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Using EUNIS Habitat Classification for Benthic Mapping in European Seas

MESH ATLANTIC
MAPPING ATLANTIC AREA SEABED HABITATS FOR BETTER MARINE MANAGEMENT

European Union
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INVESTING IN OUR COMMON FUTURE

Ibon Galparsoro
(Guest Editor)

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Using EUNIS Habitat Classification For Benthic Mapping in European Seas

Aquarium of San Sebastian (Spain), 23rd-24th April 2012

Programme

Monday, 23rd April

9:00-9:25	**REGISTRATION**	
9:30-9:40	Welcome	Ibon Galparsoro AZTI-Tecnalia (Spain)
9:40-9:50	Aperture talk: The need for marine habitat classification and mapping to support EU policies	David Connor European Commission
9:50-10:10	Linking EUNIS habitat classification, the Marine Spatial Planning and the Marine Strategy Framework Directive	Ángel Borja AZTI-Tecnalia (Spain)
10:10-10:30	The EUNIS habitats classification, past, present & future	Doug Evans ETC/BD (France)
10:30-10:40	MeshAtlantic or the relevance of EUNIS as a European standard	Jacques Populus Ifremer (France)
10:40-11:20	**COFFEE BREAK**	
Theme 1	**EUNIS suitability for habitat description**	**Chairman: Fernando Tempera University of Azores (Portugal)**
11:20-11:45	Experience from developing a Norwegian system for habitat and biotope categorization: How to deal with compatibility between classification schemes	Pål Buhl Mortensen IMR (Norway)
11:45-12:10	A review of Azores shelf biotopes	Fernando Tempera University of Azores (Portugal)
12:10-12:35	Plunging into the Azores deep-sea biotopes	Fernando Tempera University of Azores (Portugal)
12:35-13:00	Evolution and use of marine habitat typologies in French marine conservation programs	Noëmie Michez & Annabelle Aish MNHN (France)
13:00-13:25	Using EUNIS habitat classification in the Basque continental shelf (SE Bay of Biscay)	Ibon Galparsoro AZTI-Tecnalia (Spain)
13:30-15:00	**LUNCH TIME**	
Theme 2	**EUNIS suitability for habitat mapping**	**Chairman: Jorge Gonçalves University of Algarve (Portugal)**
15:00-15:25	"EUNIS and main benthic habitats classification systems analysis toward mapping proposals: Application to Brittany Region"	Touria Bajjouk Ifremer (France)
15:25-15:50	The EUNIS signatures catalogue	Mickaël Vasquez Ifremer (France)
15:50-16:15	Mediterranean habitats in EUNIS: considerations on habitat hierarchy structure and lessons learned from mapping	Giulia Mo ISPRA (Italy)
16:15-16:40	Classifying cold-water coral habitats - the CoralFISH approach	Anthony Grehan National University of Ireland, Galway (Ireland)

16:40-17:05	First approach to the characterization of deep-sea habitats in the Cantabrian sea	Francisco Sánchez IEO (Spain)
17:05-17:30	Mapping the Deep - a massive head-ache!	Kerry Howell University of Plymouth (UK)
20:00-21:30	**COCKTAIL and CONFERENCE EVENING**	

Tuesday, 24th April

Theme 3	**Improving thresholds for physical habitats mapping**	**Chairman: Fergal McGrath** **Marine Institute (Ireland)**
9:00-9:25	EUSeaMap: using the EUNIS classification to predict broad-scale habitats for 2,000,000 km2 of European seabed	Helen Ellwood JNCC (UK)
9:25-9:50	Using EUNIS in broadscale regional mapping: some problems and potential solutions based on case studies in the English Channel	Roger Coggan Cefas (UK)
9:50-10:15	Challenges and confidence levels associated with modelling EUNIS level 5 Biotopes: Case study from the North Sea	Caroline Chambers Marine Ecological Surveys Ltd. (UK)
10:15-10:35	Proposed changes to the deep-sea component of the Marine Habitat Classification of Britain & Ireland and it's possible application to EUNIS	Chris Jenkins JNCC (UK)
10:35-11:20	**COFFEE BREAK and POSTER SESSION**	

Theme 4	**EUNIS from the marine management approaches perspective**	**Chairman: Victor Henriques** **IPIMAR (Portugal)**
11:20-11:45	Coastal and Marine Ecological Classification Standard (CMECS) Version 4.0: The US Framework	Kathy Goodin Natureserve (USA)
11:45-12:10	The U.S. Coastal and Marine Ecological Classification Standard (CMECS): opportunities to inform science and marine spatial planning	Emily Shumchenia University of Rhode Island (EEUU)
12:10-12:35	Goods, Services and Sensitivity of European Biotopes: building on the EUNIS database with a view to facilitating Marine Spatial Management	Maria Salomidi HCMR (Greece)
12:35-13:00	The Red List project at the Helsinki Commission - HELCOM	Jannica Haldin Helsinki Commission (Finland)
13:00-15:00	**LUNCH BREAK**	

Theme 5	**The way forward**	**Chairman: Jacques Populus** **Ifremer (France)**
15:00-16:30	Applicability, current status and perspectives of EUNIS. How to propose new habitat classes and habitat description improvements to fit with European habitats. Who is the EUNIS custodian and how do we apply to EUNIS updates	Doug Evans and David Connor ETC/BD (France)
16:30	**END OF THE CONFERENCE**	

Using EUNIS Habitat Classification For Benthic Mapping in European Seas

Aquarium of San Sebastian (Spain), 23rd-24th April 2012

Introduction

There is presently an increasing demand worldwide for marine habitat maps. These maps are improving our knowledge of seascape distributions and are supporting the implementation of marine legislation; *e.g.* in Europe, the Habitats Directive and the Marine Strategy Framework Directive are promoting such development of habitat mapping. Moreover, these initiatives are also linked with other marine management approaches, such as the Marine Spatial Planning and the ecosystem-based management. Against this background, different classification schemes have been developed worldwide with the aim of producing a common understanding and terminology for classifying habitats throughout regional seas.

This Workshop, organized within the MeshAtlantic project action plan (Mapping European Seabed Habitat Maps in the Atlantic area; InterReg Atlantic Area Transnational Programme of the European Regional Development Fund; www.meshatlantic.eu), will focus mainly upon the experience of different scientists and case studies, using the EUNIS (the European Nature Information Service) habitat classification. The benefits and problems arisen in the application of the classification will be highlighted, whilst the necessary improvements to make it ecologically-meaningful and to be used by managers and decision-makers will be discussed. New biotope classes observed in the field, poorly represented biogeographic areas such as the southwestern European seas (with a particular focus on the Atlantic Area region, the Bay of Biscay and the Azores) and the deep-sea realm, will be also considered.

Objectives of the workshop

The present workshop aims are: (i) to bring together scientists with experience in the use of the EUNIS classification, and representatives from the European Environment Agency (EEA); (ii) to agree on enhancements to EUNIS, that ensure an improved representation of south-western European marine habitats; and (iii) to establish practices that make marine habitats maps produced by scientists more consistent with managers and decision-makers needs.

Expected results

The workshop content is focused on the interchange of scientific knowledge obtained in different habitat mapping programmes around European regions, including Baltic, Atlantic, Mediterranean, North Sea and USA experience.

The use of habitat classification and mapping on the implementation of European Directives (i.e. Marine Strategy Framework (Council Directive 2008/56/EC) Directive and Habitats Directive (Council Directive 92/43/EEC)) will be discussed. Specially, in terms of the implementation of the MSFD, habitat maps are being used at various steps; starting from the qualitative descriptors for determining good environmental status (e.g. biological diversity and seafloor integrity), as indicative lists of characteristics, pressures and impacts (e.g. predominant habitat types, identification and mapping of special habitat types, biological features). The use of habitat classification and mapping for new management initiatives such as the Marine Spatial Planning and goods and services valuation will be considered.

Hence, it intends to share experiences of different research teams both in the current use, adaptation and development of the present EUNIS classification scheme for present and future needs.

Another "added value" of the workshop will be the final round table led by EEA representatives, which is foreseen to serve for a synthesis of the present status on habitat classification and mapping using EUNIS and future developments.

The workshop results are foreseen to contribute to the revision and development of the current version of the classification, governance of the classification, and for communication of the work in progress.

Hence, this is an ideal occasion to meet marine investigators with deep experience on habitat mapping, coming from different research centres with a concern on the development of a common understanding on marine habitats and its applicability for different management approaches. For the above presented reasons at the moment of writing this document, 22 oral presentations and 11 posters were accepted and more than 100 colleagues confirmed their attendance.

Thank you all for the interest shown and we hope that you enjoy your stay in San Sebastian!

Dr. Ibon Galparsoro, AZTI-Tecnalia
Chairman of the workshop
Pasaia 2nd April 2012

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Partners:

Linking EUNIS habitat classification, the Marine Spatial Planning and the Marine Strategy Framework Directive

Ángel Borja[1]

Abstract

The seas and oceans show high levels of complexity, diverse habitats and support a high level of biodiversity. Besides, they provide different goods and services, which can be used by humans as food, energy, leisure, etc. (Costanza *et al.,* 1997), and which should be undertaken in a sustainable way. However, the marine environment is facing increasing and significant human pressures, which include pollution (hazardous substances, litter, oil-spills, etc.), tourism, commercial fishing, introduction of alien species, eutrophication, aquaculture, sediment discharges, sand extraction, maritime transport, and climate change (Halpern *et al.,* 2008).

In response to these problems, policy-makers world-wide tend to develop strategies to protect, conserve and recover the marine environment (Borja *et al.,* 2008). In Europe, several policies refer full or partly to the marine environment, such as the Habitats Directive (HD, 92/43/EEC), the Water Framework Directive (WFD, 2000/60/EC), the Common Fisheries Policy (CFP and the new reform COM(2010)241 final) or the Recommendation on the Integrated Coastal Zone Management (2002/413/EC). Additionally to several existing international regional conventions (i.e. OSPAR, in the Atlantic Ocean; HELCOM, in the Baltic Sea; Bucharest, in the Black Sea; Barcelona, in the Mediterranean Sea), in 2008, the European Parliament approved the Marine Strategy Framework Directive (MSFD, 2008/56/EC), for the protection of all seas of the European Union (Borja *et al.,* 2010).

The main objectives of the MSFD are to protect and/or restore the European Seas, ensuring that human activities are carried out in a sustainable manner and to provide safe, clean, healthy and productive marine waters; in summary, 'to promote the sustainable use of the seas and conserve marine ecosystems' (see Borja, 2006). Similar objectives were established for the WFD in estuarine and coastal waters (Borja, 2005), and much scientific expertise have been gained from the implementation of this directive, since its approval in 2000 (Noges *et al.,* 2009; Hering *et al.,* 2010).

