora including zones of floristic and faunistic ecological interest (ZNIEFF) (Maurin, in press) and the marine ZNIEFF (Dauvin *et al.,* 1993, 1994, in press).
2. Distribution of flora and fauna species, detailed inventories of species and their populations, mainly flora, vertebrates, birds, mammals and for three years inventories of Crustacea Decapoda (Noël, 1993).

3. Bibliographical listings of plants and animals including historical data. Following more than ten years of work, the fauna data base includes over 2.5 million items and almost 20,000 areas of major biological interests.

The main elements in processing data in the fauna-flora information system (Beaufort & Maurin 1988) are:

1. input of data: field, collection and bibliography data;
2. maintenance of information on data banks for:
   a. distribution of the Flora-Fauna species
   b. areas of the Flora and Fauna studies
   c. flora and fauna bibliography and also a taxonomic file and reference files;
3. output of products and services: data processing, automatic mapping, studies and synthesis, thematical bibliographies, publications, statistics, taxonomic lists and typology references.

There are numerous links between the three different sub-units of the Fauna-Flora information system (Maurin, in press) and between the typology reference files, mapping reference files and bibliographical reference files.

The fauna-flora data base is the result of a political decision, but also of a good collaboration of participants including administrative institutions, public bodies and non-governmental or private organisations. One of the original features of the archiving of data of natural heritage is the complementary nature of amateur partners and their essential role in the collection of data. The role of the SFF is also essential to produce a national approach and to co-ordinate all these national and, certainly in the next years, European networks of naturalists.

What is a ZNIEFF?

<u>It is a portion of the national territory:</u>

- in which scientific experts have identified remarkable features of the natural heritage;
- localised by mappable features and administrative boundaries
- characterised by:
  - a physical and ecological description, and
  - the presence of species of wild fauna and flora.

<u>The aim of each ZNIEFF is to list:</u>

- protected species;
- threatened, rare or remarkable species;
- species or associations of species characteristic of the regional natural heritage.

<u>The large scientific inventory of the ZNIEFF aims:</u>

- to apply a standardised working method and a computerised management;
- to be held by specialists and validated by scientific councils at the regional and at the national level.

In summary, a ZNIEFF is an image of the scientific knowledge of national territory.

<u>The main partners of the inventory are:</u>

- Ministry of the Environment, Direction of Nature and Landscapes
- National Museum of Natural History, Secretariat of Fauna and Flora
- Regional Directories of the Environment
- Regional Scientific Council for Natural Heritage and Secretariat

A national ZNIEFF committee co-ordinated the action of each partners especially those of the 22 administrative regional partners which is based on a network of about 4,000 amateur naturalist for the terrestrial ZNIEFF.

At the beginning of 1994, 14,200 terrestrial ZNIEFF were defined in the first ZNIEFF inventory (1982-1994) which covered about 120,000 km^2 and 20% of the national French territory. Now, the Ministry of the Environment and the SFF are preparing the second generation of terrestrial ZNIEFF in better agreement with CORINE and habitat typologies.

Marine ZNIEFF

Simultaneously to the terrestrial ZNIEFF inventory, it appeared necessary to co-ordinate an inventory of marine ZNIEFF for the zones of interest on the French continental shelf (0-200m) and if necessary of the Exclusive Economic Zone (extending outwards to 200 nautical miles from the coast). In fact, some littoral marine ZNIEFF were described at the same time as terrestrial ZNIEFF in several regions with a coast (11 administrative regions including eight regions for the Atlantic coast and three regions for the Mediterranean coast). The PACA region (Provence Alpes Côte d'Azur) had described 107 ZNIEFF offshore of the coast and initiated the first marine ZNIEFF inventory with a typology and parameters adapted only for the Mediterranean Sea.

To begin with the national inventory of the ZNIEFF at a scale of all the metropolitan French coasts, it had been necessary to adapt a special typology of marine ZNIEFF with a respect of consistency with terrestrial ZNIEFF and with the two types of marines environment along the Mediterranean Sea and the Atlantic Ocean (Atlantic, English Channel and North Sea). The marine typology must also be coherent with the CORINE biotope and habitat directive typologies. An *ad hoc* group was created in 1991 at the National Museum of Natural History around the Secretariat of Fauna and Flora and the Laboratory of Biology of Marine Invertebrates and Malacology in association with colleagues from other laboratories from the Museum (Ichthyology, Cryptogamy, Geology, Physiology, Birds and Mammals) and from several marine biological stations (Wimereux, Roscoff, Concarneau, Marseille) and Universities (Caen, Brest, Marseille). During two years from the end of 1991 to the end of 1993, the group worked on the marine ZNIEFF typology and published a first version of their work "*Typologie des ZNIEFF-MER LISTE des parametres et des biocenoses des côtes francaises métropolitaines*" (Dauvin *et al.* 1993) and a second version in 1994 with an increasing of consistency with the second generation of terrestrial ZNIEFF and the habitat directive (Dauvin *et al.* 1994).

Description of the marine ZNIEFF

The description of the marine ZNIEFF is summarised on a checking form which indicated information on:

- location of the zone and date of the description: administrative region, maritime description, reference marine map with indication of the minimal and maximal depths, area of the zone;
- physical factors: tropism (oligo-, eu- or dystrophism); hydrology and hydrodynamism; exposure to waves and swell; salinity; turbidity; currents; thermocline;
- description of geomorphology (eg estuary, bay); milieux (based on the CORINE biotope reference); lithology (characteristics of the sediment and the stone); granulometry, status of the property; human activities and protection status;
- marine communities located in the zones classified in relation to four 'étages': supralittoral, mediolittoral, infralittoral and circalittoral and the substratum;
- main interests of the zone (faunistic, floristic interests);
- general comments on the zone: anthropogenic and natural factors pressure on the zone (extraction of sediment, fishing, tourism, erosion) and conditions for better conservation of the zone (if necessary indicate the proposal of an optimal conservation of the zone); criteria of delimitation of the area and link with other ZNIEFF;
- bibliography and other source of information about the zone.

It is clear that there is not a single criteria to define a ZNIEFF, this is often subjective and depending of the author. But a ZNIEFF should be identified in relation to:

- the diversity of the habitats and biotopes;
- the presence of rare or remarkable species;
- the species richness of the zone;

It is important to draw up the list of the protected, threatened and remarkable species of each zone. But the number of protected marine species is very low. For the French coast, among the plants, only two species *Posidonia oceanica* and *Cymodocea nodosa* are protected and, among the invertebrates, one gastropod (*Patella ferruginea*), three bivalves (*Lithophaga lithophaga, Pinna nobilis,* and *Pinna pernula*), the decapod *Scyllarides latus* and the sea urchin *Centrostephanus longispinus* are protected. These eight species live in the Mediterranean Sea. All the marine mammals, sea turtles and many marine birds are also protected along the French coast.

The list of the protected, menaced and remarkable species of the ZNIEFF will indicate the Linnean nomenclature, the 'étage' of observation, the biocenosis, the status (accidental, endemic), the abundance (A= rare, only few specimens, B=form a population, C=population abundant or very dense population). For each species, if possible, the year of the observations of the species and the year of appearance and disappearance (if necessary): *e.g.* date of the appearance of an introduced species, changes of repartition of a species in relation to climatic changes.

Classification of marine communities

In France, the Endoume School under the leadership of Pérès and Picard developed the classification of Mediterranean communities and proposed a ranking system based on the nature of the substratum and the light. The Pérès and Picard classification (1964) was the reference classification of the Mediterranean community; although researchers such as

Guille (1969) in the area of Banyuls proposed a classification of marine communities similar to that described form the Atlantic.

Along the Atlantic French coast, Glémarec and his collaborators (Glémarec, 1973) added another factor to define the 'étage': the temperature or more exactly its degree of variability between surface and bottom. Glémarec (1973) consequently defined three main 'étages' for the subtidal zones including an infralittoral, a coastal circalittoral and an open sea circalittoral.

In the English Channel, in a part of the sea with very strong tidal currents, Cabioch and his collaborators (Cabioch, 1968) made a geomorphological and edaphical distinction between the pre-littoral and the fronto-littoral and in each of these assemblages they distinguish the coastal and deep-water communities.

In summary, for the French coasts there are three main typologies of marine communities all based on the notion of 'étages' in relation to environmental factors (temperature, light, substratum) and their influence on the repartition of organisms. They are:

- in the Mediterranean Sea, the Pérès & Picard classification recorded the soft bottom and hard bottom communities;
- for the Atlantic French subtidal zone, the Glémarec classification recorded the soft bottom communities from the continental shelf, and
- for the English Channel, the Cabioch classification recorded the subtidal soft-bottom and hard bottom communities.

More recently Castric (personal communication) has recorded the subtidal hard bottom communities in Brittany explored by SCUBA diving and her work completes this overview of communities of the French coast and continental shelf. However, although there is a large tidal range on the Atlantic part of the French coast, the French researchers have relatively few works and publications of the littoral zone which is nevertheless very extensive in some part as in the Mont Saint Michel Bay.

The classification of the communities recorded from the French coasts in the marine ZNIEFF typology (Dauvin *et al.* 1993, 1994) was the results of:

1. the compilation of the published works on community of biocenosis;
2. the synthesis work of the *ad hoc* group in 1992 and 1993.

The communities were classified in four 'étages' according to the nature of the substratum from mud to rock:

- **supralittoral**: humification by seawater, very irregular immersion;

- **mediolittoral**: emergent (very eurythermal environment of great seasonal and also daily and tidal amplitude);

- **infralittoral**: from emergent saturated in water to the lower limit of photophilous algae (eurythermal eurythermal environment of great seasonal and also daily and tidal amplitude)

- **circalittoral**: from the lower limit of photophilous algae to the lower limit of sciaphilous algae, separated into a coastal circalittoral (eurythermal environment of weak seasonal amplitude, lower that 10°C), varying slowly to an offshore circalittoral ('circalittoral du large') with a stenothermal environment.

It is improtant to note that 'étages' are independent of the bathymetry, Pérès & Picard (1964) wrote "L'indication en mètres d'un niveau altitudinal (au dessus ou au dessous de zéro) n'aura qu'une signification locale ou, au plus régionale, et la notion de niveau bathymétrique ne sera jamais invoquée pour caractériser un étage. Cette conception, non bathymétrique, mais biologique, de l'étagement est le meilleur argument en faveur d'une valeur mondiale de systeme propose".

The supralittoral and mediolittoral 'étages' correspond to the intertidal or littoral zone, and the infralittoral and circalittoral 'étages' to the subtidal zone.

In a majority of cases, in the list of the biocenosis recorded on the French coast, the homology of communities between the Atlantic and the Mediterranean had been searched and, when it was not possible to find homology, the communities of each coast were described successively. Only the main 'faciès' (dominance of a species) were listed and the list of the main characteristic species of each biocenosis and faciès were given.

Summary and perspectives

The French approach to an inventory of Zones of Natural, Ecological, Faunistic and Floristic Interest provides:

1. a standardised method at a national scale and a computerised management;
2. a typology of marine ZNIEFF which is a tool for regions which have to make the inventory.

However, it is clear that in the 11 coastal regions, the inventory of marine zone will be executed by or under the responsibility of specialists located in Marine Stations and Universities.

The distribution of marine littoral communities around the marine stations and for most of the subtidal communities of the continental shelf are well known but some parts of the littoral zone of the Atlantic coasts and a large area of the subtidal zone between the Rhône and the area of Banyuls remains to be studied.

The programme for the marine ZNIEFF inventory will be:

- 1995: start of inventory in some pilot regions;
- 1996: first national evaluation and start of the inventory in all the 11 regions.

The marine ZNIEFF *ad hoc* group and the Secretariat of Fauna and Flora should initiate links with other countries on further development of inventories of protected marine habitats and environments in the EU, including proposals for modification of CORINE and the Habitat Directive. It will also prepare a marine typology adapted to the overseas French Department communities (Martinique, Guadeloupe, Guyana and Réunion).

In the same time, two books about marine biocenoses and their protection have been prepared:

- the first one about the biocenoses of the Mediterranean Sea co-ordinated by Bellan-Santini *et al.* (1994) had just been published;
- the second one, on the biocenoses of the Atlantic, English Channel and North Sea French coast co-ordinated by J C Dauvin will be ready at the beginning of the 1996.