However, the protection of marine ecosystems, and the increasing use of marine goods and services, needs a good planning of marine waters through a Marine Spatial Planning (MSP, Douvere and Ehler, 2009). Hence, the mapping of geomorphological and biological features within European regional seas is highly relevant for MSP, MSFD and HD and constitutes the basis for any further implementation of this legislation. This mapping could be based upon the EUNIS (European Nature Information System) classification, allowing to a harmonized interpretation of European habitats across the regional seas.

The information obtained from the geomorphological and biological mapping can be used for a variety of investigations, which converge finally into an integrated management of the regional seas, as highlighted by Galparsoro *et al.* (2010): (i) Marine Spatial Planning, including renewable energy exploitation, fishing, oil-gas extraction, transport, aquaculture, etc.; (ii) essential fish habitat and economically-relevant species habitat suitability, for resources exploitation and conservation; (iii) dredged sediment disposal management and aggregate extraction; (iv) offshore aquaculture; (v) Marine Protected Areas and biodiversity conservation; (vi) benthic and pelagic habitat mapping; (vii) goods and services valuation; (viii) biological quality index development, for large spatial scale application; (ix) land-sea exchange modelisation; (x) the integration of such information for environmental status assessment, within the WFD and the MSFD; and (xi) human activity sensitivity maps.

In this contribution an analysis on how the EUNIS classification can be linked to the MSP and the MSFD is provided.

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References

Borja, A., 2005. The European water framework directive: A challenge for nearshore, coastal and continental shelf research. *Continental Shelf Research*, 25: 1768-1783.

Borja, A., 2006. The new European Marine Strategy Directive: Difficulties, opportunities, and challenges. *Marine Pollution Bulletin,* 52: 239-242.

Borja, A., S.B. Bricker, D.M. Dauer, N.T. Demetriades, J.G. Ferreira, A.T. Forbes, P. Hutchings, X. Jia, R. Kenchington, J.C. Marques, C. Zhu, 2008. Overview of integrative tools and methods in assessing ecological integrity in estuarine and coastal systems worldwide. *Marine Pollution Bulletin*, 56: 1519-1537.

Borja, Á., M. Elliott, J. Carstensen, A.-S. Heiskanen, W. van de Bund, 2010. Marine management - Towards an integrated implementation of the European Marine Strategy Framework and the Water Framework Directives. *Marine Pollution Bulletin*, 60: 2175-2186.

Costanza, R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, M. van den Belt, 1997. The value of the world's ecosystem services

and natural capital. *Nature,* 387: 253-260.
Douvere, F., C.N. Ehler, 2009. New perspectives on sea use management: Initial findings from European experience with marine spatial planning. *Journal of Environmental Management,* 90: 77-88.
Galparsoro, I., Á. Borja, I. Legorburu, C. Hernández, G. Chust, P. Liria, A. Uriarte, 2010. Morphological characteristics of the Basque continental shelf (Bay of Biscay, northern Spain); their implications for Integrated Coastal Zone Management. *Geomorphology,* 118: 314-329.
Halpern, B.S., S. Walbridge, K.A. Selkoe, C.V. Kappel, F. Micheli, C. D'Agrosa, J. F. Bruno, K.S. Casey, C. Ebert, H.E. Fox, R. Fujita, D. Heinemann, H.S. Lenihan, E.M.P. Madin, M.T. Perry, E.R. Selig, M. Spalding, R. Steneck, R. Watson, 2008. A Global Map of Human Impact on Marine Ecosystems. *Science*, 319: 948-952.
Hering, D., A. Borja, J. Carstensen, L. Carvalho, M. Elliott, C. K. Feld, A.-S. Heiskanen, R. K. Johnson, J. Moe, D. Pont, A. L. Solheim, W. v. de Bund, 2010. The European Water Framework Directive at the age of 10: A critical review of the achievements with recommendations for the future. *Science of The Total Environment,* 408: 4007-4019.
Nöges, P., W. van de Bund, A. Cardoso, A. Solimini, A.-S. Heiskanen, 2009. Assessment of the ecological status of European surface waters: a work in progress. *Hydrobiologia,* 633: 197-211.

The EUNIS habitats classification - past, present & future

Douglas Evans[1]

Abstract

In the mid 1980s the European Commission's CORINE (**Co**-**or**dination of **In**formation on the **E**nvironment) project, which can be considered as a precursor of the European Environment Agency, started work on an inventory of biotopes of major importance in the European Community and it quickly became apparent that a European classification of habitats or biotopes (the two have become synonyms) was required. At the time there were several national classifications and phytosociology gave a common framework for plant communities, especially in southern and central Europe, but no single classification covering all of Europe, and including marine, terrestrial and freshwater systems, was available (Moss & Wyatt, 1994). The resulting classification was published in 1991 (Devillers, Devillers-Terschuren & Ledant, 1991) and was the basis for the selection of habitats listed in Annex I of the 1992 Habitats Directive (Evans, 2010).

The CORINE classification, although not phytosociological, was clearly inspired by the Braun-Blanquet approach. The level of detail used in the CORINE biotopes classification varies and as stated in the introduction "habitats that did not figure prominently in the mapping programme, such as marine ecosystems, were not detailed" (page 7 in Devillers, Devillers-Terschuren & Ledant, 1991) and only 3 pages (of 266) are given to 'Ocean & Seas'.

The CORINE classification was later extended to Central and Northern Europe, then, with the collaboration of the Council of Europe, to the entire Palaearctic region, the new, expanded, version being published by the Council of Europe in 1996 as the Palaearctic habitat classification (Devillers & Devillers-Terschuren, 1996). As with CORINE, the Palaearctic classification only includes a summary treatment of marine habitats.

Neither CORINE nor the Palaearctic classifications gave criteria for distinguishing the classes and the need for an improved European habitat classification was recognised at an international workshop on the CORINE Biotopes sites database and habitat classification organised by the European Environment Agency's European Topic Centre on Nature Conservation (a predecessor of the European Topic Centre on Biological Diversity) in Paris in October 1995. The workshop was attended by 76 people drawn from a wide range of expertise and from 24 countries.

The EUNIS Habitat classification (from **E**uropean **U**nion **N**ature **I**nformation **S**ystem) has been designed to give a common European reference set of habitat units with a common description of all units and a common hierarchical classification to allow the reporting of habitat data in a comparable manner for use in nature conservation (inventories, monitoring and assessments). It is not intended supplant existing national or sectoral systems. The classification was intended to;-

- provide a common and easily understood language for the description of all marine, freshwater and terrestrial habitats throughout Europe
- be objective and scientifically based, with clear definitions and principles
- hold information in a relational database allowing interrogation based on a number of parameters
- seek as far as possible to achieve a consensus amongst those concerned with habitat classification as developers or users
- be comprehensive, but applicable at a number of hierarchical levels of complexity in recognition of the variety of its applications
- be flexible so as to evolve and allow the admission of new information, but also sufficiently stable to support users of its predecessors and other systems

The terrestrial part of the classification was largely developed during 1996 and 1997 by a series of meetings and workshops led by the Institute of Terrestrial Ecology, a British partner of the ETC-NC, and the principals established have remained unchanged during subsequent development.

A series of meetings dedicated to marine habitats began in 1998, leading to three workshops in 1999-2001 on marine habitat classification under the joint auspices of ICES, OSPAR and the EEA. Many marine experts suggested that there should be several level 1 units covering the marine environment rather than a single unit but this was rejected. Instead it was agreed that the classification would be developed to level 4 for the marine environment rather than level 3 as for the terrestrial (including freshwater) habitats. The marine part of EUNIS was heavily influenced by the British BioMar classification (Connor *et al* 1997a, b) although later work has tried to ensure it also covers habitats elsewhere. For example at a workshop for Baltic experts in July 2004 it was agreed that in fact the unique Baltic habitats were in sublittoral rock, and could be accommodated at level 3 under A3 and A4. Three units were added, corresponding

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to different exposure levels (which are different from those in open oceanic seas).

The EUNIS classification was developed to level 3 (terrestrial) and 4 (marine) but to give a more detailed classification additional levels have been included by adding the appropriate classes from other classifications such as Biomar or the Palaearctic.

The classification has been used in many applications, both research and applied. For example work on critical loads for atmospheric pollution has used EUNIS (e.g. Bobbink & Hettelingh 2011) and the Council of Europe is now using the classification as the basis of its Resolution 4, the list of habitats to be protected by the Emerald network of sites (Council of Europe 2010). The classification has also been used by marine mapping projects such as Balance, MESH and EUSeaMap, as shown by figure 1 and the 2008 EU Marine Framework Strategy Directive has based its 'predominant habitat types' on the EUNIS classification. EUNIS is also one of the habitat classifications for use under the EU ISPIRE directive.

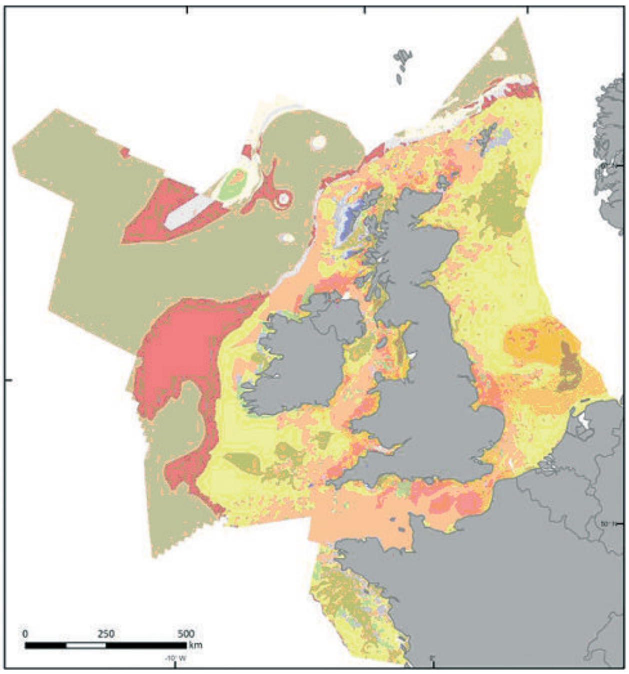

Figure 1. A map of predicted marine habitats around the British Isles and Northern France using the EUNIS habitats classification (from Coltman *et al* 2008)

These mapping projects and other work have greatly increased our knowledge of the marine environment and revealed many problems with the current version of the EUNIS habitats classification, for example as will be outlined by Giulia Mo and colleagues later in this meeting for the Mediterranean (Mo *et al*, this volume). Another possible revision would be to follow the suggestions by Kerry Howell for deep sea habitats (Howell 2010).

The current version of the classification dates from 2004 (Davies *et al* 2004) with only minor changes since then. The absence of revision was to allow a period of stability for users but as noted above it is becoming increasingly evident that further development and revision is now necessary and a meeting was held at the EEA in October 2011 to discuss both the types of revision required and the future governance of the classification. A paper on a proposed governance structure will be put to the EEA later this year which will hopefully establish a mechanism for evaluating proposals from users and for more strategic evaluations of required developments.

References

Bobbink R & Hettelingh J-P (eds.) (2011) Review and revision of empirical critical loads and dose-response relationships, Coordination Centre for Effects, National Institute for Public Health and the Environment (RIVM). http://www.rivm.nl/bibliotheek/rapporten/680359002.pdf

Coltman N, Golding N & Verling E (2008) *Developing a broad-scale predictive EUNIS habitat map for the MESH study area.* In: MESH Guide to Marine Habitat Mapping, www.searchMESH.net.

Connor DW, Brazier DP, Hill TO & Northen KO (1997a). Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 1. Littoral biotopes. Version 97.06. *JNCC Report*, No. 229.

Connor DW, Dalkin MJ, Hill TO, Holt RHF & Sanderson WG (1997b). Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 2. Sublittoral biotopes. Version 97.06. *JNCC Report*, No. 230.

Council of Europe (2010) Revised annex I of Resolution 4 (1996) of the Bern Convention on endangered natural habitats types using the EUNIS habitat classification. T-PVS/PA(2010)10revE, Council of Europe, Strasbourg. https://wcd.coe.int/com.instranet.InstraServlet?command=com.instranet.CmdBlobGet&InstranetImage=1763389&SecMode=1&DocId=1648180&Usage=2

Davies CE, Moss D & Hill MO (2004) Eunis Habitat Classification Revised 2004 http://eunis.eea.europa.eu/upload/EUNIS_2004_report.pdf

Devillers, P, Devillers-Terschuren J. & Ledant J-P (1991) *CORINE biotopes manual. Vol. 2. Habitats of the European Community*. Office for Official Publications of the European Communities, Luxembourg.

Devillers P & Devillers-Terschuren J (1996) *A classification of Palaearctic habitats*. Council of Europe, Strasbourg: Nature and environment, No 78.

Evans D (2010) Interpreting the habitats of Annex I – Past, present and future. *Acta Botanica Gallica* 157(4): 677- 686.

Howell KL (2010) A benthic classification system to aid in the implementation of marine protected area networks in the deep/high seas of the NE Atlantic. *Biological Conservation* 143 (5): 1041–1056.

Mo G, Agnesi S, Evans D, Populus J & Tunesi L (2012) Mediterranean benthic EUNIS habitats: structural considerations and lessons learned from mapping. *This volume*.

Moss D & Wyatt BK (1994) The CORINE biotopes project: a database for conservation of nature and wildlife in the European community. *Applied Geography* 14: 327–349.

EUNIS and the MeshAtlantic project

Jacques Populus[1]

Introduction

The success of the MeshAtlantic project, as with the Mesh project before it, strongly depends on having adopted a seabed habitat classification that ensures homogeneous mapping throughout the project area. The EUNIS classification has already become a standard in Atlantic Europe owing to the initial impetus given by the UK Joint Nature Conservation Committee and its subsequent application in several projects. This conference, organised by the MeshAtlantic project, intends to help shape the future EUNIS.

Let's examine more closely how EUNIS has been instrumental in the development of both map collation initiatives in Member states and European transnational cooperation in seabed mapping.

A European portfolio of habitat maps

EUNIS has enabled the harmonisation of a number of collated maps into a seamless portfolio, which by successive additions is aiming to end up in a comprehensive description of the European seabed. Even though there remain several gaps and discrepancies in scale between the maps that have been stitched together, in France we can boast a rather thorough coverage as shown in figure 1 (Croguennec, 2011).

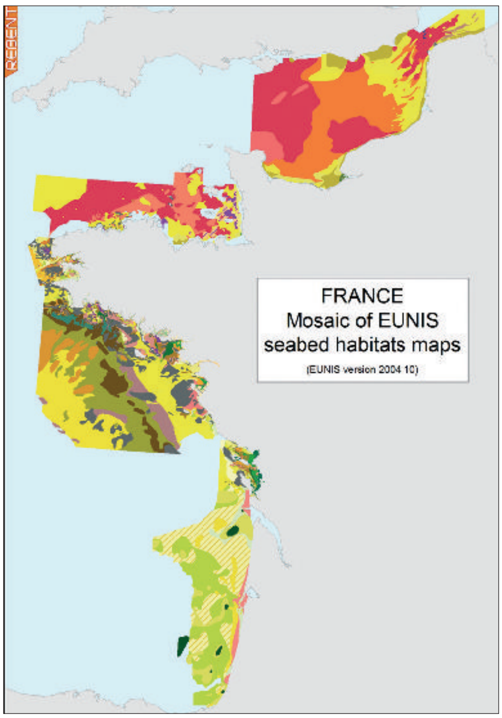

Figure 1. Corpus of French habitat maps translated into the EUNIS classification

Besides this overview, about 30 more recent detailed maps can also be found. The translation of original maps to EUNIS has taken many painstaking years of work and a lot of convincing the original authors to comply with it! A better situation certainly exists in the UK, although not as easy to display because in several places abundant sample data have not been turned into maps. Regarding the Iberian Peninsula and Ireland, collation and translation efforts are underway to make sure all the map legacy is safely stored in a homogeneous way.

The ICES working group on marine habitat mapping (ICES, 2011) has also been quite instrumental in spreading the word, as illustrated by the ICES data centre webGIS which offers a discovery site for habitat maps over the North Atlantic area, listing many EUNIS maps (http://geo.ices.dk/viewer.php?add_layers=ices_eg:wgmhm_surveyed_habitat_maps).

Modelling broad-scale EUNIS habitats

Regarding physical habitat modelling, after a quick attempt at describing the seabed in a marine landscape approach, the Mesh and EuSeaMap (Cameron 2011) projects have used EUNIS to express the output of their broad-scale models. MeshAtlantic is now doing the same, with a view to expanding the coverage to south-west Europe. EUSeaMap, a DG/Mare Emodnet preparatory action, went as far as expressing Mediterranean biocenoses in EUNIS, a challenging exercise that had not been trialled before and will be demonstrated in the next session. Emodnet is planning to go even further and extend the broad-scale map to the eastern Mediterranean and the Black Sea with yet more biogeographic challenges to overcome. Figure 2 is an example of an improved version of EUSeaMap in Brittany, a 100m resolution modelled map commissioned for France by the Marine Protected Area Agency.

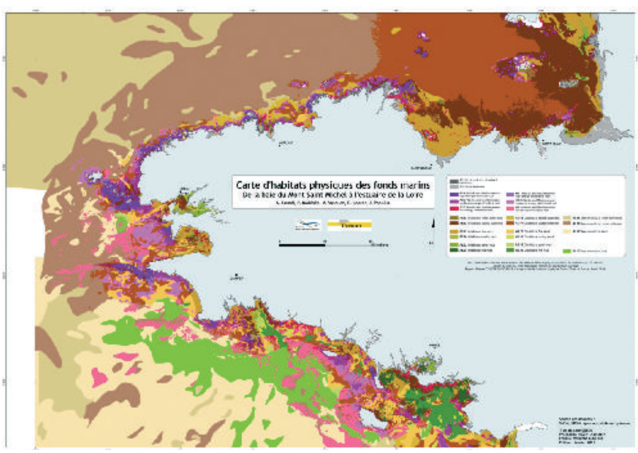

Figure 2. EUNIS physical habitats in Brittany.

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These new projects question the soundness of EUNIS as a fully European standard, bringing about some new biogeographical issues not previously addressed. In particular, EUNIS top level categories, being defined in a qualitative way, need to be specified by quantitative thresholds that best represent the variety of the physical environment with regard to lower classes stemming from them. Although several basins or sub-regions may share identical features or parameters (e.g. substrate type, seabed energy and depth zone in the Atlantic sub-regions, see Mac Breen 2011), their magnitude and therefore their thresholds may vary substantially between basins. This is the case in the Mediterranean where currents are typically weaker than in the Atlantic, yet with a significant effect as habitat presence drivers. Secondly, as basins have their own specificities in terms of communities and biological components, there are strong reasons for introducing more biogeographical aspects to EUNIS. These physical drivers would have to appear at top levels within EUNIS, obviously a big issue if the hierarchical structure is to be maintained. As an illustration of this constraint, the EUSeaMap (project had to produce two separate maps for the Baltic Sea (Figure 3), depending on the choice between energy and salinity because the classification does not support jointly both.

The use of EUNIS maps

In recent years the availability on the web of mosaics of habitat maps has triggered the interest of the management community. Instead of disparate maps with boundary inconsistencies, they are now able to download maps with homogeneous legends and colour codes covering vast expanses of sea. This is most relevant for regional studies such as those carried out for aggregate extraction or renewable energy master plans and more broadly for Marine Spatial Planning issues.

A key point is that correspondences have always been maintained between the EUNIS translation and other established classifications as well as with the authors' own classifications, a guarantee to be able to go back to the original work at all times.

Conclusions

When looking more closely at the lower biological EUNIS levels, it is puzzling to notice EUNIS was made on the basis of field samples (very local by essence) at bottom levels, which due to the hierarchical structure had to be reconciled with abiotic data (more regional in essence) at top levels. The latter lend themselves much better to mapping but lack a quantitative definition, hence some of the difficulties. Whilst in many cases a species or a community may have a one-to-one correspondence with any combination of environmental parameters (such as the above-mentioned EUNIS triplet), in many other cases there may be a one-to-many relationship. In the latter case the physical features cannot be inferred from the biology, which implies working out the abiotic parameters separately. It is expected the biological and physical visions of the seabed can converge towards a more thorough and universal description.

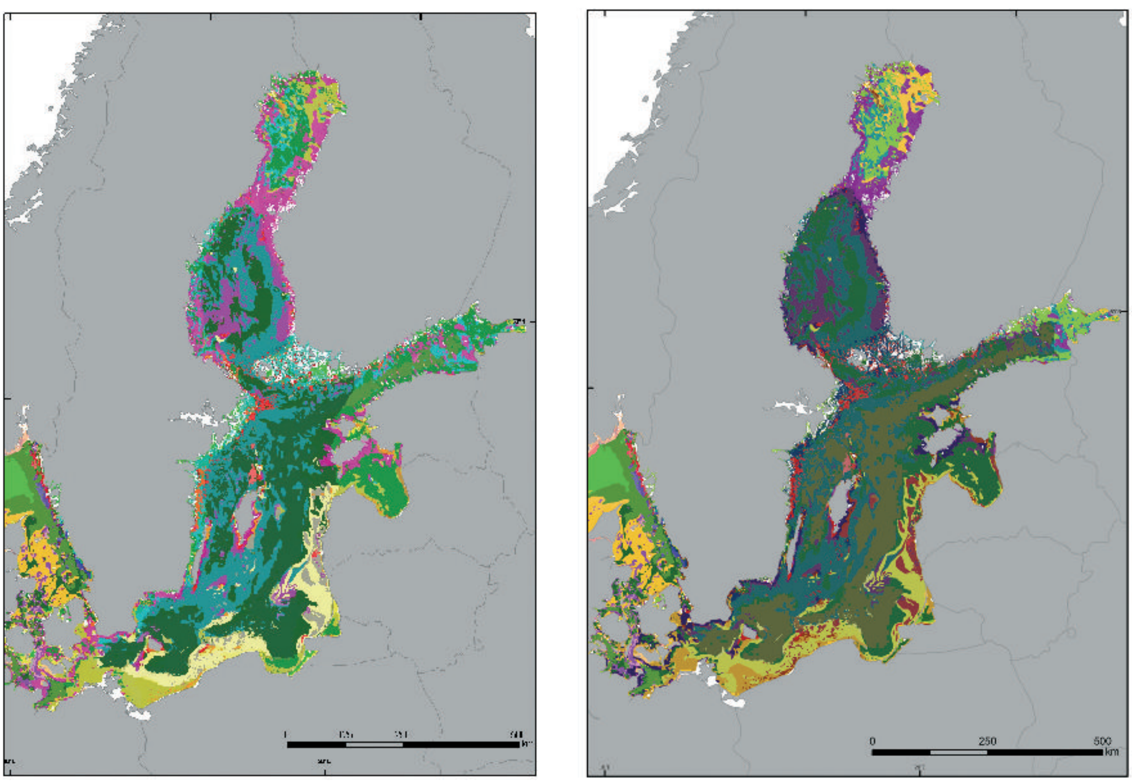

Figure 3. EUSeaMap for the Baltic Sea, with respectively 31 and 52 habitats depending on whether energy (3 classes) or salinity (4 classes) were introduced into the model.