Acknowledgements

I thank all my colleagues of the *ad hoc* group ZNIEFF from the Museum and the other marine laboratories, specially Concarneau, Marseille and Roscoff, and D Richard who have made the translation of the ZNIEFF document. This work is an issue of a collective work on marine biocenoses and not a personal one. I thank also the BioMar program for their invitation to present the ZNIEFF programme at the marine classification workshop, and Keith Hiscock for his help in correcting the manuscript.

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Discussion following the papers by David Connor and Jean-Claude Dauvin

Mediterranean classifications

Gerard Bellan indicated that the authoritative sources for description of Mediterranean biocenoses were particularly Pérès & Picard (1964) and Ros *et al.* (1985) rather than the report by Augier (1982). [Additional reference to those given in the paper by David Connor:

Ros, J.D., Romero, J., Ballesteros, E. & Gili, J.M. 1985. Diving in blue water. The benthos. In: *Key environments: western Mediterranean*, ed. by R. Margalef, pp. 233-295. Oxford, Pergamon Press.]

ZNIEFF and MNCR classifications

Tom Pearson asked if there were any major differences in the ZNIEFF approach and that of the system outlined by David Connor - it seemed that they were very similar. The MNCR team had compared the classifications and found some identical types and many similarities and a similar level of differentiation. Denise Bellan-Santini reported on discussions with Professor Pérès in which he had suggested that there were only two ways to classify - 1) by level on the shore/bathymetry and 2) by ecology with different conditions of hydrodynamics, substratum, light, temperature etc. With these different conditions in different parts of the world, a similar type classification is obtained. For the different communities in the different type of classification there are two methods of approach - qualitative and quantitative. The first uses the dominance of one or two species (characteristic species). The second method is to use all of the species in a quantitative way to represent the community. If we chose to have a classification by the ecological approach it should be possible to have good co-ordination with the different classifications. Where there have been problems it has been because data were not sufficiently important or sufficiently precise especially at the species level.

David Connor clarified that, in the analysis of field survey information, all of the data collected are used although, when the biotope is named, it is generally through the most conspicuous or preferential species. However, a species named in the title of a biotope might sometimes not be present in samples and this was a consequence of not being able to name all of the characterising species in a reasonably succinct title. Michel Glémarec identified that, in relation to agreeing the broad framework for the classification, in Great Britain the term "zone" was used for rocky areas and sediment areas. In France, the ecological factors which define the different *ambience* in the rocky and sediment areas they are not the same and this caused problems in intermediate habitats.

Utilising MNCR biotopes for mapping the littoral and sublittoral environment

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The BioMar partners based at Newcastle University are primarily concerned with developing relatively rapid and cost efficient methodologies for mapping the distributions of littoral and sublittoral biotopes. The purpose of the presentation was to show how biotopes as derived by the MNCR have been used as units for mapping.

Sublittoral biotope mapping adopted by the BioMar team is based on acoustic remote sensing using an echosounder which produces information of the hardness and roughness of the sea floor under the survey vessel as it proceeds. The acoustic properties of the ground between ships' tracks are interpolated so that a continuous coverage of the sea floor is generated. This acoustic map is then ground-truthed using a remote video supplemented by other sampling methods. Littoral survey utilises aerial photographs combined with Ordnance Survey maps to produce a base map which can be ground-truthed by site visit.

In both cases, the purpose of ground truthing is to recognise MNCR biotopes and not to obtain detailed descriptions of habitat and the abundance of species in the biotopes. Thus, the ground truth data tends to be at a more general level than the data collected by the MNCR survey methods.

The problems associated with mapping littoral and sublittoral biotopes are quite different from each other. The sublittoral survey produces a very general picture and, even with extensive tracking and ground truthing, there is a limit to the detail that can be mapped due, ultimately, to positioning errors. Single biotopes can rarely be displayed due to the heterogeneous nature of the sea floor. Instead, suites of biotopes are displayed that typify large areas of the sea floor. Thus, there is little to be gained from producing the sublittoral maps at scales greater than 1:50,000.

Littoral surveys, on the other hand, can produce very detailed biotope maps limited only by the time available for survey. Data also has to be simplified for display at map scales of 1:5,000 and 1:10,000. To produce a littoral map with the same level of generality as the sublittoral maps (when combining littoral and sublittoral maps, for example) the littoral biotopes must be combined into some larger unit that can be represented at the chosen scale (1:50,000 to 1:150,000).

How can the MNCR biotopes be combined to form mappable units at these larger scales? One option might be to arrange the biotopes into an hierarchical structure and use the more general biotope categories as mapping units. However, this assumes that these more general biotope categories equate with larger spatial units which is not the case: very different biotopes can form a small, heterogeneous area.

What is required is a system to describe suites of biotopes and their associates 'landforms'. The littoral environment is generally characterised by zones running parallel to the shoreline and shores can be characterised by commonly recurring suites of biotopes found on shores of differing exposure and profile. The shores can, therefore, be represented by a string of shore types whose thickness represents the width of the shore or, in the case of cliffs or steeply sloping shores, are of a nominal thickness representing an essentially linear feature. Examples of how detailed biotope maps could be generalised into maps of shore type were taken from recent work on the Berwickshire coast.

Very extensive shores and much of the offshore sublittoral environment is composed of more extensive patches of single biotopes or of extensive heterogeneous patches with a limited range of biotopes arranged isotropically throughout. To date, these have been described and mapped as encountered without any universal system for their classification. However, some universal classification of marine landscape features appropriate to mapping would be desirable.

In conclusion, the MNCR biotopes have been found to be useful for the recognition of biotopes in the field and from the analysis of video tapes and they have been used as the basic units from which larger landscape features have been described.

Practical application of the biotope classification: nature conservation and site selection

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Introduction

The classification of benthic marine biotopes is being developed to underpin management and conservation of marine ecosystems. It does this in a number of ways:

- By providing a standardised framework in which to place results of ecological survey (and also encourages standardised collection of data)
- It provides a common language for describing the biological character of the marine environment. (thereby allowing different workers to speak the same language)
- It allows the distribution and extent of different biotopes to be mapped, thereby assisting management of marine environment and
- It provides a basis for comparison of the nature conservation importance of individual sites and larger areas. This paper aims to outlines the way that the classification of benthic marine biotopes will be used to assess areas of high conservation importance.

Which is the best area to conserve?

In the past, the identification of important marine biological areas was often carried out with a large degree of subjectivity. While this approach may have still selected the best areas for conservation, it is much less easy to justify decisions based on subjectivity alone. One of the major advantages of the classification of benthic marine biotopes is that it will allow a more scientific approach to site selection to be used.

We are currently developing a protocol for identifying and assessing areas of high marine biological importance.

When complete, this protocol will be used to draw comparisons between a number of different sites of the same physiographic type. In this way we can then select of the most appropriate sites or area/s for nature conservation.

The biotopes classification is important at 2 levels of this conservation assessment:

- **At the site level**: By grouping similar records into the same biotope type, it is possible to identify those sites containing the most highly rated examples of each biotope (comparing like with like). This provides us with a measure of biotope quality (see below).

The second level of assessment is made:

- **In a larger area.** The different biotopes present within a larger area are used to compare and evaluate similar physiographic features to identify the best example/s for nature conservation.

Although it is still under development, the main features of the conservation assessment protocol are as follows:

A. At the site level:

The first step in assessing the marine biological importance of sites involves the analysis of field survey results for an Area of Search (this AOS is large, usually one of the fifteen MNCR coastal sectors). This gives an inventory and distribution of biotopes within the area of search.

Once this biotopes classification is complete, it is then possible to undertake a comparative assessment of records within each biotope type (comparing like records with like). This will then identify the locations of the most highly rated examples of each biotope. A number of criteria are used in this assessment and in ranking sites which contain a particular biotope, all of these factors must be considered together:

1. **Typicality** - an assessment of how close the record is to the type biotope.
2. **Species richness** - Sites which have a greater species richness (and abundance) will be ranked higher (care is however needed here - consider in parallel to typicality as atypical records can be highly diverse).
3. **Species rarity** - sites which contain rare or scarce species will be favoured. This assessment should be carried out at a regional and national level, and the species should be conspicuous and reliably identified when present.
4. **Naturalness** - Non-natural features, such as artificial substrata, pollution, and the presence of non-native species which affect community composition, will down-grade a site.

Overall the sites where each biotope occurs can then be ranked in order of this Biotope Quality, and at this stage it is possible to identify the locations of the most highly rated examples of each biotope.

B. On a larger scale

The classification of biotopes is useful for assessing the nature conservation importance of a number of larger scale features such as sealochs, estuaries, or sections of open coastline.

A number of further criteria are also used to aid this assessment. These are as follows:

1. **Representativeness**: The best example/s of a feature will contain most biotope types.
2. **Biotope rarity:** Rate those areas that contain rare biotopes (both at a regional and national level)
3. **Biotope richness**: weight areas with high biotope richness particularly if they occur in a small area- since it indicates high biodiversity.
4. **Biotope quality** : Rate areas that contain the most highly rated examples of each biotope type (see section A above).
5. **Species rarity**: Rate those areas that contain rare or scarce species (this also relates to biotope quality)

6. **Naturalness**: rate natural areas more highly than disturbed/ polluted areas (also relates to biotope quality).
7. **Species richness (overall)**: Give weighting to those areas that have the greatest number of species - since they tend to include populations of rarer species (assess separately for rock/sediment and littoral/ sublittoral biotopes).
8. **Extent of biotope:** Particularly important for rare biotopes and species.

It should be stressed, however, that these criteria are not independent of each other and it is the product of their interaction which is important at assessing the most highly rated example of a particular physiographic feature. In addition, these criteria may not be equally weighted.

Summary

It is clear then that the completion of the biotopes classification will have considerable gains for our work on the identification of sites and areas of nature conservation importance. Although the biotopes classification is still under development, it is already being used to assist in the further development of the conservation assessment protocol outlined in this paper. This will, in turn, allow us to compare similar sites and confidently recommend the most appropriate ones for conservation.

Reference

Sanderson, W.G. In prep. Rare marine benthic flora and fauna in Great Britain: the development of criteria. *Joint Nature Conservation Committee Report*, No. 240.

Footnote

As the MNCR site assessment protocol is still under development, further modifications to the criteria have been made since this paper was presented. At the time of going to press (August 1995), further development of the conservation assessment protocol is continuing through the work of a JNCC and United Kingdom nature conservation agencies task force. This task force is due to report in the Autumn of 1995.

The Marine Nature Conservation Review database: its role in data analysis and the further development of the classification

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Introduction to the Marine Nature Conservation Review (MNCR) database

The MNCR database is an invaluable tool that underpins the development of the MNCR's biotope classification system. It has enabled the staff of the MNCR to carry out very detailed and meticulous examinations of a huge and continuously growing amount of widescale and complex data from surveys undertaken all around the UK littoral and sublittoral zones.

The database has helped to ensure that the classification developed by the MNCR is as accurate and comprehensive as possible. With successful implementation of plans for further development of the database in areas such as site assessment, the database can provide a working model of how computers and the MNCR approach to biotope classification could be used to underpin nature conservation not just in Great Britain but throughout Europe.

The MNCR gathers data in a variety of ways. Although some data is collated from existing sources of information through the published literature, the bulk of its field data is derived from field surveys. Additional field survey data is available in the published papers and commissioned research reports as supplements to reports or as completed field survey forms from surveys commissioned prior to the commencement of the MNCR. Also, many organisations and individuals carry-out field surveys using broadly similar methods and can supply data in database files, on spreadsheets or on paper.

The MNCR uses a computerised database to assist with the organisation, storage, rapid and easy retrieval, querying and analysing of the data gathered from both their information review and from their field surveys. The database was intended primarily as a repository for MNCR data and secondarily as a tool to assist the MNCR scientific staff in the basic analysis and interpretation of their data and in the production of reports based on that data.