EUNIS has slowly diffused into the seabed mapping community and people have been happy to work with it in spite of some flaws which will be analysed in depth during this meeting and for which solutions are expected.

References

Cameron, A. and Askew, N. (eds.). (2011). EUSeaMap - Preparatory Action for development and assessment of a European broad-scale seabed habitat map final report. JNCC, UK. http://jncc.gov.uk/euseamap.

Croguennec C. et al. (2011). Rebent - Atlas de cartes d'habitats historiques. Ifremer, Dyneco/AG. http://www.rebent.org//medias/documents/www/contenu/documents/REBENT_RAF_033_Atlas_Cartes_historiques_ed2011_v1r0.pdf.

ICES (2011). Annual meeting report of Working Group on Marine Habitat Mapping, http://www.ices.dk/reports/SSGSUE/2011/WGMHM11.pdf (J. Populus ed.).

McBreen, F., Askew, N., Cameron, A., Connor, D., Ellwood, H., Carter, A. (2011). UK SeaMap 2010 - Predictive mapping of seabed habitats in UK waters. http://jncc.defra.gov.uk/default.aspx?page=2117

Experience from developing a Norwegian system for habitat and biotope categorization - How to deal with compatibility between classification schemes

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Abstract

Spatial information is essential for management of natural resources, including biodiversity and vulnerable habitats. Norwegian marine waters comprise a great variety of benthic habitats. At a broad scale fjord, coast, continental shelf, shelf break, slope and the deep ocean floor are marine landscapes with different environments and biological communities. Within these landscapes different seabed substrates, water masses and current patterns lead to mosaics of habitats and biotopes with their characteristic species compositions.

The Mareano (Marine area database for Norwegian Waters – www.MAREANO.no) mapping programme was launched by the Norwegian government in 2005 in order to provide species inventories and better biotope and sediment maps from the southern Barents Sea and the northern Norwegian Sea. Mareano collects new information about the seabed and biological communities using a suite of sampling tools including high-definition video recording and multibeam echosounder.

A new Norwegian Biodiversity Act was proposed in 2004, and enforced 1 July 2009.

This act is based upon a new definition of 'nature type', and requires a consistent system of 'nature types' that covers all areas under Norwegian sovereignty, including the sea and the Arctic. Awareness that a consistent framework for description of all natural variation will improve nature management. On this background the project 'Nature types in Norway' was launched in 2006, the year after the MAREANO project started. The first draft version of a nature typology, based upon explicit theoretical principles (NiN version 1) was launched in 2009 (www.naturtyper.artsdatabanken.no).

A 'Nature type' is a region where the nature is relatively homogeneous, and where there are some characteristic features that make the landscape different from other regions. Each 'nature type' usually contains a unique species composition. The actual species composition is determined by environmental conditions in the region.

Mareano has now mapped detailed bathymetry from around 67,000 km^2 with multibeam echosounder. Video records have been obtained from 822 locations within this area, and 134 stations have been sampled. Results from analyses of the video records serve as the main data material for biotope classification including multi-scale analyses, which is crucial to select the relevant spatial scales for prediction of habitats and biotopes. Multibeam echosounder data provide full coverage bathymetry and acoustic backscatter information from the seabed. This gives excellent information not only on the seabed terrain but also on the nature of the seabed (hard, soft bottom etc.).

A general procedure for classification of seabed observation sites has been developed based on the species composition, and to evaluate predictors of potential use for habitat modeling. Analyses of large data sets tend to reveal general patterns with limited usefulness for management and poor improvement of the ecological understanding or species distribution. However, sequential analyses of subsets (identified with DCA) of the data provide a useful method for identifying biotopes at a local scale. The biotopes were characterized by different compositions of species, substrata, depths, and values for terrain parameters. Prediction of biotope distribution was performed using a supervised GIS classification and maximum entropy distribution modeling (Maxent) with the MBES-derived physical seabed descriptors that combined had the strongest explanatory ability.

The relationships between species distributions and the environment is the necessary basis for defining for mapping of biotopes. Ideally, a biotope comprises a specific range of environmental conditions that has a predictable species composition. Practical (representative and cost effective) habitat mapping can then be carried out by use of indicators with tested reliability; geomorphological (topographic), substrate-related or in other ways environmental indicator, or biotic (indicator species).

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A review of Azores shelf biotopes

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Abstract

The Azores are a northeast Atlantic archipelago composed of nine islands situated at latitudes ranging between 37ºN and 40ºN. The islands spread across an extent of 617km and are surrounded by narrow shelves. The shoreline is predominantly rocky, being composed of large irregular rock masses resulting from coastal cliff erosion or lava flows entering the island shelf. Sediments are limited to pocket beaches and sheltered areas. Most shores are exposed to oceanic swells, except for some small bays and harbours that create sheltered environments (Wallenstein & Neto, 2006). In the last two decades several works have provided information on the shore habitats of the Azores and their associated assemblages (Hawkins *et al*., 2000; Tittley & Neto, 2000; Álvaro *et al*., 2008; Wallenstein *et al*., 2008; Neto, 2011). According to Tittley & Neto (2000), the Azores share some littoral and sublittoral biotopes with the Atlantic coast of mainland Europe but generally lack the functionally-important fucoids and laminarians that dominate the macroalgal assemblages of temperate North Atlantic continental shores.

A review of the Azores shelf biotopes (including supralittoral, eulittoral, infralittoral and circalittoral) was made based on published literature (Álvaro *et al*., 2008; Castro & Viegas 1983; Hawkins *et al*., 1990; Morton 1990; Morton *et al*., 1998; Martins *et al*., 2008; Neto 1992; Neto & Tittley 1995; Neto 2001; Pryor 1967; Tittley *et al* 1998; Tittley & Neto 2000; Wallenstein & Neto 2006; Wallenstein *et al*., 2007; Wallenstein *et al*., 2008; Wallenstein *et al*., 2010) as well as on own data from infralittoral and circalittoral surveys. For each biotope occurrence the database includes information on biological zone, geographical distribution of the known occurrences, depth range, level of hydrodynamic exposure, substrate, dominant species composition and translation into the EUNIS classes (existing and proposed).

The current list includes 86 biotopes spread over seven islands spread over the three island groups of the Azores (Figure 1), as well as a few seamounts such as Formigas, Princess Alice, and Dom João de Castro banks. A total of 44 shelf habitats found correspondence on EUNIS level-2 categories: A1. Littoral rock/Hard substrate; A3. Infralittoral rock/hard substrate and A5. Sublittoral sediment. Level-5 analogues were identified that spread throughout several biogeographic regions, including the Atlantic, Mediterranean and Black Sea (Pontic).

Forty-two (42) shelf habitats were found in the Azores that did not have correspondence in the EUNIS classification (see list and suggested EUNIS name in Table 1). These habitats will be included in a proposal to be submitted to EUNIS.

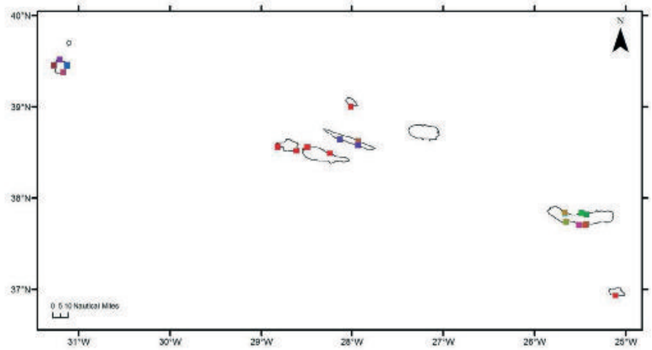

Figure 1. Literature-based occurrences of biotope and bionomic profiles data collected for the Azores.

Some harmonisation issues were identified in some of the habitats for which matches were found. For example, some shelf habitats classified as “Moderately exposed” in the Azores are seemingly matches of Atlantic EUNIS classes defined as “Exposed”. Given that the Azores archipelago is located in an oceanic location exposed to the full force of North Atlantic swells, relative exposure perceptions may be different from mainland locations and harmonization with other biogeographic regions is necessary. On the other hand, there are cases where the habitats found in the Azores seem to spread over broader exposure classes than in other regions. For instance, *Cystoseira spp.* is characteristic of Infralittoral rock classes in the existing EUNIS classification but they are actually found also in Eulittoral zones in the Azores. Situations like these may stem from the concentration of biological zones observed in the archipelago as a result of steep shorelines and microtidal regime which results in a greater mix between species that typify biological zones elsewhere.

Such reviews and information are crucial to the adaptation of the EUNIS hierarchical habitat classification to the Macaronesian biogeographic region. The translation, harmonization and integration of the region’s marine biotopes will facilitate the mapping of harmonised biotope data across Europe.