The database, currently developed in the database management software called *Advanced Revelation*, is used on a computer network within the JNCC. This offers the advantage that one master copy of the data is kept and many users can have access to the same up-to-date data. There are also a number of external users including outposted teams from the MNCR, the country nature conservation agencies (English Nature, Scottish Natural Heritage and the Countryside Council for Wales), and some other organisations and contractors where the database exists in both networked and stand-alone versions. A copy of the database is held by BioMar colleagues in the Republic of Ireland who add data from their surveys. All the data collected by these different organisations are entered onto their copies of the database. At intervals, data are downloaded to floppy disk and sent in to the database manager. The data are then merged with those on the JNCC system with data updates later being sent out to the external users. This ensures that the database provides wide-ranging data to develop the biotopes classification..

The database has been developed as a highly functional and powerful application. It has many standard reports, full facilities for users to generate *ad-hoc* reports and interfaces directly with several external software packages, allowing data to be exported and used directly using appropriate options from the database application menu.

Examples of interfaces with external packages

Examples of the kinds of packages that have been interfaced include mapping software and statistical analysis packages. These are summarised below.

UKDMAP — A useful data display and presentation tool allowing data to be shown on a UK map, such as the distribution of particular biotopes across the UK. This can be done easily and data points can be set up to provide basic responses to queries.

Plot 5 — A map plotting package for producing reasonably high resolution distribution maps for inclusion in reports and publications.

DMap — A mapping tool combining qualities from *UKDMAP* and Plot 5 allowing the generation of distribution plots and concurrence maps.

TWINSPAN — Applies traditional classification or cluster analysis techniques to MNCR data and is used to assist determination of a biotope classification. The database application prepares and exports data in the appropriate format, runs *TWINSPAN*, saves the output in DOS files, and then returns to the database.

DECORANA — Applies traditional classification/ordination techniques to MNCR data through correspondence analysis. Once again, the database application formats the data appropriately and then runs the analysis through *DECORANA*.

The database also interfaces directly with Lotus 1-2-3 formatted spreadsheet files and can export data in dBase and ASCII file formats.

Size of the database

In November 1994, the database was 70 megabytes in size and the number of records held for each of the major raw data files in the database are summarised in the following table.

File	No. records
Literature references	> 11,300
Slides catalogued	> 16,640
Surveys	= 472
Sites	> 9,490
Habitat records	> 20,430

Applications of the database

There are a number of uses to which the field survey data can be put through the database.

- Survey reporting

The field database module can generate lists of sites surveyed and species lists and many other kinds of reports containing summary or detailed information.

- Geographic index to field surveys

Because the survey details include positional grid references and other geographic details such as country region/district/county, information about marine habitats can be tracked down according geographic criteria. For example, if someone needed information about MNCR survey work carried out in Sutherland, Scotland, this information could be accessed readily.

- Survey planning and identification of gaps in survey coverage

Because the database holds data for all the marine surveys carried out under the auspices of the MNCR and others besides, it provides a comprehensive catalogue of areas that have been sampled. It can therefore be used in determining where survey work is required and avoiding replication of previous work. It also allows assessment of data quality, and on the basis of such assessments, decisions can be made about whether it is necessary to survey areas again.

- Site inventory

A simple use of the database is in providing site listings or site inventories for identifying areas that have been covered in the surveys. For these sites, reports can be compiled detailing desired information about the habitats present at these sites along with distribution maps.

- *Ad-hoc* queries

The database allows users to query data in simple or complex ways. For instance, the user could pose a question such as "in which habitats was the sea pen *Funiculina quadrangularis* recorded?" This could then be further refined to "In how many of these habitats, at greater than 30 m depth, did *Funiculina* co-occur with the Norway lobster *Nephrops norvegicus*?"

- Mapping

The interfaces with map plotting tools can use the positional information gathered with the field data to display geographic distributions and various attributes of the data.

- Electronic publication

Plots created in *UKDMAP* can be published in electronic form as atlases of data.

- Support for advice service

When MNCR staff are contacted by the country agencies for advice on various aspects of marine conservation, the database provides invaluable information that helps formulate a response.

- Analysis of field survey data

A major feature of the database is that it provides the user with access to a variety of analytical tools through its interfaces with multivariate analytical packages.

- Classification of marine ecosystems

Over the last decade, various classifications of littoral and sublittoral communities have been developed specifically to assist the selection of marine sites for nature conservation. The MNCR's classification is primarily based on physical features and major habitat types within a biogeographical framework. The database therefore provides a fundamental underpinning to the development of the classification. Recent development work has provided a dictionary that is used to define biotopes, allowing storage of information on characteristic species of the community and the physical conditions in which the community occurs. Any habitats that are related to the given biotope can then be tagged and thereby cross-referenced.

- Site assessment

Once the described habitats are attributed to a particular category in the classification, a process of comparative assessment can be carried out to indicate the key sites. This evaluation is undertaken using site assessment protocol developed by the MNCR. Although much of this process would require manual manipulation of data at present, the database is currently being developed to provide the necessary information on demand.

The process of developing a classification and the database's role

Sketching out the process involved in classifying a biotope and thereby building a classification is a good way to illustrate how the database underpins the development of a classification. A classification scheme can be applicable to a particular region or series of related areas from sealochs to the whole of the British Isles. Sealochs, for example, can therefore form a single classification scheme. Within each such scheme is a developing and growing range of biotopes.

The initial determination of a biotope is often based on knowledge and assumptions. For example, *Fucus serratus* on littoral rock is a well known and widespread biotope type. As a simplistic example, determining whether this *Fucus serratus* biotope could be broken down further into, say, those on bedrock and boulders, would involve the compilation of all relevant records for that region. The list would then be refined according to the quality of data and other appropriate criteria. The data would then be ready for analysis. This basically involves taking large datasets and splitting them up into subsets according to statistical distances of similarity. The splitting is done primarily using traditional cluster analyses or correspondence analyses. These analysis methods are applied by running the data through standard and widely used multivariate statistical packages, *TWINSPAN* and *DECORANA*. There are also other statistical packages available if different analyses are required.

On responding appropriately to prompts for certain decisions about the kind of analysis required and on activating the analysis, the database formats the data appropriately, launches the analysis packages and runs the analysis before returning to the database application. The analyses are set up to run and output the results to files which can then be viewed by the user. The resulting subsets or clusters can then be examined for correspondence to biotope types. If groupings can be identified the classification may begin to form. For example, one cluster might consist entirely of *Fucus serratus* on littoral bedrock and another entirely of *Fucus serratus* on boulders. However, although we could be looking at two distinct biotopes, the interpretation of clusters and sample units making up the results is critical in deciding about the development of the classification. So, although the splitting is done using multivariate statistics the experienced marine ecologist maintains a controlling influence throughout the process. When the user is satisfied that there is a biotope type, the database can then be used to assign it to the appropriate scheme and store a definition in the biotope dictionary. The biotope definition in the dictionary is then used to tag each habitat record that belongs to that biotope type.

Ultimately, the different regional classification schemes have to be amalgamated into a comprehensive British Isles classification. This may involve combining equivalent biotopes or further splitting as appropriate. By comparing the biotopes defined for different regions, some similarity and commonality may be found along with some differences. Some of these differences may be due to more or less habitat records being involved in the analysis. Some may be due to individual decisions made along the way. For example, one ecologist may have decided that habitats with certain species occurring less than frequently should be excluded while another may decide that any occurrence of a given species should be considered and therefore included. A further source of variation may result from different biogeographical characters of the regions.

By analysing data at a larger British Isles level using much the same process as for regional classifications, it is possible to then compare the biotope definitions that appear with those at the regional levels.

Through this comparative approach, it is possible to refine each of the classifications. This then effectively becomes an iterative process, to which the database is central, arriving at clear, sensible and effective biotope definitions, leading eventually to a sturdy British Isles classification.

Discussion following the papers by Bob Foster-Smith, Tim Hill and David MacDonald

Rarity

Following questions about rare species Tim Hill indicated that assessment of rarity was based on IUCN guidelines. "Rarity" of a species is determined by the proportion of 10 km by 10 km squares (of the Ordnance Survey national grid) in which a species was recorded. Rarity was not therefore habitat- or biotope-based, but was assessed for the whole coast of Great Britain. Further details of the criteria for rarity assessment in the marine benthos are given by Sanderson (in prep.).

Conservation assessment

The use of the biotopes classification in the comparison of two areas was questioned by Ole Anderson. The criteria were of different types and this was likened to basing an assessment of nature conservation importance on comparing apples and pears. Keith Hiscock indicated that this could be a problem if a formula was used to produce a scoring system, but this was not the case. The criteria produced a structure to what might otherwise be unstructured decisions about nature conservation importance.

Adequacy of species recording

The problem of inadequate recording of species distributions was raised by Tom Pearson who reminded the meeting of how the distribution of a species often followed the distribution of marine laboratories. However, the meeting was reassured by David Connor that in order to overcome that sort of problem, the comparisons which were made by the MNCR relied on one team to provide the information to similar levels of taxonomic skills. Inevitably there was some variability in detail of records depending on the activities of taxonomic experts in the area. The brief for the MNCR team is that they should be able to identify all the conspicuous species present during survey work, although we acknowledge that taxonomic specialists will boost records of certain groups from the sites that they survey. The role of field recording was highlighted by Bob Foster-Smith into two separate processes - data analysis which is used to identify biotopes present and the use of the biotopes to which criteria for conservation assessment are made.

Howard Platt reminded the meeting that records did not need to be of the highest possible quality and that the consistent form in which the MNCR data was collected should be good enough to identify sites of nature conservation importance around the British Coast.

Methods to identify biotopes from database information

Mark Costello asked how the data was used to identify biotopes. Tim Hill replied that the ways of selecting data was guided by a manual prepared by David Mills. However, the methods were continually adjusted. Richard Warwick asked for clarification of how multi-variate analysis was used to identify groups of sites. The talk had indicated that if multi-variate analysis produced groups not corresponding to pre-conceived ideas of biotopes the results were rejected. He had further observed that the computer analysis could not be used because if it suggested groupings that could not be identified in the field, the results would be rejected. The system therefore had to be subjectively based. David MacDonald indicated that if the results of analysis did not match the established biotopes, further consideration would be required. He emphasised that the results of analyses were likely to indicate the effectiveness of the analytical criteria and the data selected - if the results showed no pattern the wrong question was being asked. David Connor addressed the question of the level at which the results of analysis should be split. Records from say 1,000 sites could be split at the level of two types or 200 types, for instance. The decision at which level to split had to be a practical one. Computer analysis was important in identifying trends in data and correlating species and habitat characteristics but, in the end, the results of analyses had to be related to field observations. However, environmental factors were correlated with biological data without the aid of the computer although it would be beneficial to use the computer. Jean-Claude Dauvin reminded the meeting that seasonality could also be important as could the number of stations supplying data and whether data was qualitative or quantitative. The experience of the worker is also important in producing a realistic classification.

Discussion following the first day

Species 'rarity'

The importance of species and species rarity was raised by Tom Pearson especially in relation to applying schemes which use rarity in a north east Atlantic context. Methods of assessing rarity seemed to be nationally based rather than biogeographically based. In response, Bernard Picton acknowledged that a species rare in Great Britain but common outside of Great Britain constituted a different sort of rarity. Another aspect of species characteristics raised by Richard Warwick was that on conspiciousness or charisma and how important these features were in assessing nature conservation importance. Keith Hiscock responded that large charismatic species, particularly vertebrates, are a very important focus in nature conservation. That focus was important politically and we do rely on birds and cetaceans in particular to provide support for nature conservation in general. Another important feature related to species was vulnerability. However, our knowledge of the sensitivity of species to various activities and impacts is very poor and vulnerability was a difficult criterion to apply. Jean-Claude Dauvin also reminded the group that some species were key species because they were themselves sustaining particular biotopes. For example, *Posidonia*. Tom Pearson also noted that species were important to the biotopes classification because of the need to identify characterising species. However, there were not always clear characterising species.

Biogeography

There was a wide-ranging discussion about biogeography and the geographical area which would be covered by the biotopes classification. The area which seemed to be agreed extended from east of North Cape to the entrance to the Mediterranean including the Azores, Faeroe Islands and Iceland. However, because of separate work being undertaken in the Baltic that area would be excluded. It was nevertheless important to ensure that work being undertaken in the Atlantic was interfaced with work being undertaken in adjacent areas particularly the Mediterranean and the Baltic. Although it was felt that consideration of biogeographic zones along the coast could be a distraction to the main aims of the meeting, it was very important to establish what those zones were for the selection of conservation areas within them.

Basis of the classification

There was concern about the relative use of physical habitat in the classification versus biological assemblages. It was suggested that the classification would require a multi-dimensional approach in which it should be expected that the same biotopes would occur in different physiographic situations.

Workshop subgroups

Introduction (Keith Hiscock)

The workshop subgroups were asked to discuss the structuring features for a framework to the classification and to report back. The topics suggested for discussion are noted below.

1. Which environmental factors are of key importance in determining community structure. These are likely to include:

Substratum	Temperature (biogeography)
Height/depth (desiccation/light penetration/ thermal stability, wave disturbance)	Geomorphology
	Geology
	Pollution
Exposure to wave action	Oxygenation
Strength of tidal streams	Wave surge
Salinity	Scour/turbidity/siltation

   It may be helpful to consider the key biological factors as well, e.g. grazing/predation, competition, recruitment, and how these are dealt with in the classification.

2. Are the elements of height/depth and wave exposure (rocky habitats) or height/depth and sediment type (sediment habitats) acceptable as a broad basis in which to develop the classification (with other variables being accounted for within this)?
3. What are the most appropriate divisions to adopt for zonation, wave exposure and sediment type (grain size). Are the MNCR divisions used appropriate to apply across the north-east Atlantic? If necessary, come correlation of terminology may be appropriate; e.g. for zonation. In some areas, these divisions might benefit from more detailed discussion of biotopes to establish key differences say between depth regimes and sediment types.
4. Within an agreed framework, consider how best to develop the classification within the time available. This might include:

   Establishment of broad types within each main area of the matrix and the likely extent of variation, e.g. indicating the characterising species in shallow muds and that there are likely to be variants in fully marine, variable and low salinities, but that muds in moderate depths only occur in marine and variable salinities.

   Consideration of the types currently listed by the MNCR at a broader geographical level and addition of types to cover other areas in north-east Atlantic.

Specific sub-groups

Rock	Littoral	Is use of broader divisions, e.g. for fucoids, desirable and workable without disrupting the close association of types in the listing of types? How best to accommodate shores with very narrow tidal ranges.
	Sublittoral	Should there be a deep circalittoral zone defined? (circalittoral du large?).
Sediment	Littoral	What are the most appropriate broad sediment types to group biotopes under and map? How many divisions of salinity are appropriate? What is the significance of variable salinity (estuaries) compared with stable reduced salinity (brackish lagoons, the Baltic)?
	Sublittoral	As for littoral + Can major depth zonation divisions be established with broad correlation to rocky zonation (algal communities in shallow water/ wave disturbed - infralittoral; communities in moderate depths - thermally unstable - circalittoral; communities in deep thermally stable water)
Lagoons		Thinking about lagoon habitats is likely to vary markedly from proposed structure BUT need it? What factors are not adequately accommodated. Is there significant correlation between lagoon communities and Baltic systems?

Report of the littoral rock workshop subgroup

Members: John Baxter (Chairman), Frank Gentil, Tim Hill, Ruth Nielson, Mandy Richards, Sai Salinas, Ian Tittley (Rapporteur).

Definitions

In the definition of UK and north-east Atlantic rocky shore biotopes the group advocated a pragmatic approach (practical but not necessarily perfect).

The group proposed a definition the "littoral" zone of the sea-shore based on physical factors. The "littoral" is an area of coast intermittently covered by water, due to conditions of tide, meteorology, wave action, and may range in vertical extent from almost zero to many metres.

Despite the physical approach outlined above, the group arbitrarily defined the upper limit of the "supralittoral" zone (from the adlittoral zone of marine/maritime influence) at the upper limit of the yellow lichen zone. The Group agreed that the supralittoral was a part of the sea-shore never regularly covered by water but affected by salt spray.

The Group agreed that there is a part of the coastline permanently covered by water - the "sublittoral" zone.

The Group felt unable to agree whether the "*Himanthalia* biotope" was a "lower littoral" or "sublittoral fringe" biotope. The Group noted that "infralittoral fringe" biotopes defined by colleagues in France corresponded to "lower eulittoral" biotopes defined by MNCR.

The Group agreed that the top (y) axis of the UK rocky shore biotope matrix was the next most important feature, and agreed (arbitrarily and pragmatically) also the five main categories, but noted that elsewhere (e.g. Spain, Denmark) three (or more than five) are commonly used. The Group recognised the necessity for a calibration of the terms "very exposed to very sheltered" throughout the north-east Atlantic area.

The Group agreed the following environmental factors of KEY importance (but not in order of importance):

Substratum
Height on the shore
Wave-action
Salinity
Water temperature

The following factors were modifiers of the main factors (not in order of importance):

Tidal induce streams	Pollution
Air Temperature	Disturbance (anthropomorphic)
Day-length	Oxygenation (especially in rock pools)
Ice-scour	Sand-scour
Geomorphology (a major modifier)	Turbidity/siltation
Geology	Insolation

The Group briefly considered biological factors.

Biological factors may modify a biotope and for practical purposes the modification may be deemed a separate biotope e.g. a grazed out algal biotope by limpets could be defined a limpet biotope.

Introduced species can characterise a biotope e.g. *Sargassum muticum.*

Defined biotopes may reflect stochasticity in recruitment and species interaction.

Re-evaluation of depth zones in rocky shore biotope matrix.

Depth zones were previously considered in a physical context, and were now re-assessed in the context of defining biotopes.

The group concluded that *Fucus serratus* occurs in the lower (eu/medio) littoral.

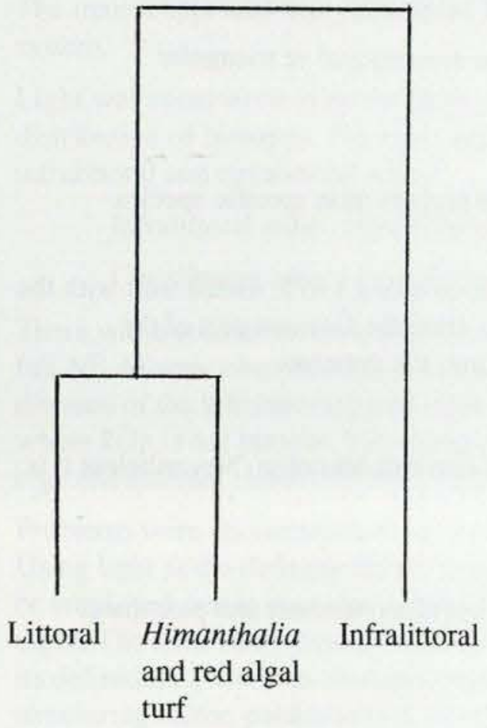
Biotopes below this occur in the infra- (sub) littoral fringe and included:

Himanthalia elongata (? wetness dependent)	
Red algal turf	(wetness dependent)
Laminaria digitata	(wetness dependent)
Alaria esculenta	(wetness dependent)

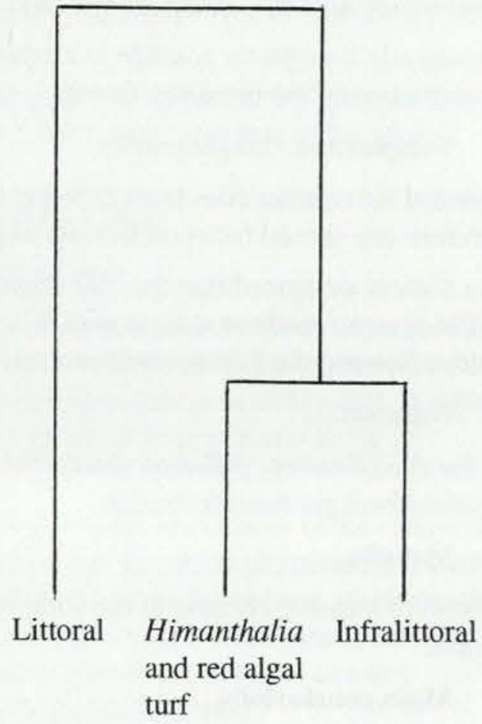
As the group was unable to agree whether the *Himanthalia* + red algal turf biotopes were better referred to the lower eulittoral or to the sublittoral (infralittoral) fringe, data

analysis based on comparison of species similarities was suggested. The group proposed testing for the following likely outcomes of such an analysis:

Himanthalia and red algal turf part of the littoral



Himanthalia and red algal turf part of the infralittoral



Report of the littoral sediments workshop subgroup

Members: Paul Brazier, Mark Costello, D.J.M. Dewarumez, , Ingrid Krönke (Rapporteur), Don McLusky (Chairman), Maria Helena Moreira, Howard Platt.

Definition of littoral zone

Because of the wide variety of littoral zones we agreed on the pragmatic approach of accepting the mean low water spring as the border between littoral and sublittoral.

Environmental factors

1. Substratum

We agreed on the substratum as being the major structuring factor (biological implications behind physical parameters should not be forgotten!).

Standard definitions of sediment type (for example mud, muddy sand, sand and gravel) should be adopted, preferably according to the Wentworth scale.

The quality of the sediment, for example TOC-concentration or gray or white mud, has to be taken into consideration.

Exposure to wave action, strength of tidal streams, wave surge and scour, turbidity can be summarised under "Hydrodynamics" and are reflected by the sediment structure.

2. Height and depth

We prefer "immersion". Immersion depends on the angle of the slope.

3. Salinity

Salinity is a third key-factor and becomes increasingly important in estuarine systems. Therefore we agreed to establish a second matrix of substratum against salinity.

Alternatively it might be possible to establish a three dimensional or triangular representation of the three key-factors.

4. Temperature / biogeography

In general the communities from different latitudinal regions miss specific species. Therefore one should focus on functional groups.

Nevertheless we agreed that the "Glémarec"-system, columns 1 to 5, match well with the MNCR-system, medium sand to mud. Communities from the German part of the Wadden Sea and the Portuguese coast also fit well into the systems.

5. Pollution

For the classification, pollution should not be taken into consideration. Nevertheless it is important background information.

6. Maturity

Difficult to measure because of the wide variety of larval recruitment and patchiness patterns.

Main conclusions

1. For classification purposes, the littoral is a valid division.
2. Key factors for matrix are: substratum, salinity, immersion.

[Following the workshop, Michel Glémarec provided a classification of soft habitats in the Gulf of Gascony and English Channel. This is included at the end of the report]

Report of the sublittoral rock workshop subgroup

Members: Enric Ballesteros, Denise Bellan-Santini, Annie Castric, John Davies (Chairman), Rohan Holt (Rapporteur), Mario deKluijver, Stig Nielson, Kate Northen, Arne Nörrevang, Are Pedersen, Bernard Picton.

Initial discussions within the group centred on defining the limits of the sublittoral environment. Two ideas were proposed:

1. The upper limit of the sublittoral could be defined on phytosociological grounds: i.e. the top of the zone will coincide with the upper limit of the kelp forest. There was a consensus view that this approach was not tenable, mainly on biogeographical grounds, because kelp forests do not occur at all locations throughout the north-east Atlantic.

2. The upper limit of the sublittoral zone could be defined by physical factors which can be linked to physiological limits of organisms. Thus the upper limit of the sublittoral should be linked to the lower limit of tidal emmersion/submergence.

There was a consensus view that the top of sublittoral zone should be the lowest limit of continual submergence.

During the morning session, the majority of the discussion centred on determining which were the key factors to employ to provide a framework for the biotope classification. The matrix approach was considered to be the most appropriate method to display the system.

Light was considered to be the most appropriate factor to represent the vertical distribution of biotopes. The most appropriate terms to represent this factor were infralittoral and circalittoral where:

Infralittoral zone - zone characterised by erect algae.

Circalittoral zone - zone characterised by animals.