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Biological zones	EUNIS Level 2	Suggested name
Supralittoral	A1. Littoral rock/Hard substrate	B3.113X *Melarophe neritoides* and *Verrucaria maura* on littoral fringe rock
Eulittoral		A1.11X *Littorina striata* on upper littoral rock
		A1.1X *Ulva spp.* on exposed upper eulittoral rock
		A1.1X Non calcareous (thin) turf (*Centroceras clavulatum and Ceramium spp.*) and *Ulva spp* . on exposed mid eulittoral rock
		A1.XX Non calcareous *Caulacanthus ustulatus* and /or *Chondrachanthus acicularis* (thick) turf on mid eulittoral rock
		A1.1X Calcareous turf and *Ulva spp.* on exposed mid eulittoral rock
		A1.1 Non calcareous encrusting species (*Codium adhaerens* and *Nemoderma tingitanum*) on exposed and moderately exposed mid-littoral to infralittoral rock
		A1.X *Asparagopsis armata* on lower eulittoral to infralittoral fringe
		A1.1X *Cladophora spp.* on exposed littoral rock
		A1.XX *Rhodymenia pseudopalmata* turf lower eulittoral
		A1.2XX *Pterocladiella capillacea* turf in moderately exposed to sheltered lower mid eulittoral to infralittoral fringe rock
		A1.3X *Valonia utricularis* on sheltered lower eulittoral rock
		A1.3X *Codium fragile* turf on sheltered lower eulittoral rock
		A1.1X *Cystoseira abies-marina* turf on exposed to moderately exposed mid or lower eulittoral rock
		A1.1X *Padina pavonica* turf on exposed to moderately exposed mid or lower eulittoral rock
		A1.1X *Colpomenia sinuosa* on exposed to moderately exposed mid or lower eulittoral rock
Rockpool		A1.4XX Rockpools dominated by *Codium fragile* in sheltered
Infralittoral	A3 - Infralittoral rock/hard substrate	A3.X Foliose algae on infralittoral rock
		A3.1X *Dictyota spp* . and *Zonaria tournefortii* on exposed mid depth infralittoral rock
		A3.1X *Zonaria tournefortii* on exposed deep infralittoral rock
		A3.1X Sparse *Zonaria tournefortii* and coralline crusts on exposed deep infralittoral rock
		A3.15X *Dictyota spp.* on exposed to moderately exposed infralittoral rock
		A3.15X *Sphaerococcus coronopifoliuson* on deep infralittoral
		A3.15X *Plocamium cartilagineum* on deep infralittoral
		A3.1X *Padina pavonica* on exposed to moderately exposed infralittoral rock
		A3.1X *Asparagopsis armata* on exposed to moderately exposed infralittoral rock
		A3.2X *Taonia atomaria* on moderately exposed infralittoral rock
		A3.1X Ceramiales, giant barnacles and/or limpets on exposed to moderately exposed infralittoral rock
		A3.1X Serpulids, barnacles and bryozoans in mobile cobbles and peebles on exposed to moderately exposed infralittoral rock
		A3.2X *Caulerpa webbiana* on moderately exposed infralittoral rock
		A3.1X Cladostephus spongiosus on exposed to moderately exposed rock mixed with sand
		A3.1X *Cotoniella filamentosa* on exposed to moderately exposed rock mixed with sand
		A3.1X Gelatinous red algae on exposed to moderately exposed sand-abraded boulders
		A3.1X *Liagora spp* . on exposed to moderately exposed rock mixed with sand
	A5 - Sublittoral sediment	A5.23 X *Ervillia castanea* beds in well sorted infralittoral sard
		A5.2X *Ditrupa arientina* in sandy bottom
		A5.24X *Myxicola infundibulum* in muddy sands with cobbles
		A3.1X Maldanidae polychaetes on exposed to moderately exposed sand mixed with boulders
Circalitoral	A4 - Circalittoral rock/ hard substrate	A4.13X Circalittoral oyster beds on exposed and tide-swept rock and cobbles
		A4.11X *Antipathella subpinnata* on tide-swept deep circalitoral rock
		A4.11X *Polyplumaria flabellata* and sponges on deep circalittoral rock
		A4.11X *Antipathella wallastoni* on exposed circalitoral rock

Table 1. New shelf habitats compiled for the Azores archipelago and the suggested name for EUNIS classification.

References

Álvaro NV,Wallenstein FM, Neto AIMA, Ferreira J, Nogueira EM, Santos CI, Amaral AF (2008). The use of digital photography for the definition of coastal biotopes in Azores. Hydrobiologia, 596: 143 – 152

Castro MLF, Viegas M (1983). Estudo dos Povoamentos de Algas Fotófilas da Ilha de S. Miguel (Açores). 1-Resultados Preliminares Sobre a Fácies de Corallina elongata Ellis & Sollander. Arquipélago. Série Ciências da Natureza, 4: 7-30.

Hawkins SJ, Burnay LP, Neto AI, Tristão da Cunha R, Frias AF (1990). A description of the zonation patterns of molluscs and other biota on the south coast of São Miguel, Azores. Açoreana, Supl., 21-38.

Morton B (1990). The Intertidal Ecology of Ilhéu de Vila Franca - A Drowned Volcanic Crater in the Azores. Açoreana, Suppl.:3-20.

Morton B, Britton JC, Martins AMF (1998). Coastal Ecology of the Açores. Sociedade Afonso Chaves, Ponta Delgada, 249pp.

Martins GM, Thompson RC, Hawkins SJ, Neto, AI, Jenkins SR (2008). Rocky eulittoral community structure in oceanic islands: scales of spatial variability. Marine Ecology Progress Series, 356: 15-24.

Neto AI (1992). Contribution to the Taxonomy and Ecology of the Azorean Benthic Marine Algae. Biological Journal of the Linnean Society, 46: 163-176

Neto AI, Tittley I (1995). Structure and Zonation of Algal Turf Communities on the Azores: a Numerical Approach. Boletim do Museu Municipal do Funchal, Sup. No. 4: 487-504.

Neto AI (2001). Macroalgal species diversity and biomass of subtidal communities of Sao Miguel (Azores). Helgol Mar Res 55: 101-111.

Neto AI, Tittley I, Raposeiro P (2005). Flora Marinha do Litoral dos Açores, Secretaria Regional do Ambiente e do Mar, Horta. 159pp.

Pryor J (1967). Intertidal Marine Algae of São Jorge. In: Chelsea College Azores Expedition July-October 1965 Final Report. London, pp.86

Tittley I, Neto AI, Farnham WF (1998). Marine algae of the island of Flores, Azores: Ecology and floristics. Boletim do Museu Municipal do Funchal, sup. no. 5: 463-479.

Tittley I, Neto AIMA (2000). A provisional classification of algal-characterised rocky shore biotopes in the Azores. Hydrobiologia, 440, 1: 19-25.

Wallenstein FFMM, Neto A (2006) Intertidal rocky shore biotopes of the Azores: a quatitative approach. Helgoland Marine Research 3, 60: 196-206.

Wallenstein FFMM, Neto AI, Álvaro NV, Santos CI (2008). Algae based biotopes of the Azores (Portugal): spatial and seasonal variation. Aquatic Ecology 42(4): 547-559.

Wallenstein FM, Peres SD, Xavier ED, Neto AI (2010). Phytobenthic communities of intertidal rock pools in the eastern islands of Azores and their relation to position on shore and pool morphology. Arquipelago. Life and Marine Sciences 27: 9-20.

Cataloguing deep-sea biological facies of the Azores

Fernando Tempera[1*], José Nuno Pereira[1], Andreia Braga Henriques[1], Filipe Porteiro[1], Telmo Morato[1], Valentina de Matos[1], Miguel Souto[2], Brigitte Guillaumont[3], Ricardo Serrão Santos[1]

Abstract

The Azores is an volcanic archipelago located in the northeast Atlantic approximately 1,600km westwards of Portugal's mainland coast. Portugal's marine jurisdiction around the islands encompasses an Exclusive Economic Zone of almost 1 million km^2 and a claimed continental shelf extension that expands Portuguese sovereignty to approximately twice this value.

The topographically-rich seafloor that surrounds the archipelago comprises a variety of open ocean deep-sea habitats, from island slopes and numerous seamounts to hydrothermal vents at various depths and abyssal plains exceeding 5,000m depth. This habitat mosaic holds a diversity of fauna including sensitive habitat-building deep-sea corals and sponges. However, literature is scarce on bathyal (200-2000m depth) and abyssal (2000-4000m depth) epibenthic biological assemblages encountered outside the minute hydrothermal vent fields (Braga-Henriques *et al*., 2012; Pérès *et al*., 1972; Perès, 1992; Tempera *et al*. 2012). This paucity of information should be rapidly addressed in view of: (i) the shifting of fishing activities towards areas further offshore and depth ranges that likely hold long-living sensitive benthos, (ii) the impending interests to exploit deep seafloor mineral and energy resources, and (iii) the interest in finding pristine deep-sea grounds in view of establishing historical baseline conditions. The effort to catalogue, characterize and map these biotopes, particularly those dominated by habitat-building megafauna and representing *vulnerable marine ecosystems* (VMEs), has therefore become a priority for ongoing European-wide programmes focusing on habitat mapping (e.g., MESH-Atlantic, CORALFISH, HERMIONE) and proceeds in parallel with the development of the deep-sea sections of the European hierarchical biotope classification system (EUNIS).

Revisiting the sizeable imagery archives accumulated by the deep-sea expeditions that visited the Azores region since the 1950s is considered a necessary and cost-effective approach to address this need. The current paper introduces the ongoing review based on imagery archives at the University of the Azores (DOP/UAz), the Portuguese Task-Force for the Extension of the Continental Shelf (EMEPC), IFREMER-Brest, Centre d'Océanologie de Marseille and MARUM-Bremen. The bathymetric distribution of biotopes of conservation importance (coral gardens, scleractinian reefs, deep-sea sponge aggregations and hydrothermal vent fields) catalogued so far in the Azores region is presented and examples are given of EUNIS level-4 to 6 deep-sea epibenthic facies identified on the basis of dominant conspicuous macrofauna.

A geographical rectangle containing the Azores EEZ polygon delimited the study area between latitude 44ºN and 33ºN and longitude 20ºW and 35ºW (Figure 1). Fifty-seven (57) expeditions were identified that conducted visual surveys in this area dating as far back as 1954. They were led by a variety of teams originating from France, USA, Portugal, Russia, Germany, Norway, Great Britain and Japan and have explored various geomorphological contexts including abyssal plains, banks, seamounts, fracture zones, several segments of the mid-Atlantic rift and hydrothermal vent fields.

A minimum of 663 successful deployments of optical platforms capable of recording video and still photography (including manned submersibles, remotely-operated vehicles, drop-down cameras and towed camera sleds) were identified in the delimited study area. The distribution of these deployments is shown in Figure 1.

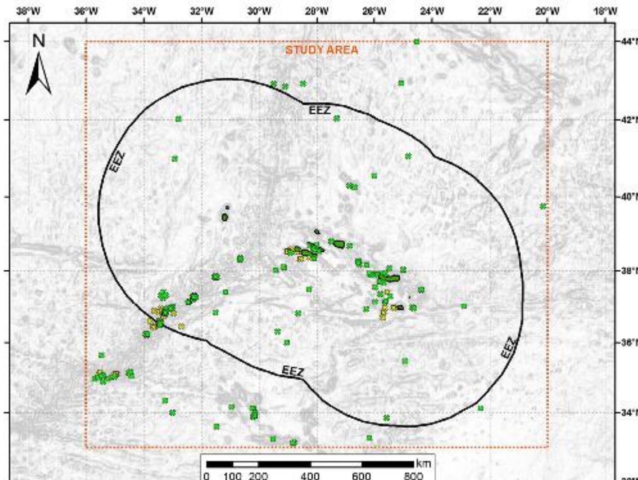

Figure 1. Location of image-based surveys inside the study area.