There was a consensus view that it was not necessary to subdivide these zones for the full NE Atlantic classification because of biogeographical differences. In particular, division of the infralittoral based on the density of kelp would pose difficulties in areas where kelp is not present. The group proposed that sub-division should occur in regional/national classifications if appropriate.

Problems were encountered when discussion moved to the lower limit of the circalittoral. Using light as the defining factor, it was considered that the terms phytal/aphytal could be employed where the lower limit of the circalittoral was the lower limit of multicellular algae. The term bathyal posed some difficulties because it embodied thermal stability in its definition. There was disagreement in the use of multifactorial terms as a key structuring factor, particularly in the universal application of terms.

The final consensus was that the key structuring factor was light and the terms to be employed were infralittoral/circalittoral. Nevertheless, it was considered important that there should be a literature review to ensure that the correct definition of the these terms were employed within the classification.

There was a consensus view that the second factor within the display matrix was a measure of hydrodynamic effects. There was considerable discussion on this factor because hydrodynamic effects embody both chaotic and linear movement.

It was suggested that wave exposure would be the most appropriate term for the full north-east Atlantic classification but other factors could be employed at a regional/national level. In particular, there was consensus that wave exposure was more important for most infralittoral biotopes, whereas currents may be more important for circalittoral biotopes.

Thus the consensus view was that light and hydrodynamics were the two factors to provide the basic framework for the display of biotopes.

In the second session, the initial discussion determined the definition of rock. There was a consensus view that rock embodied the concept of stability and that rock biotopes comprised epibiotic species. Thus a rock biotopes would comprise all stable substrata with epibenthic assemblages - down to the level of small pebbles.

Further discussion determined which were the most important factors in the definition of rock biotopes. It was considered that the following factors were the most important in the definition of biotopes:

substrata
light/insolation
wave action
currents
salinity
temperature - maximum, minimum and range
turbidity
aspect/slope
sediment effects - turbidity, smothering, scour

Unfortunately there was insufficient time to discuss the biotopes proposed in the different systems. There appeared to be a general agreement between the French and the MNCR classifications, and no problems were perceived when attempting to match biotopes to the basic framework.

The final consensus was that the system is a complex multidimensional system and it is important to retain these dimensions when defining the biotope and when defining matrices to display the biotopes.

Report of the sublittoral sediments workshop subgroup

Members: Gerard Bellan, Torleiv Brattegard, Jean-Claude Dauvin, Gerard Duineveld, Bob Foster-Smith, Michel Glémarec (Chairman), Jørgen Jensen, Paul Kingston, Anita Künitzer, Mike Little, Eduardo López-Jamar, Derek Moore, Tom Pearson, Uwe Reicken, Mike Roberts, Richard Warwick (Rapporteur).

Top-level classification

The problem with a top-level classification of habitats based on a two-way matrix of sediment type (fine to coarse) by depth is that a given association of species will vary in depth with latitude and will therefore occur in more than one cell of the matrix. One solution to this which we explored at length was the use of the concept of the étage, rather than depth. However, this had a number of conceptual difficulties. The definition of an étage incorporates both variability (e.g. in temperature) and absolute values (the latter largely determining differences in the depth range of a community between latitudes), and it is not possible to express these as a single value. We therefore felt that it would be more appropriate to adhere to the original MNCR formulation (table on p. 68 of the MNCR document "Marine Biotopes"), but producing such a table separately for each zoogeographical region (Arctic, Boreal, Lusitanean) to overcome the problem of these latitudinal differences. This would encompass earlier community classifications based on geographical and environmental characteristics (Jones, 1950), e.g. the "Boreal offshore sand community" and also classifications based on characterising species (Petersen, 1918; Thorson, 1957), the latter entered into the cells of the matrices.

The sediment grade categories we recommend are as follows:

1. Mud (>80% silt/clay, i.e. the fraction <63µm)
2. Sandy-mud (80-30% silt/clay)
3. Muddy-sand (30-10% silt/clay)
4. Fine sand
5. Medium sand (sand waves)
6. Coarse sand and gravel (to include *Phymatolithon calcareum* Maerl)
7. Mixed sediments (gravel & mud, to include *Lithothamnion corallioides* Maerl)

Grades 4-6 are equivalent to Wentworth grades

Second and third order environmental variables

We identified those additional environmental variables considered important in structuring soft-bottom benthic communities as second order (varying in a predictable way) and third order (varying in a more stochastic way):

SECOND ORDER VARIABLES	THIRD ORDER VARIABLES
Turbidity	Pollution
Light	Gas seepage
Salinity (use the Venice system)	Volcanic activity
Oxygen	Anthropogenic disturbance(fishing, aggregate extraction etc.)
Organic carbon	
Hydrodynamics (currents, waves, swell)	
Carbonate content.	

Characterising species

We felt that the designation of community types by two or three characterising species was insufficient, and would not cover the range of variability in composition found over the NE Atlantic, or even the variability in dominants found in samples within any one region. A larger number, say ten, was suggested, to include at least some less conspicuous small short-lived species (mainly polychaetes).

[Following the workshop, Michel Glémarec provided a classification of soft habitats in the Gulf of Gascony and English Channel. This is included at the end of the report]

Report of the brackish (standing waters) workshop subgroup

Members: Ole Anderson, Roger Bamber, Richard Barnes (present for part), Johan Craeymeersch, Roger Covey (Rapporteur), Jack Matthews (Chairman), Sandy Downie, Brenda Healey

Scope:

We agreed the definition of our habitats was: Marine saline systems where the normal tidal range and exchange of water are reduced by physical features, but water is continually present. Generally these systems were around 1-10 km in dimension, but we recognised that some similar biotopes may be present in larger systems. We recognised that this definition was not totally exclusive, but served to clarify our thoughts.

Range of physiographic types

We agreed that the conditions described above were met in a range of systems, which could be subdivided into 5 main groups

1. Silled sea inlets
2. Sluiced pools
3. Bayheads (restricted by distance from the sea)
4. Percolation pools
5. Isolated lagoons (those which receive seawater only by overtopping)

We agreed that these represented two main categories - those which have direct connection to the sea (1, 2 & 3) and those where seawater was subject to some 'filter' inhibiting recruitment of species

Structure of biotope classification

We agreed that at present it was feasible to accept depth and substratum type as the primary axes for construction of biotope matrices, **but** we proposed that principle component analysis should be carried out to confirm that these were the primary structuring factors controlling the biotopes present in the various systems. Further subdivision should be on the basis of:

Salinity (range rather than average)

Water dynamics (a means of expressing water exchange as a function of wind, temperature, wave exposure, surface area, *etc*. needs to developed)

We need to carry out further work to clarify the importance of topography on biotopes, i.e. whether the same biotopes exist in different topographic systems, or whether they are different biotopes.

Further to this we need to analyse the range of biotopes in the different topographic types (Europe-wide).

We need to test the validity of both the structure of the classification and the biotope descriptions both within the NE Atlantic and more widely with the Baltic and Mediterranean (see above).

Environmental factors

We produced a list of environmental factors which were likely to be important in structuring biotopes. Many of these had no strict numerical limits within the habitats we were considering, but we recognised that their variability and interaction were important.

- Variability (Physical and recruitment of species)
- Salinity (variable from 0 to 40 ‰)
- Oxygenation
- Mode of water exchange
- Rate of water exchange (limited)
- Tidal range (reduced)
- Sill depth (interacts with water exchange)
- Shape of lagoon
- Size of 'lagoon'
- Maturity in lagoonal succession
- Meteorological exposure
- Substratum
- Depth
- Stratification (horizontal and vertical)
- Nutrient availability
- Latitude/biogeography

The relative importance of these factors in different topographic systems should be assessed with the aid of principal component analysis and experimentation.

Key action points (summarised from above)

1. Development of a multidimensional framework for the classification.
2. A means of expressing water dynamics (as a function of wind, temperature, wave exposure, surface area *etc*. needs to be developed.
3. We need to clarify the effect of topography on biotope type to decide whether for example a *Ruppia* biotope in a percolation pool is the same as a *Ruppia* biotope in a silled inlet.
4. The range of biotopes present in different topographic types should be analysed.
5. The validity of the classification structure and biotopes should be tested by application to the NE Atlantic, Baltic and the Mediterranean. This can be done by incorporating published biotopes into the existing structure, checking for synonymous biotopes.

Discussion after the workshop subgroups (plenary session)

It seemed that most groups could identify and agree on the fine level biotopes but different approaches to presenting the information needed to be tried. However, Richard Warwick commented that it seemed that presentation already seemed to have been established in the format described by the MNCR. To change now would be a drastic step. The multi-dimensional framework of a classification was a key issue to address particularly when presenting information in a two-dimensional illustrated form.

Richard Warwick explained how a multi-variant analytical approach might be used to match sample types to environmental variables. However, in order to undertake such analyses data had to be collected in the same way. Also, detailed data had to be available. The classification had to accommodate biotopes which were known to occur (Donald McLusky used the example of the *Donax* community) but MNCR appeared to have no survey information for that community. Also, there was a great deal of literature which did not include necessary information on environmental conditions at a site where a particular community had been described but that information had to be capable of being incorporated into the classification. David Connor explained that gaps would be identified by plotting communities within an environmental matrix and identifying where there were gaps and particular habitat types, if they were present, would need to be investigated. There was a further problem, drawn attention to by Jean-Claude Dauvin, of having a sufficient pool of experienced workers to undertake these studies. Keith Hiscock reminded the meeting that detailed records were not always necessary and that at least close matching was often possible from descriptive information.

Summary of conclusions from the workshop subgroups

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The main conclusions and agreements reached by each of the sub-group working sessions on 17 November 1994 are summarised below. It was recognised that there remained areas requiring further discussion and some differences in terminology used by different countries, but that overall there was considerable agreement on many aspects important to allowing further development of the classification.

1. There had been much valuable discussion within each of the sub-groups, including an increase in people's knowledge of marine ecosystems within a broader geographical perspective and a greater awareness of the issues and problems associated with establishing a sound marine classification system for the north-east Atlantic.
2. There was wide recognition of the need for a common classification system at a north-east Atlantic level and the sense in maintaining a degree of pragmatism in its development. The workshop participants, however, collectively brought with them a considerable wealth of experience to ensure that it continued to developed on a sound ecological basis.
3. It was recognised that defining biotopes for a classification was a multi-dimensional problem, in which a series of physical and biological factors inter-act to determine the precise species composition at any one place on the shore or seabed. The most important physical factors within each of the major habitat types were identified and are used to structure the classification (see below).
4. There was general approval for the approach adopted by the MNCR of displaying the relationship of biotopes to each other within a matrix which used important physical factors for the vertical and horizontal axes. The practicality of using matrices was demonstrated by the ease with which the existing French classifications of Michel Glémarec and Annie Castric had been adapted to this presentational style prior to the workshop. Two dimensional matrices were useful presentational tools and should be further developed to improve presentation of the classification. A series of matrices was required to fully present the relationships of biotopes within classification, particularly in more complex areas of the classification. This two dimensional presentational system should not be confused with the multi-dimensional approach required (and used by the MNCR) to define biotopes in the first instance.
5. Environmental factors were recognised as the major driving force behind determining community composition. Certain factors were more important than others, although the same factors were not necessary the most important in all habitats. Each sub-group identified the most important factors (and those of lesser importance) for the habitat types they considered. Overall the following were considered important to all habitats:

- Substratum
- Zone (height/depth)
- Water movement (wave action, currents)
- Salinity
- Temperature

Some of these are an integration of a variety of factors, but were recognised as an effective method of recording and defining an often complex series of different factors. For instance, sediment types were a reflection of the hydrodynamics of the area and biological zonation could be used to indicate the physical nature (e.g. desiccation on shore, light attenuation in the sublittoral) of a site.

6. Vertical zonation patterns (height up the shore, depth into the sublittoral), although widely recognised as highly useful to structure the classification, posed significant problems in their definition. The patterns relate to factors of light attenuation, temperature stability and wave disturbance which may independently affect community composition. Depending on geographical location each may have greater importance than the others, leading to difficulties in adopting a single approach with universal application throughout the north-east Atlantic. The most widely applicable approach was proposed by the sub-groups.

7. The workshop participants had been divided into five sub-groups (littoral rock, littoral sediment, sublittoral rock, sublittoral sediment and lagoonal habitats). Even at this course division of a classification system the groups felt it necessary to define what was meant by the division they were allocated to:

Rock	Stable hard substrata which supports epibiota
Sediment	Substrata which supports infauna (may also support epifauna)
Lagoons	Isolated water bodies, subject to a range of salinities, but of a size restricted to 10's km (rather than 100's km) maximum length.

The distinction between littoral and sublittoral zones proved more difficult to define, as the practicalities of being able to reach certain habitats on the lower shore on very low spring tides (and hence define as littoral) conflicted with a more scientifically oriented definition relating to the degree of wetness and frequency of exposure of the habitat to immersion and its consequent biological character. The ultimate structures for vertical zonation put forward by both rock and sediment groups related to physical/biological parameters and effectively by-passed any need to define the terms littoral and sublittoral.

8. The sub-group considering littoral rocky habitats considered height on the shore, wave exposure, salinity and water temperature to be the prime factors of

importance. The sublittoral group identified depth and water movement as of key importance, with wave energy on the whole more important than currents (the term currents rather than tidal currents or tidal streams was considered more correct). The following zonation scheme was considered widely applicable (rather than the more finely split rocky zonation scheme used by the MNCR which had some limitations in a wider north-east Atlantic context):

ZONE	MAJOR BIOTA	KEY PHYSICAL FACTOR
Supralittoral	Lichens	A salt spray zone; not regularly covered by seawater
Eulittoral (≡ mediolittoral)	Fucoid algae / barnacles	An emergent or drying zone
Infralittoral	Algae, including kelps	Submerged, with sufficient light for dense erect algae
Circalittoral	Animals	Submerged, lacking sufficient light for dense erect algae

The presence of a deeper zone, relating to lack of light and/or thermal stability, caused some difficulty in defining. The term bathyal was not considered fully compatible with such a zone, especially where it referred to shallow communities with no algae (where turbidity was very high).

9. The sediment sub-groups recognised that sediment type was of key importance to community structure and that it was to a large degree a reflection of the hydrodynamics of the shore or seabed in question. A series of sediment types were typically used by the offshore benthic ecologists and were accepted by the littoral sub-group as appropriate for shore habitats as well:

- Mud (80% silt/clay)
- Sandy mud (80-30% silt/clay)
- Muddy sand (30-10% silt/clay)
- Fine sand
- Sand (medium) (includes sand waves)
- Coarse sand / gravel
- Mixed sediment (gravel / mud)

The sediment sub-groups, although recognising that height up the shore and depth into the subtidal was important, found definition of appropriate 'zones' more difficult. The following was broadly acceptable as a framework although the sublittoral zones, which relate to thermal stability, turbidity, wave disturbance and salinity, require clearer definition:

Littoral	Drying (unsaturated)
	Wet (saturated)
Sublittoral	Inshore
	Nearshore
	Offshore

In the littoral zone salinity if low could over-ride other factors and biogeography was also considered important:

Salinity	Marine
	Variable
	Low

Biogeography	Arctic
	Boreal
	Lusitanean

11. The lagoon sub-group found substratum, depth and salinity to be the most important factors, and additionally considered it important to determine the relationship of the biology to the physical environment of lagoon systems.

12. Following the conclusions of the workshop sub-groups a revised framework, within which the classification can be further developed, has been drawn up. This is shown below and is modified from that currently used by the MNCR in the following way:

    - The zonation scheme for rocky habitats is more generalised (lacking subdivisions of the main zones) to allow for geographical variation within the north-east Atlantic.
    - A deep circalittoral zone (which has a sediment equivalent - the offshore zone) is added to account for thermally stable habitats which typically occur below 50 m or so. This zone was discussed somewhat inconclusively by the sublittoral rock sub-group, who disliked the term bathyal and found conflict between light attenuation and thermal stability in defining such a zone. A more correct term may be available for this zone and practical application in developing the classification should determine how best to deal with deeper rocky habitats.
    - The divisions for sediment type and zones are modified as indicated by the workshop. Pebbles/shingle is added to the list of sediment categories. Despite supporting few species shingle forms beaches and extends at least into the shallow sublittoral and consequently needs to be accounted for within the classification.

- A strandline zone is shown (as an equivalent to the rocky supralittoral zone) although this was not discussed in detail by the littoral sediment group.

From this primary matrix, the rocky habitats should be displayed against a wave exposure gradient whilst the sediment habitats, particularly fine littoral sediments, may benefit from display against salinity gradients. Other matrices can of course be developed to aid presentation of complex areas of the classification.

FRAMEWORK FOR BIOTOPE CLASSIFICATION

ZONE (rock)	Rock	Mixed rock & sediment	Pebble (shingle)	Gravel / coarse sand	Medium sand	Fine sand	Muddy sand (10-30% silt/clay)	Sandy mud (30-80% silt/clay)	Mud (>80% silt/clay)	Mixed sediment (gravel / mud)	ZONE (sediment)
Supralittoral (lichens)											Strandline / Saltmarsh
Eulittoral (=mediolittoral) (fucoids & barnacles)											Drying (unsaturated)
											Retention (saturated)
Infralittoral (algae, inc. kelps)											Inshore
Circalittoral (animals)											Nearshore
Circalittoral (deep / offshore)											Offshore

Discussion following the summary by David Connor

Country specialities

Tom Pearson reminded the meeting that the classification would need additional categories for polls, fjords and fjards as they would not fit into the lagoons system or near-shore system of classification. The application of the classification to the Mediterranean was raised by Gerard Bellan and, following discussion, it was observed that although the BioMar programme would not specifically address the Mediterranean biotopes it was hoped that the system being developed by BioMar might be applied wider than the north-east Atlantic, perhaps with specific additional funding.

Hierarchical structure

Throughout the meeting discussion had centred around a classification with quite fine divisions. There was concern that if the project submits the full range of biotopes at its finest level of classification to the European Commission, the flexibility of the system could be restricted. Further work was therefore required to combine the fine level groupings into coarser ones which would be less liable to future change. David Connor confirmed that when a classification is submitted to CORINE we must feel content with it and it was therefore most likely that would be reflected in coarser rather than finer divisions.

Keith Hiscock felt that the question of hierarchical structure and the associated coding system had not been adequately addressed at the meeting although there is already a tiered system in both the ZNIEFF and MNCR classifications, Keith Hiscock suggested that there is no one hierarchical structure which will satisfy all of the uses of classification. From a scientific point of view, a system analogous to the Linnaen system of taxonomy might be developed. This approach was reflected in the coding system which MNCR used. However, for mapping, a different approach where clusters of biotopes commonly occurring together (for instance, zonal biotopes on different shore types or the biotopes occurring within particular physiographic features) was required as a coarse level. The common feature to both approaches was at the level of the biotope. David Connor reminded the meeting that there were already two parallel systems in the CORINE classification: habitat based and physiographic feature based. Tom Pearson provided a further analogy with the development of species taxonomy. Linnaeus had used a dichotomous system of classification but recently, keys had changed and, in the last 50 years, from being dichotomous to being tabular. In the last 10 years, cladistics, which take a multi-variate approach to defining species, genera, families, etc were being used. Particularly considering the disparate data being used to identify biotopes, it could be that the methods used in cladistics might be appropriate to identify biotopes - they are specifically designed for taking multivariate-data and assembling them into hierarchies. However, Bernard Picton warned against too close an analogy between the work being undertaken on biotopes and taxonomy. Evolution had occurred along one hierarchical path for each species whilst biotopes have not developed in the same way. There are many ways of classifying biotopes and these ways were likely to be arbitrary and capable of construction in several different hierarchies each of which is equally valid. In relation to the BioMar exercise, Mark Costello identified three different issues noted below.

1. How to get to the identification of a biotope.
2. How the classification is presented (which can be in several forms such as dendrograms, lists etc
3. What is presented to the EC (which is likely to be a linear list).

Coding systems

Keith Hiscock explained the importance of using letter codes not numbers in the coding system being developed by MNCR. This avoided problems of inserting newly identified biotopes in an established numerical sequence. Also the CORINE coding system which did not allow for use of numbers at the finest level beyond "9" lead to confusion. The meeting was also reminded, by David Connor, to beware of the apparent hierarchy in the CORINE numbering system which was not a hierarchy merely a code. Paul Brazier was concerned that the 'scale' applied to the different levels of the hierarchy might be different. For instance, a middle level of the hierarchy might be called "fucoids" in a mapping scheme or "*Fucus vesiculosus*" in the detailed scheme. The finally divided classification had advantages in allowing for much more flexibility and bringing together of fine level biotopes to relevant coarser levels.

The way forward: further development of the classification

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Introduction

The November 1994 BioMar workshop in Cambridge, UK, agreed a broad framework for a classification of inshore marine biotopes suitable for the north-east Atlantic (a working definition of the north-east Atlantic is from northern Norway to the Straits of Gibraltar, including if possible the Azores and Iceland).

As part of the BioMar programme the MNCR will continue to develop, in collaboration with BioMar partners and others, a classification for the British Isles based on extensive field data sets collected throughout Britain and Ireland. Development will continue through the review of literature to help establish the main biotopes and through appropriate ordination and clustering techniques to analyse large data sets to ensure the classification is robust and that differences between closely related types are clearly defined.

BioMar will submit a classification to the EU Commission's *Life* programme by June 1997.

Wider development in the north-east Atlantic

To adequately represent marine biotopes found elsewhere in the north-east Atlantic, the classification needs to be significantly expanded beyond that currently being developed by the MNCR for British Isles. Delegates to the Cambridge workshop gave an initial indication of their commitment to this further development as follows: Britain (MNCR), Ireland (BioMar), France (ZNIEFF), North Sea (Künitzer *et al.*) and English Channel (Glémarec). There remains significant gaps in both habitat and geographical coverage.

The MNCR is willing to co-ordinate further development of the classification, through collaboration with appropriate institutes and experts in other countries bordering the north-east Atlantic. The ultimate success at a wider north-east Atlantic level will, however, depend on the level of input other countries can achieve and the attraction of resources to undertake the work. .

Proposed method for development of the classification to cover the north-east Atlantic

1. MNCR to co-ordinate further development of the classification, through collaboration with appropriate institutes and individuals, and further workshops (next workshop at the ECSA Symposium, Dublin in September 1995, funded by BioMar).
2. Countries, institutes or individuals to co-ordinate development within their stated area of expertise (avoiding overlap in coverage as much as possible) and prepare submissions to the classification in a standard format to assist the co-ordination and review process (guidelines on the format of submissions are given below). It is expected that contributions from other countries will be based largely on existing classifications and the review of available information. However it is highly desirable that contributions are derived from thoroughly assessed field data whenever possible

to ensure the validity and robustness of types put forward for inclusion in the classification.

3. The MNCR to incorporate the submissions (either by synonymy with currently defined types or by addition to the classification) into a working north-east Atlantic classification.
4. A panel of specialists (derived from delegates to the BioMar workshop) to be established for each major habitat (littoral rock, littoral sediment, sublittoral rock, sublittoral sediment, brackish lagoons) to review proposed submissions (through workshops and by correspondence). This review process should help identify any geographical gaps in the classification.
5. In late 1996 MNCR to establish with specialists a classification suitable for submission to the European Commission. At this stage certain sections of the classification are likely to remain poorly developed; it may be appropriate to submit a classification which is only broadly defined in places and expect these areas to be developed further after 1997.
6. MNCR to prepare the final classification for submission by BioMar in June 1997.

Guidelines on the format of submissions of proposed biotopes

To allow easy comparison of biotopes from different countries, adopt the following standard format, starting each description on a new page. Italicised items are most important and should be provided if at all possible. Contributions on 3.5" computer disc in a format compatible with or convertible to Word for Windows 2.0c would be appreciated.

BioMar ***Geographical region, e.g. North Sea, Spain, of classification***

Biotope code: ***Biotope title*** (include substratum, zone + another key habitat factor + community - title should clearly distinguish this biotope from closely associated biotopes)

Classification

Salinity:	)
Wave exposure:	)
Tidal streams:	)Give predominant category or categories only (see
Zone/range *(i.e. height or depth range relative to Chart Datum):*	)MNCR classification for definitions categories used)))
Substratum:	)
Other:	For some biotopes other factors such as sand scouring, oxygenation, inclination of rock, are critical

Distribution

Give an indication of the geographical distribution of the biotope within whole region considered by classification, e.g. Bay of Biscay south to La Rochelle, southern North Sea or provide a map.