Video and/or photos from 72 of these deployments were annotated concentrating on areas outside hydrothermal vent influence. As a result of limitations in the resolution provided by many imagery sources (spanning from aged VHS footage to

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HD video and high-resolution digital photography), emphasis was given to biotopes dominated by habitat-building organisms with sizes greater than 10cm. Identification of the organisms was based on the authors' taxonomical expertise, corroborated by the macroscopic correspondence of the observations to specimens in reference collections (chiefly IMAR/DOP-UAz's COLETA).

The biotope inventory perspective used defined a distinct *facies as a visually-coherent suite of conspicuous epibenthic organisms was observed throughout a minimum estimated area of 25m^2*. For the sake of representativeness, species compositions were defined where the assemblages presented a stabilized physiognomic appearance along track, i.e., avoiding transition areas showing a high turnover rate in dominant species. Generally, the individual facies catalogued were (i) repeatedly observed in multiple seafloor photos or along a video footage stretch exceeding the minimum area and/or (ii) showed similar species compositions in the different locations where they were documented.

Forty-six (46) epibenthic facies were distinguished between 200 and 3,300m depth, confirming the bathyal and abyssal environments of the archipelago as a diverse mosaic of assemblages (Figure 2). Corals and sponges were proven to be major structuring organisms in many assemblages but a variety of other organisms such as bivalves, ascidians, xenophyophores, crinoids, brachiopods, sea-urchins, anemones and holothurians were also observed to be dominant in some habitats and/or represent important accompanying megafauna. Facies showed a clear bathymetric zonation and generally an association to consolidated or unconsolidated substrates (Figure 3). Given the succinctness of this publication, their exhaustive listing and description shall be presented elsewhere.

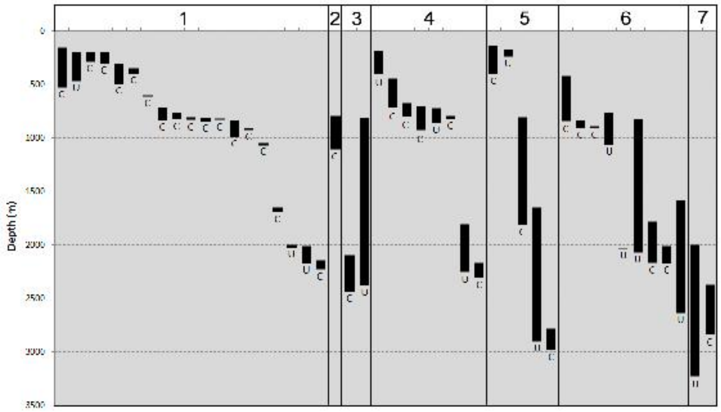

Figure 3. Bathymetric and substrate nature distribution of the main facies identified: 1-Coral Gardens, 2-Coral Reefs, 3-Sparse or small corals (*sensu latu*); 4-Sponge aggregations; 5-Sparse or small sponges; 6-Other dense invertebrates; 7-Sparse megafauna. The notations underneath each column denote substrate nature: C-consolidated; U-unconsolidated.

The diversity of facies identified demonstrates archive imagery revisiting as a valuable approach to the study of deep-sea bionomy even in those surveys where the original driver was not biotope recognition. Given the partial exploration of the archives and the fact that every new dataset analysed added new occurrences and facies, further work is suggested. Priority should be given to imagery collected in deeper areas, broader geomorphological contexts and geographical areas in order to (i) compile further assemblages and occurrences and (ii) help narrow down environmental factors driving variation in species composition.

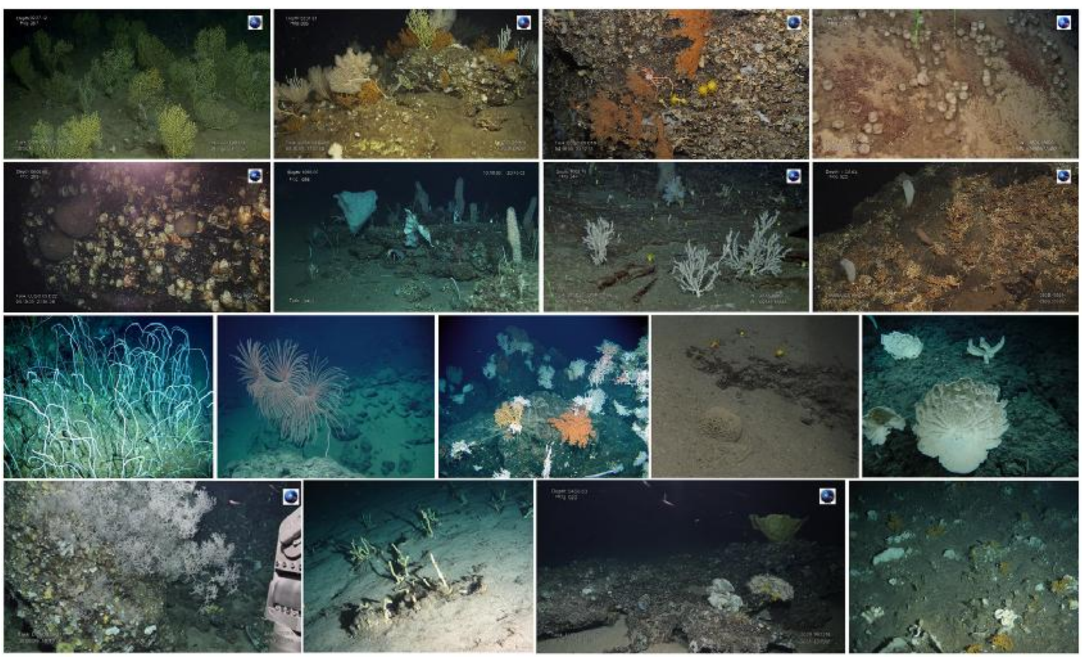

Figure 2. Examples of deep-sea facies of the Azores (Image credits: EMEPC; IMAR/DOP-UAz; GreenPeace ©Gavin Newman; SEAHMA).

At a nature conservation level, this work has proved instrumental to identify biotope occurrences that require protection under the Habitats Directive (*reefs*) and the OSPAR Convention (*coral gardens, scleractinian reefs, deep-sea sponge aggregations and hydrothermal vents*). Given that 65% of these facies (i.e., 30 out of 46) are within the present range of commercial bottom fishing in the region (extending down to 1000m depth), their qualification as Vulnerable Marine Ecosystems (VMEs) needs to be assessed. However this must done in view of the artisanal character and seemingly low levels of impact produced by the long and handline gear used in the Azores (C. Pham, unpublished data).

Additionally, the new biotope occurrences are a significant contribution towards the statistical modelling of their local and regional distribution. Regarding the quality of data being brought together, it is worth highlighting (i) the added reliability in using direct *in situ* observations to determine species presence and relevance in the assemblage, as well as (ii) the georreferencing accuracy gain of biological records located using acoustic navigation systems in comparison with by-catch records from poorly-georeferenced fishing sets.

Finally, it must be emphasized that a detailed description of epibenthic assemblages requires further dedicated collections of voucher specimens and continued taxonomy research on multiple animal groups that should be brought together (in as much as taxonomically possible) in image-based identification keys and catalogues.

Acknowledgements

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References

Braga-Henriques A, Carreiro-Silva M, Tempera F, Porteiro FM, Jakobsen K, Jakobsen J, Albuquerque M, Santos RS (2012). Carrying behavior in the deep-sea crab *Paromola cuvieri* (Northeast Atlantic). Mar Biodivers, 42(1): 37–46.

Pérès J-M 1992. Le bathyscaphe français Archimède aux Açores: Études bionomiques et écologiques du benthos profond. Pp. 237-264 in: Saldanha L, Ré P, Martins AF (eds.). Centenaire de la Dernière Campagne Océanographique du Prince Albert de Monaco aux Açores à bord de l'Hirondelle. Açoreana, Supl. 1992.

Pérès J-M, Maul GE, Arnaud P, Carpine C, Laubier L, Saldanha L, Zibrowius H, Jarry J, Franqueville C, Sibuet M. 1972. Bathyscaphe "Archimède". Campagne 1966 à Madère. Campagne 1969 aux Açores. Publ CNEXO. 124 pp., 1 plate.

Tempera, F., Giacomello E, Mitchell NC, Campos AS, Braga Henriques A, Bashmachnikov I, Martins A, Mendonça A, Morato T, Colaço A, Porteiro FM, Catarino D, Gonçalves J, Pinho MR, Isidro EJ, Santos RS, Menezes G (2012). Mapping the Condor seamount seafloor environment and associated biological assemblages (Azores, NE Atlantic). In Harris PT, Baker EK (eds.), pp. 807-818. Seafloor Geomorphology as Benthic Habitat: Geohab Atlas of Seafloor Geomorphic Features and Benthic Habitats. Elsevier, London.

Evolution and use of marine habitat typologies in French marine conservation programs

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Introduction

The 'Service du Patrimoine Naturel' (Natural Heritage Service) is a part of the French National Museum of Natural History. One of the primary functions of the SPN is to provide scientific advice to the French Government and associated public bodies on natural heritage conservation (with a focus on biodiversity and geodiversity), thereby providing a link between scientific research and the requirements of public administration. Its specific responsibilities include: i) managing a national inventory of natural heritage, which indicates the spatial and temporal distribution of species and habitats; ii) developing national registers of species and habitats to underpin French conservation programs; iii) providing scientific advice on the implementation of European directives and international conventions to French and international administrations, and iv) coordinating national programs on the inventory, assessment, monitoring, management and preservation of biodiversity.

Although nature conservation (both nationally and globally) has for a long time focused on species, over the last decades the importance of habitat diversity has come to the fore. As a consequence, many national conservation programs (ZNIEFF SINP, CARTHAM), European directives (Habitats Directive, MSFD) and international conventions (OSPAR, Barcelona) have developed their own lists or 'typologies' of pertinent habitats. The need for consistency across these programmes is growing, particularly in terms of the definition and classification of habitats. The French Ministry of Ecology therefore asked the Service du Patrimoine Naturel to update and harmonise French marine habitat classification systems. The goal was to create an over-arching typology of all marine habitats present in France which would meet the needs of national, European and international conservation programmes, and which would be strongly supported by the French marine scientific community. This national typology would help to optimise the utilisation, management and sharing of marine habitat data, and provide a 'common language' for use amongst public bodies, environmental consultancies and the research community. It would also present a common set of 'units' upon which marine habitat management, monitoring or assessment could be based.