Description

Describe the habitat, particularly in relation to the main factors noted above, and its associated community. Give as much indication as possible of the spatial arrangement of the predominant species and indicate which species characterise the habitat (although they may be present in relative low densities compared with other space occupying or highly populous species).

Spatial or temporal variation

Indicate any spatial (regional) and temporal (seasonal, annual) variation in community composition known. This is often only known for well studied communities.

Synonyms

Give names/codes of synonymous biotopes in published literature (supply references) and MNCR working classification (state version used).

Species composition

Give *a list of species which regularly occur in the habitat* (enormous lists of rare species are not helpful - the MNCR gives species occurring in 25% or more of records), with where possible some indication of the abundance of each species (refer to MNCR abundance scales or give nos./m² or percentage cover as appropriate). Mark those species which are highly preferential (characteristic) of the habitat.

The following notes, giving definitions of terms for the classification, are extracted from *Guidance notes for the completion of MNCR recording forms*:

SALINITY - Salinity, particularly in estuaries and lagoons, may be difficult to assess on site, but a review of the literature prior to the survey may assist in categorising each site. The species present on site may also indicate the overall salinity regime to which the site is subject.

The categories are defined as follows, with the points of separation are around critical tolerance limits for marine species:

Full (marine)	30-40 ‰
Variable	18-40 ‰
Reduced	18-30 ‰
Low	<18 ‰

The following categories may alternatively be used where salinity data is more accurately known:

Lower estuary	25-30‰
Middle estuary	18-25‰
Inner estuary	5-18‰
Upper estuary	0.5-5‰

WAVE EXPOSURE - These categories take account of the aspect of the coast (related to direction of prevailing or strong winds), the fetch (distance to nearest land), the degree of open water offshore and the depth of water adjacent to the coast. Estimation of wave exposure will require inspection of charts and maps. The wave exposure can often be arrived at by using the guidelines on the form, but fuller descriptions are given below:

Extremely exposed - This category is for the few open coastlines which face into prevailing wind and receive oceanic swell without any offshore breaks (such as islands or shallows) for several thousand km and where deep water is close to the shore (50 m depth contour within about 300 m, e.g. Rockall).

Very exposed - These are open coasts which face into prevailing winds and receive oceanic swell without any offshore breaks (such as islands or shallows) for several hundred km but where deep water is not close (>300 m) to the shore. They can be adjacent to extremely exposed sites but face away from prevailing winds (here swell and wave action will refract towards these shores) or where, although facing away from prevailing winds, strong winds and swell often occur (for instance, the east coast of Fair Isle).

Exposed - At these sites, prevailing wind is onshore although there is a degree of shelter because of extensive shallow areas offshore, offshore obstructions, a restricted (<90°) window to open water. These sites will not generally be exposed to strong or regular swell. This can also include open coasts facing away from prevailing winds but where strong winds with a long fetch are frequent.

Moderately exposed - These sites generally include open coasts facing away from prevailing winds and without a long fetch but where strong winds can be frequent.

Sheltered - At these sites, there is a restricted fetch and/or open water window. Coasts can face prevailing winds but with a short fetch (say <20 km) or extensive shallow areas offshore or may face away from prevailing winds.

Very sheltered - These sites are unlikely to have a fetch greater than 20 km (the exception being through a narrow (<30°) open water window, they face away from prevailing winds or have obstructions, such as reefs, offshore.

Extremely sheltered - These sites are fully enclosed with fetch no greater than about 3 km.

Ultra sheltered - Sites with fetch of a few tens or at most 100s of metres.

MAXIMUM SURFACE TIDAL STREAM STRENGTH - This is maximum tidal stream strength which affects the habitats recorded. **Note for shores and inshore areas this may differ considerably from the streams present offshore.** In some narrows and sounds the top of the shore may only be covered at slack water, but the lower shore is subject to fast running water. Where tidal streams are significantly different for individual habitats (either enhanced or reduced) compared with the overall strength at the site this should be noted under 'Modifiers' on the individual habitat record form.

The categories are defined as follows:

Very strong	>6 knots (>3 m/sec.)
Strong	3-6 knots (1.5-3 m/sec.)
Moderately strong	1-3 knots (0.5-1.5 m/sec.)
Weak	<1 knot (<0.5 m/sec.)
Very weak	negligible

The velocity may be shown on Admiralty charts (either shown directly or as a diamond keyed elsewhere on the chart) or in coastal pilots. However, it is uncommon to have such a direct record for the site being surveyed and you may have to extrapolate considerably. Tick the 'not known' box where necessary.

BIOLOGICAL ZONES

The zones are defined below:

Supralittoral - colonised by yellow and grey lichens, above the *Littorina* populations but generally below flowering plants.

Upper littoral fringe - this is the splash zone above High Water of Spring Tides with a dense band of the black lichen by *Verrucaria maura*. *Littorina saxatilis* and *Littorina neritoides* often present. May include salt marsh species on shale/pebbles in shelter.

Lower littoral fringe - the *Pelvetia* (in shelter) or *Porphyra* (exposed) belt. With patchy *Verrucaria maura, Verrucaria mucosa* and *Lichina pygmaea* present above the main barnacle population. May also include salt marsh species on shale/pebbles in shelter.

Upper eulittoral - barnacles and limpets present in quantity or with dense *Fucus spiralis* in sheltered locations.

Mid eulittoral - barnacle-limpet dominated, sometimes mussels or dominated by *Fucus vesiculosus* and *Ascophyllum nodosum* in sheltered locations. *Mastocarpus stellatus* and *Palmaria palmata* patchy in lower part. Usually quite a wide belt.

Lower eulittoral - *Fucus serratus, Mastocarpus stellatus, Himanthalia elongata* or *Palmaria palmata* variously dominant; barnacles sparse.

Sublittoral fringe - dominated by *Alaria esculenta* (very exposed), *Laminaria digitata* (exposed to sheltered) or *Laminaria saccharina* (very sheltered) with encrusting coralline algae; barnacles sparse.

Upper infralittoral - dense forest of kelp.

Lower infralittoral - sparse kelp park, dominated by foliose algae except where grazed. May lack kelp.

Upper circalittoral - dominated by animals, lacking kelp but with sparse foliose algae except where grazed.

Lower circalittoral - dominated by animals with no foliose algae but encrusting coralline algae.

MARINE NATURE CONSERVATION REVIEW

SACFOR ABUNDANCE SCALES

S=Superabundant, A=Abundant, C=Common, F=Frequent, O=Occasional, R=Rare

GROWTH FORM			SIZE OF INDIVIDUALS / COLONIES					
% COVER	**CRUST / MEADOW**	**MASSIVE / TURF**	**<1 cm**	**1-3 cm**	**3-15 cm**	**>15 cm**	**DENSITY**	
>80%	S		S				>1 / 0.001 m^2 (1x1 cm)	>10,000 / m^2
40-79%	A	S	A	S			1-9 / 0.001 m^2	1000-9999 / m^2
20-39%	C	A	C	A	S		1-9 / 0.01 m^2 (10x10 cm)	100-999 / m^2
10-19%	F	C	F	C	A	S	1-9 / 0.1 m^2	10-99 / m^2
5-9%	O	F	O	F	C	A	1-9 / m^2	
1-5% or density	R	O	R	O	F	C	1-9 / 10 m^2 3.16x3.16 m)	
<1% or density		R		R	O	F	1-9 / 100 m^2 (10x10 m)	
					R	O	1-9 / 1000 m^2 (31.6x31.6 m)	
						R	>1 / 10,000 m^2 (100x100 m)	<1 / 1000 m^2

PORIFERA	Crusts *Halichondria*	Massive spp. *Pachymatisma*		Sml. solitary *Grantia*	Lge solitary *Stelligera*	
HYDROZOA		Turf species *Tubularia* *Abietinaria*		Small clumps *Sarsia* *Aglaophenia*	Solitary *Corymorpha* *Nemertesia*	
ANTHOZOA	*Corynactis*	*Alcyonium*		Sml solitary *Epizoanthus* *Caryophyllia*	Med solitary *Virgularia* *Cerianthus* *Urticina*	Large solitary *Eunicella* *Funiculina* *Pachycerianthus*
ANNELIDA	*Sabellaria spinulosa*	*Sabellaria alveolata*	*Spirorbis*	Scale worms *Nephtys* *Pomatoceros*	*Chaetopterus* *Arenicola* *Sabella*	
CRUSTACEA	Barnacles Tube amphipods		*Semibalanus* Amphipods	*B. balanus* *Anapagurus* *Pisidia*	*Pagurus* *Galathea* Small crabs	*Homarus* *Nephrops* *Hyas araneus*
MOLLUSCA	*Mytilus* *Modiolus*		Sml. gastropod *L. neritoides* Sml. bivalves *Nucula*	Chitons Med gastropod *L. littorea* *Turritella* Med bivalves *Mytilus* *Pododesmus*	Lge gastropod *Patella* *Buccinum* Lge bivalves *Mya* *Pecten* *Arctica*	
BRACHIOPODA				*Neocrania*		
BRYOZOA	Crusts	*Pentapora* *Bugula* *Flustra*			*Alcyonidium* *Porella*	
ECHINODERMATA				*Echinocyamus* *Ocnus*	*Antedon* Sml starfish Brittlestars *Echinocardium* *Aslia* *Thyone*	Large starfish *Echinus* *Holothuria*
ASCIDIACEA	Colonial *Dendrodoa*			Sml solitary *Dendrodoa*	Lge solitary *Ascidia* *Ciona*	*Diazona*
PISCES					Gobies Blennies	Dog fish Wrasse
PLANTS	Crusts Maerl *Audouinella* Fucoids/Kelp *Desmarestia*	Foliose Filamentous			*Zostera*	Kelp *Halidrys* *Chorda* *Himanthalia*

Examples of groups or species for each category

November 1990

Use of the MNCR SACFOR abundance scales

The MNCR cover/density scales adopted from 1990 provide a unified system for recording the abundance of marine benthic flora and fauna in biological surveys. The following notes should be read before their use:

1. Whenever an attached species covers the substratum and percentage cover can be estimated, that scale should be used in preference to the density scale.
2. Use percentage cover scale A for all species excepting those given in scale B.
3. Where two or more layers exist, for instance foliose algae overgrowing crustose algae, total percentage cover can be over 100% and abundance grades will reflect this.
4. Percentage cover of littoral species, particularly the fucoid algae, must be estimated when the tide is out.
5. Use quadrats as reference frames for counting, particularly when density is borderline between two of the scale.
6. Some extrapolation of the scales may be necessary to estimate abundance for restricted habitats such as rockpools.
7. The species (as listed over) take precedence over their actual size in deciding which scale to use.

Acknowledgements

The success of the meeting depended on teamwork from a large number of people. In no particular order they are:

The participants

The Chairmen and Rapporteurs

Mark Costello especially for administering financial aspects

Joan Barker and Lynn Beechey for registration and enquiry

Rohan Holt for the audio-visual facilities

David MacDonald for computing facilities

Ian Reach for airport pick-up and take-back

Colin McLeod and Naomi Stevenson for much work back at base

Kate Northen for language skills

The organisation of conference facilities was undertaken by *White Rose Conferences* (particularly Nick Jordon and Joan Barker) and the University Arms Hotel in Cambridge provided the venue.

Programme for the meeting

Wednesday 16 November

0930 onwards Registration

1030 - 1100. Coffee available in the Parkers Bar Lounge.

1100 Opening of the meeting:
The Earl of Selborne KBE FRS,
Chairman, Joint Nature Conservation Committee

First session. Chairman: Professor Jack Matthews

The BioMar programme - including links to the EU CORINE programme :
Dr Mark Costello, Trinity College Dublin

Objectives and application of a classification of marine benthic biotopes.
Objectives of this workshop:
Dr Keith Hiscock, Joint Nature Conservation Committee

Discussion of objectives. (Rapporteur Roger Covey assisted by Mike Little)

1230 Buffet lunch

1400 Second session. Chairman: Professor Michel Glémarec

The development of a biotopes classification in Great Britain and Ireland - structure and principals of classification:
David Connor, Marine Nature Conservation Review,
Joint Nature Conservation Committee, UK

The development of the ZNIEFF marine classification in France:
Dr Jean-Claude Dauvin, Museum National d'Histoire Naturelle, Paris

Discussion. (Rapporteur Mike Little assisted by Paul Brazier)

1530 Tea/Coffee

1615 Third session: Practical application of the classification. Chairman: Dr Tom Pearson

Use at a 'mapping' scale:
Dr Bob Foster-Smith, BioMar, Newcastle University, UK

Application for nature conservation and site selection:
Dr Tim Hill, Marine Nature Conservation Review,
Joint Nature Conservation Committee, UK

1700 The role of the MNCR database in analysis and further development of the classification:
Dr David MacDonald, Marine Nature Conservation Review,
Joint Nature Conservation Committee, UK

1730 Discussion. (Rapporteur Paul Brazier assisted by Roger Covey)

2000 Dinner

Thursday 17 November

0900 Introduction to the sub-group workshops

The role of habitat sub-groups in developing a classification framework and feedback information required.

Dr Keith Hiscock/David Connor,
Joint Nature Conservation Committee, UK

1000 Habitat sub-groups meet in syndicate rooms. (Coffee provided in syndicate rooms)

1230 Buffet lunch

1400 Plenary session - Rapporteurs provide brief initial conclusions and especially draw attention to areas requiring common development/problem solving.

1500 Habitat sub-groups re-convene. (Tea/coffee provided in syndicate rooms)

1700 Plenary session - Rapporteurs present conclusions. Discussion.

2000 Dinner.

Friday 18 November

Plenary session

0900 (Session facilitated by Keith Hiscock.)

Where have we got to? Summary of perceived conclusions. (David Connor).

Next moves - different countries (including agreement of further development in different countries and responsible individuals/ institutes)

1030 Coffee

1115 (Session facilitated by Mark Costello & David Connor)

Next moves - agreed forward plans (including liaison with EU Environment Agency and links to CORINE).

Next year - continuing the process at the ECSA meeting in Dublin

1215 Closing remarks

1230 Lunch and departure

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Paper prepared by Michel Glémarec and submitted following the meeting

Classification of soft habitats in the Gulf of Gascony and English Channel

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La classification des fonds meubles en tant qu'habitats pour la macrofaune endogée n'est pas nouvelle et s'appuie sur des principes déjà publiés (Glémarec, 1973; Chassé et Glémarec, 1976). Elle tient compte de la synthèse de Dauvin et al. (1994) et s'appuie largement sur le concept d'étage établi par l'école d'Endoume (Pérès et Picard, 1964).

On sait que tout peuplement est composé de catégories d'espèces qui réagissent de façon similaire par rapport aux conditions édaphiques. Ces catégories d'espèces vasicoles, sabulicoles, gravellicoles ... peuvent se regrouper, se recombiner de façon originale selon les sites. C'est pour cela qu'en toute rigueur certains benthologues refusent de désigner les peuplements par les espèces leaders comme l'ont fait Petersen ou Thorson. Selon les secteurs étudiés, pour le même habitat, les espèces leaders, désignés sur des bases quantitatives, peuvent changer ne serait-ce qu'en fonction des interactions biotiques et des conditions locales.

Dans le texte et dans le tableau ci-dessous, l'identification de l'habitat correspond à une reconnaissance d'entités sédimentaires qui ont une signification biologique d'où le terme de biosédimentaire. Il est possible dans un souci de simplition de ne reconnaître que 7 à 8 entités biosédimentaires. Les frontières entre ces catégories sont bien entendu perméables. L'axe vertical permet d'isoler des 'étages', c'est-à-dire des ambiances climatiques caractérisées par la plus ou moins grande variabilité des facteurs climatiques. Parmi ces derniers, c'est la température qui est la plus expressive mais c'est tout un ensemble de facteurs qui interagissent et certainement pas la température seule. De la même façon, on n'oubliera pas que les limites centre étages ne sont pas des limites bathymétriques, elles varient selon le brassage hydrodynamique réalisé localement. En Bretagne, si l'infralittoral est généralement limité aux 15-20 premiers mètres, en Aquitaine cet étage peut descendre au-delà de 30 mètres. C'est une réponse à l'action des houles particulièrement efficaces au large du littoral aquitanien.

La référence à une ou deux espèces permet aux benthologues de se situer par rapport à une classification de type Petersen-Thorson. Cette désignation n'a pas d'autre ambition et la référence aux catégories biosédimentaires, et également à l'étage, reste la base de la classification comme l'a initiée Jones (1950).

Cette classification des habitats et non des biocénoses partant du principe qu'une biocénose peut habiter des sédiments identiques mais placés sur les plateformes continentales sous des climats hydrologiques ou étages différents. Par émergence ou sumbergence, les biocénoses se déplacent donc selon la latitude en fonction des températures de suivie et de reproduction supportées ou exigées par les espèces. Ce concept qui est aussi démontré en milieu rocheux (Hiscock, 1985) permet de mieux comprendre pourquoi en Atlantique l'infralittoral et le circalittoral côtier, qui sont caractérisés par des espèces eurythermes à des degrés différents, hébergent chacun des peuplements assez semblables dans chaque étage. Cette affinité avait déjà été pressentie par Picard (1965) qui définit en Méditerranée des peuplements qui sont

"indépendants de l'étagement", il s'agit de peuplements des sédiments grossiers des deux étages précités.

Les peuplements du circalittoral du large sont composés d'espèces qui peuvent avoir une autre histoire, à l'échelle évolutive (Glémarec, 1978). Ce sont des espèces qui sont encore peu séparées de l'étage acyclothermique, le bathyal, et qui existent sur les plateformes lorsque les variations annuelles des températures sont faibles, c'est ce qui se passe sous les eaux stratifiées par exemple (sous le bourrelet froid du nord du Golfe de Gascogne ou sous un vortex en Mer d'Irlande).

Cette classification est établie à partir des travaux réalisés dans l'ensemble du Golfe de Gascogne, de la Galice à la Bretagne et une transposition des étages en Mer du Nord a été proposée (Glémarec, 1973).

I SUPRALITTORAL

1.1 à 3 - Vases et sables envasés

Faune et flore du schorre des baies profondes et rias.

1.4 - Sables des hauts de plage à *Talitrus saltator*

II MEDIOLITTORAL

II.1 à 3 - Vases et sables envasés des milieux estuarien, lagunaire et dessalé

Faune et flore de la slikke.

Nereis diversicolor, Arenicola marina, Pygospio elegans, Streblospio spp., Abra tenuis, A. ovata, Cerastoderma edule, C. glaucum, Macoma balthica, Mya arenaria, Scrobicularia plana, Hydrobia spp. Corophium volutator.

Faciès d'herbiers de *Zostera noltii*.

II.4 - Sables fins

II.1.1 Sables fins de mode semi-battu à *Scoloplos armiger, Spio martinensis, Urothoë spp.*

II.4.2 Sables fins de mode battu à *Donax vittatus, D. trunculus, Nephtys cirrosa, Nerine bonnieri, Bathyporeia spp.*

II.5 - Sables moyens dunaires à *Nerine cirratulus, Ophelia bicornis, O. ratkei, Haustoriidae, Mesoderma corneum*

II.6 - Sables grossiers et graviers à *Dosinia exoleta, Venerupis aureus, V. pullastra*

II.7 - Sédiments hétérogènes envasés et cailloutis à *Perinereis cultrifera, Sphaeroma spp.* et *Gammarus spp.*

Champs de blocs

Faunes caractéristiques des substrats de roche en place et des sédiments eutrophes (peuplements à Cirratulidés). La faune des "dessus" de blocs se surimpose à celle des "dessous" avec mélange des faunes correspondant à plusieurs ceintures en milieu rocheux.

III - INFRALITTORAL

III.O - Vases et sables envasés des milieux estuarien et lagunaire. On trouvera en milieu estuarien le peuplement II.1 à 3 qui par submergence occupe cet habitat dont les espèces marines sont exclues

III.1 - Vases pures à *Nucula turgida - Sternaspis scutata - Abra nitida*

III.1.1 - Vases molles à *Turritella communis* ou *Abra nitida*

III.1.2 - Vases indurées à *Barnea candida*

III.2 - Vases sableuses à *Nucula turgida - Melinna palmata*

III.3 Sables fins envasès à *Acrocnida brachiata - Clymene oerstedii*

III.3.1 - Faciès à *Magelona alleni*

III.3.2 - Faciès à *Pharus legumen - Ophiura texturata*

III.4 - Sables fins à *Venus gallina - Mactra corallina*

III.4.1 - Faciès des sables sales à *Tellina fabula - Spisula subtruncata*

III.5 - Sables moyens à *Nephtys cirrosa - Magelona papillicornis - Tellina tenuis*

III.5.1 - Faciès dunaire monospécifique à *Spisula spp.*

III.5.2 - Faciès dunaire à *Abra prismatica - Ophelia borealis*

III.6.1 - Sables grossiers à *Echinociamus pusillus - Tellina pygmaea*

III.6.2 - Graviers à *Branchiostoma lanceolatum - Venus fasciata*

III.6.2.1 - Faciès envasé à *Venus verrucosa, Tellina donacina, Aponuphis bilineata, Spatangus purpureus*

III.6.2.2 - Faciès du maërl, *Phymatolithon calcareum* à *Venerupis rhomboides*

III.7 - Sables hétérogènes envasés à *Nucula nucleus - Venus ovata*

III.7.1 - Faciès à *Lanice* sous courant d'eau turbide

III.7.2 - Faciès du maërl, *Lithothamnium corallioides*

III.8 - Sables mal triés à *Abra alba - Corbula gibba* (*)

III.8.1 - Faciès à *Ampelisca spp*

Herbiers de *Zostera marina;* Ils s'installent sur des sédiments très variés, des sables fins aux vases

IV - CIRCALITTORAL COTIER

IV.1 - Vases pures à *Virgularia mirabilis - Sternaspis scutata*

IV.2 - Vases sableuses à *Maldane glebifex - Clymene modesta*

IV.2.1 - Faciès des vases compactes à *Haploops tubicola*

IV.3 - Sables fins envasés à *Amphiura filiformis - Tellina serrata*

peu différents de III.3

IV.4 - Sables fins à *Venus gallina - Dosinia lupina*

peu différents de III.4

IV.5 - Sables moyens

peu différents de III.5 et faciès dunaires

IV.6 - Sables grossiers et graviers

peu différents de III.6 et 7

IV.7 - Sables hétérogènes envasé s

peu différents de III.8

V - CIRCALITTORAL DU LARGE

V.1 - Vases pures à *Ninoë armoricana - Sternaspis scutata*

V.2 - Vases sableuses à *Nucula sulcata - Briosopsis lyrifera*

V.3 - Sables fins envasés à *Nothria britannica - Auchenoplax crinita*

V.4 - Les sables fins propres n'existent pas dans cet étage

V.5 - Sables dunaires moyens et coquilliers à *Ditrupa arietina - Dentalium entalis* (sables a alènes)

V.6 - Sables grossiers et graviers à *Astarte sulcata - Venus casina*

Faciès à *Echinocardium pennatifidum*

V.7 - Sables hétérogènes envasés à *Nuclula nucleus - Pitar rudis - Amphiura chiajei*

(*) Ces sables mal triés caractéristiques du bas de plage des côtes françaises de la Manche sont peuplés d'espèces relativement ubiquistes et tolérantes vis-à-vis des facteurs édaphiques d'où la présence d'*Albra alba*. Ils sont en cela différents des sables fins sales ou envasés, très bien triés (cf. III.3 - IV.4.1) ou des sables fins de stablisation du Golfe de Gascogne (Guillou, 198..). Le plus souvent, *Abra alba* caractérise des sédiments très variables, c'est pourquoi toute référence à cette espèce doit être évitée dans un souci de clarification.

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