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Materials and Methods

The development of a national habitat typology was separated into two parts, corresponding to the two French biogeographic areas: the Mediterranean and the Atlantic. For the Mediterranean, the first stage was to summarise existing information on marine habitats, including lists developed through the ZNIEFF conservation programme (Bellan-Santini *et al*., 2003 ; Dauvin *et al*., 1994) , the Habitat Directive (European Commission, 2007; Glémarec & Bellan-Santini, 2004) and the Barcelona Convention (PNUE, PAM, CAR/ASP, 2007). This summary enabled a comparison of habitat wording: a single habitat can have multiple names depending on the typology in question. It was sent to scientific experts in the Mediterranean region, who were invited to answer the following questions:

- Which habitats listed in these typologies are actually present in France?
- For those that exist in France, what names should be given to the relevant units?
- And, is it necessary to include some additional ('new') habitats in the national list?

Through a French Mediterranean marine habitat typology meeting, we brought together these experts to build a common consensus across the scientific community and validate a first version of the typology. Following this meeting, the taxonomic validity of the species names (for the listed habitats) was verified through 'matching' within TAXREF (the French taxonomic register), WORMS (the World Register of Marine Species) and via expert opinion. Finally, the relationships between those habitats in the new national typology and other French or European marine habitat classification systems (notably EUNIS) were established.

Results

Our work on the Mediterranean marine habitat typology was published in 2011 (Michez *et al*., 2011). This typology represents a continuation of the work of Pérès and Picard (1964), and does not depart significantly from their original categorisations. Any modifications occurred mainly at the level of 'facies' and 'association'. The final French Mediterranean typology includes 152 habitat units. They are divided into:

- 34 biocenoses defined by species composition and a reciprocal dependence on (relatively homogenous) abiotic characteristics (PNUE, PAM, CAR/ASP, 2007),
- 47 facies defined as different 'forms' of a biocenose, where the local prevalence of certain abiotic factors leads to the

dominance of one or a small number of animal species (PNUE, PAM, CAR/ASP, 2007),

- 68 associations defined as a permanent form of a biocenose, manifested as a predominance in a particular plant species determined by a specific ecological compatibility and environmental affinity (PNUE, PAM, CAR/ASP, 2007),
- 2 habitat units, corresponding to enclaves,
- 1 habitat unit, corresponding to three geomorphologic units.

The hierarchy is principally based on a bathymetric zonation called 'étagement' (Dauvin *et al*., 2008a ; 2008b), running from the supralittoral to the bathyal. It is subsequently divided by substratum (muds, sands, pebbles and shingles, hard substrata and rock) with one habitat unit corresponding to an engineer species. Finally, the biocenoses and their respective facies and associations are listed.

With regard to the organisation of the typology, we decided to differentiate between biocenoses on the one hand and facies and associations on the other, and to assign numeric codes to the biocenoses and alphabetic codes to the facies and associations. This is because, conceptually, the facies and associations are not considered to be different 'levels' within the hierarchy, but rather a particular expression of a specific biocenose (for example, a seasonal or geographically localised manifestation). These units – biocenose, facies and association – are considered to be at the relevant scale for management and implementation of conservation policies. They constitute integrative entities of environmental conditions and of their evolution.

Discussion

The longevity of any marine habitat typology is crucial, but there is usually a trade-off between a 'stable' categorisation and the need for regular updating based on new survey and research. Within the French Mediterranean typology, the habitat units and associated definitions were not significantly modified (with respect to the scientific literature on which they were based), but the terminology used in this literature was homogenised. This typology will now be used as the French register for Mediterranean marine habitats in the public conservation policies. It also represents a basis for any French proposals on the modification of the EUNIS Habitat classification in the Mediterranean region.

The French Mediterranean typology was sent to the Regional Activity Centre for Special Protected Areas (RAC/SPA) and there have been proposals to use this work to homogenise a Mediterranean-wide habitat classification at a national and international level (via the Barcelona Convention).

Work is currently in hand to update and harmonise an equivalent marine habitat typology for the Atlantic region of France. The initial building blocks include a coastal benthic habitat classification for Brittany, developed via a regional French initiative called 'REBENT' (led by IFREMER) (Guillaumont *et al*., 2008; Bajjouk *et al*., 2011). The next steps will involve the integration of additional coastal habitats present along the French Atlantic coast, and those of the Atlantic circalittoral and deep sea. A significant contribution will be the outputs of a nationwide Natura 2000 mapping programme called 'CARTHAM', which covers 40% of French territorial waters. As with the national Mediterranean typology, a key result of the development of a national Atlantic typology will be the identification of marine habitats present in French Atlantic waters that are not represented within EUNIS.

Conclusions

The two French marine habitat typologies described in this paper will, in combination, form a national reference for marine habitats in France, and will underpin future marine management and conservation initiatives (particularly the MSFD). In parallel, the Service du Patrimoine Naturel is ready to help support the evolution of the EUNIS Habitat classification system using our newly developed national typologies, and to coordinate this support from a French perspective (via the National Museum of Natural History). Initial proposals in this regard have already been submitted to the ETC, and we look forward to deepening our involvement in partnership with other European countries over the coming years.

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References

Bajjouk T, Derrien S, Gentil, F, Hily C, Grall J, (2010) Typologie d'habitats marins benthiques : analyse de l'existant et propositions pour la cartographie. Habitats côtiers de la région Bretagne - Note de synthèse n° 2, Habitats du circalittoral. Projets REBENT-Bretagne et Natura 2000-Bretagne. RST/IFREMER/DYNECO/AG/11-03/TB. 24 p. + Annexes.

Bellan-Santini D, Bellan G, Boudouresque CF, Francour P, Harmelin JG, Pérez T, Ruitton S, Vacelet J, Verlaque M, Zibrowius H (2003) Inventaire du Patrimoine Naturel, Programme National d'Inventaire des Zones Naturelles d'Intérêt Ecologique, Faunistique et Floristique, ZNIEFF-Mer, Documents techniques. DIREN-Provence-Alpes-Côte d'Azur, 38p.

Costello MJ (2009) Distinguishing marine habitat classification concepts for ecological data management. Marine Ecology Progress Series 397, 253-268.

Dauvin JC, Bellan G, Bellan-Santini D, Castric A, Comolet-Tirman J, Francour F, Gentil F, Girard A, Gofas S, Mahé C, Noël P et de Reviers B (1994) Typologie des ZNIEFF-Mer, liste des paramètres et des biocénoses des côtes françaises métropolitaines. Coll. Patrimoines Naturels, vol. 12. 2e éd., Secrétariat Faune- Flore/MNHN, Paris, 70 p.

Dauvin JC, Bellan G, Bellan-Santini D (2008a) The Need for clear and comparable terminology in benthic ecology. Part I. Ecological concepts. Aquatic Conservation: Marine and Freshwater Ecosystem, 18, 432-445.

Dauvin JC, Bellan G, Bellan-Santini D (2008b) The Need for clear and comparable terminology in benthic ecology. Part II. Application for the European Directives. Aquatic Conservation: Marine and Freshwater Ecosystem, 18, 446-456.

European Commission (2007) Interpretation manual of European Union habitats. EUR 27. European Commission, DG Environment, 142 p.
Glémarec M, Bellan-Santini D (2004) Habitats marins in Bensettiti F, Bioret F, Roland J, Lacoste JP (coord.) (2004) « Cahiers d'habitats » Natura 2000. Connaissance et gestion des habitats et des espèces d'intérêt communautaire. Tome 2 - Habitats côtiers. MEDD/ MAAPAR/MNHN. Éd. La Documentation française, Paris, 399 p. + cédérom.
Guillaumont B, Bajjouk T, Rollet C, Hily C, Gentil, F (2008) Typologie d'habitats marins benthiques : analyse de l'existant et propositions pour la cartographie (Habitats côtiers de la région Bretagne)-Note de synthèse, Projets REBENT-Bretagne et Natura-Bretagne, RST/ IFREMER/DYNECO/AG/08-06/REBENT. 16p + Annexes.
Michez N, Dirberg G, Bellan-Santini D, Verlaque M, Bellan G, Pergent G, Pergent-Martini C, Labrune C, Francour P, Sartoretto S (2011) Liste de référence française des biocénoses benthiques de Méditerranée. SPN-MNHN / INPN, octobre 2011.
Pérès JM, Picard J (1964) Nouveau manuel de bionomie benthique de la Méditerranée. Recueil des Travaux de la Station marine d'Endoume, 31 (47), 1-137.
PNUE, PAM, CAR/ASP (2007) Manuel d'interprétation des types d'habitats marins pour la sélection des sites à inclure dans les inventaires nationaux de sites naturels d'intérêt pour la Conservation. Pergent G, Bellan-Santini D, Bellan G, Bitar G. et Harmelin JG eds., CAR/ASP publ., Tunis, 199 p.

Using EUNIS habitat classification in the Basque continental shelf (SE Bay of Biscay)

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Introduction

The increase in intensity and diversity of pressures in marine environment and the inclusion of new marine activities, such as marine renewable energy production, have resulted in the need of better environmental information to implement informed management plans. In this sense, marine habitat mapping is being recognized as a highly useful source of information for integrated coastal management and the implementation of several European Directives seeking good environmental status, management and protection: i.e. Habitats Directive (Council Directive 92/43/EEC), Water Framework Directive (Council Directive 2000/60/EC) and European Marine Strategy Framework Directive (Council Directive 2008/56/EC); and other approaches to management such as goods and services valuation and human activities management, and its application in the Marine Spatial Planning process (European Commission, 2008).

Within this context, in 2005 a seafloor mapping programme commenced with the aim of seafloor characterisation and benthic habitat mapping of the Basque continental shelf. This investigation integrates different remote sensing and *in situ* sampling techniques to cover a continuum from land to circalittoral marine environments. The specific objectives of this investigation were: (i) to determine habitat distribution pattern, in relation to environmental factors; (ii) to classify habitats (European Natural Information System (EUNIS) (Davies *et al*., 2004)); and (iii) to identify and locate Habitats of Community Interest.

Material and Methods

The Basque continental shelf is located in the southeastern part of the Bay of Biscay (Figure 1). It is very narrow, ranging from 7 to 20km, being the total length of the coastline of ca. 150km. The marine habitats in this sector are related to geomorphology and hydrography (Galparsoro *et al*., 2012). Sandy banks are distributed from beaches and river mouths down to muddy depths; meanwhile, rocky bottoms are dominant along the shore, reaching the outer part of the continental shelf. In terms of oceanographical characteristics, waves from the northwest direction (swell) are dominant over the region and the recorded periods range from 5 to 22 s, with the most frequent being between 8 and 12 s (Castaing, 1981). The tidal wave is semi-diurnal but despite the importance of tidally-induced surface water fluctuations, the contribution of the tides to the generation of currents is somewhat modest (except within the estuaries) (Fontán *et al*., 2009).

In terms of the biogeographical aspects, the Basque coast presents some unique biogeographical characteristics. The differences are based mainly upon the scarcity, or absence, of several large brown algae (fucoids and laminarians). Thus, the dominance of several warm-temperate red algae, together with a minor presence of large brown algae typical of cold waters, shape a particular zonation; which resembles more the zonation at southern latitudes (Borja *et al*., 2004).

The Basque continental shelf, up to 100 m depth, covers a total area of 1,096km^2. Seafloor mapping was based on remote sensing techniques. Multibeam echosounder (MBES) (operating up to 100m water depth), topographic LiDAR (terrestrial land to mid-intertidal zone), bathymetric LiDAR (up to 20m water depth) (Galparsoro *et al*., 2010), and aerial photography (Chust *et al*., 2007; Chust *et al*., 2008) techniques were used. A total of 2,323 grab samples, were collated for ground-truthing and sediment characterisation. Biological benthic data included 50 grabs from soft-bottom, 405 samples from rocky seafloor taken by divers and 83 underwater image recordings at circalittoral zone. Oceanographic data were obtained from 21 CTD stations (sampled since 1998 at each season of the year), within a monitoring network (Borja *et al*., 2004). Moreover, data from 3 offshore oceanographic buoys (from January 2007 to March 2009 period), and 6 littoral oceano-meteorological stations (from 2001 to 2009) were analysed (Galparsoro, 2011).

The approach used in this investigation is based on a mixed top-down and bottom-up approach. High resolution information recorded with remote sensing techniques was used for the preliminary physiographic or seascapes classification (Roff & Taylor, 2000). Then, sedimentological and wave energy on the seafloor was integrated, which resulted in the level 3 (rock substratum) and level 4 (sedimentary substratum) of EUNIS abiotic habitat map.

The assessment of soft-bottom benthos was based upon a BIO-ENV analysis of PRIMER (Clarke & Gorley, 2001; Clarke & Warwick, 1994). It was carried out to relate the sedimentological and oceanographical conditions to species distribution. Then, LINKTREE routine was used to take the combination of variables that were identified as 'best' in BIO-ENV together with the faunal inter-station similarities to find the most effective way of describing the biological-environment relationships relative to the

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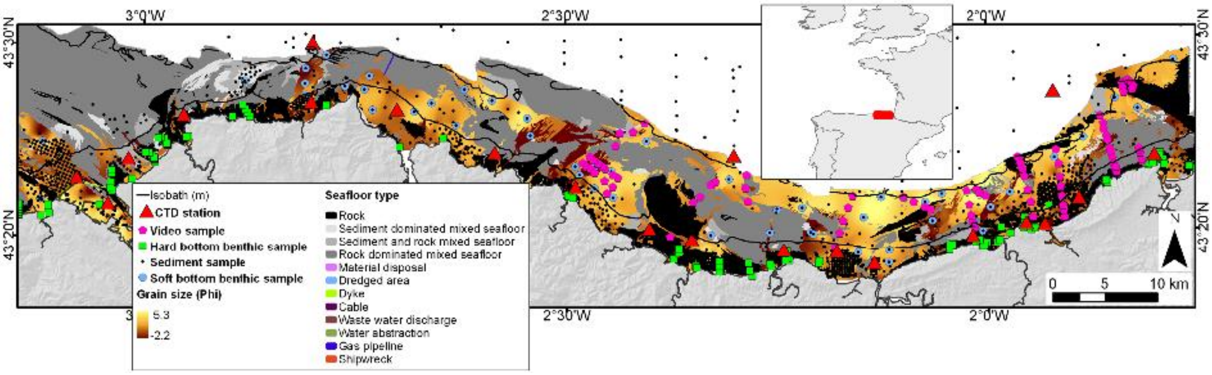

Figure 1. Study area location and available data. Modified from (Galparsoro *et al*., 2012).

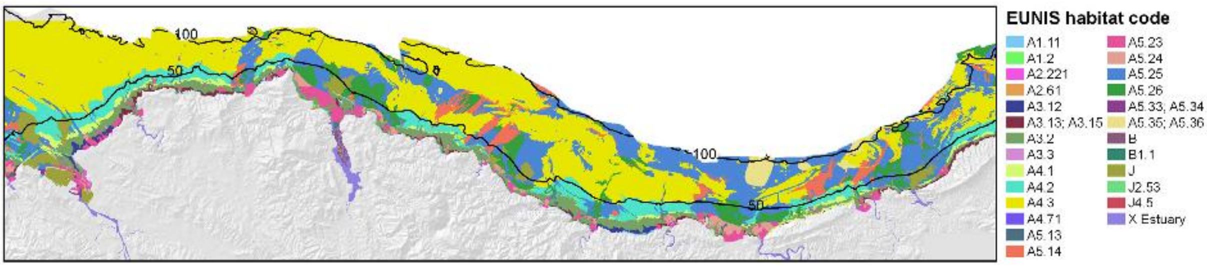

Figure 2. Benthic habitat map according to EUNIS habitat classification codes.

successive use of single environmental variables.

Rocky substratum habitats were basically classified by interpretation of underwater images, algal depth zonation derived from bibliography, wave energy distribution and expert judgement (Borja *et al*., 2004).

The aforementioned information was then used for habitat classification and mapping by environmental information layer combination in a GIS environment. The habitat classification (Davies *et al*., 2004) was based on EUNIS, but it was adapted to the specific characteristics of the Basque continental shelf habitats (Galparsoro *et al*., 2009). Apart from this, the Habitats of Community Interest (according to Natura2000) were identified and habitats of interest in the Basque area were finally identified and mapped.

Results and discussion

A total of 29 habitat classes were identified. 4 of them were classified as littoral, 19 infralittoral, from which 9 were of rocky substratum and 10 sedimentary substratum, 2 were coastal habitats, 3 artificial habitats and 1 habitat class was used for estuaries (complex habitats) (Figure 2).

The statistical analysis for sedimentary habitats demonstrated that the sedimentological characteristics, wave energy and the annual temperature and annual chlorophyll concentration near-bottom were the environmental variables that most explained the sedimentary communities' composition. Taking this into account, it could be stated that the environmental variables used in the lower levels of the EUNIS classification fit well with the obtained analytical results. In comparison to similar studies carried out in other biographic locations, in our study area, seawater showed relatively constant oxygen saturation, with values permanently over 80%. Near-bottom salinity was also not found to be an important factor structuring benthic communities in open coast (mean annual value of 35.4±0.1 UPS). In fact, the Bay of Biscay is located in a temperate zone with no extreme oceanographical changes during the year, which is translated to a moderately stable in terms of oceanographical characteristics (Valencia *et al*., 2004). As the hydrographical parameters are quite stable, the wave energy action and the sediment dynamics could be found to be the most important factors influencing sedimentary benthic assemblages (Galparsoro *et al*., *Submitted*) (probably, for rock substrate habitats).

Rocky substratum habitats statistical analysis was not conducted due to the inherent difficulty of extracting quantitative information from underwater videos. Nevertheless, information on rocky substratum habitats and its communities is scarce in this sector and the information collated in this investigation demonstrated the presence of habitats of Community Interest and species which were not cited before in this area.

During the habitat mapping process, it was observed the difficulty of producing fine scale maps using only remote sensing techniques. This is due to the resolution of the remote sensing technique and the heterogeneity of certain habitats i.e. Pontic communities at mediolittoral rocky shores, when aerial images are used for mapping; or mixed rock and sedimentary habitats in the sublittoral zone when high resolution MBES were used for habitat mapping. Moreover, the mixed rock and sediment seafloor is dominant the Basque continental shelf and it shows specific characteristics in terms of benthic communities structure.

At higher levels of EUNIS classification, specific biological composition was taken into account in the description of habitats.

Thus, EUNIS habitat classes were maintained but new structuring and characteristic species were included in the description to fit with the results obtained from statistical analysis.

In some cases, the habitat description was found to be in between two habitat classes, especially for habitat classes which were divided by slight difference of grain size: i.e. infralittoral sandy mud and infralittoral fine mud. In those cases, the habitat has been classified by both habitat classes.

For rocky substratum the problem was associated to the quantity and quality of information for an appropriate habitat classification and characterisation. Thus, oceanographic and physiographic information, were used for mapping, and the habitat biological characterisation was based on interpretation of underwater images and expert judgement.

Taking into account the results obtained during the investigations in the Basque continental shelf, it could be concluded that EUNIS hierarchical structure could be used at lower levels, as the environmental parameters used for habitat classification fit well with the ones observed in this region. Nevertheless, habitats descriptions improvements are required at higher levels in order to facilitate its application at this region.

In that sense, the hierarchical structure of EUNIS leaves an open door to the incorporation of new habitat classes. For the Basque continental shelf, new habitats were identified such as the *Gelidium corneum* habitat in the infratlittoral high energy rock (Borja, 1987; Borja, 1988). This habitat is important in terms of ecological value and will be proposed for its inclusion in the classification. Nevertheless, this type of proposals for new habitat inclusion in the classification requires of scientific community discussion in order to get commonly agreed new habitat classes.

Moreover, present or potential ecological goods and services provided by habitats, could also be integrated in the EUNIS classification; as this information could be of great value for management approaches (Pascual *et al*., 2011; Salomidi *et al*., 2012).

Thus, it is highlighted the necessity of common understanding and common classifications over European regions in order to implement the European common marine strategies such as MSFD and Marine Spatial Planning.

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References

Borja, A., (1987). Cartografía, evaluación de la biomasa y arribazones del alga Gelidium sesquipedale (Clem.) Born. et Thur. en la costa guipuzcoana (N España). Inv Pesq 51: 199-224.

Borja, Á. (1988). Cartografía y evaluación de la biomasa del alga Gelidium sesquipedale (Clem.) Born. et Thur. 1876 en la costa vizcaína (N. de España). Inv Pesq 52: 85-107.

Borja, Á., F. Aguirrezabalaga, J. Martínez, J. C. Sola, L. García-Arberas, J. M. Gorostiaga, (2004). Benthic communities, biogeography and resources management. Pages 455-492 in Á. Borja,M. Collins, editors. Oceanography and Marine Environment of the Basque Country. Elsevier.

Castaing, P., (1981). Le transfert à l`océan des suspensions estuariennes. Cas de la Gironde. Université de Bordeaux, Bordeaux. 277 pp.

Chust, G., I. Galparsoro, A. Borja, J. Franco, B. Beltrán, A. Uriarte, (2007). Detección de cambios recientes en la costa vasca mediante ortofotografía. Lurralde, 30: 59-72.

Chust, G., I. Galparsoro, Á. Borja, J. Franco, A. Uriarte, (2008). Coastal and estuarine habitat mapping, using LIDAR height and intensity and multi-spectral imagery. East Coast Shelf Sci 78: 633-643.

Clarke, K. R., R. N. Gorley, (2001). Primer v5: User manual/tutorial. Primer-E Ltd, Plymouth (2001).

Clarke, K. R., R. M. Warwick, (1994). Change in Marine Communities: An Approach to Statistical Analysis and Interpretation. Plymouth Marine Laboratory, Plymouth, UK.

Davies, C. E., D. Moss, M. O. Hill, (2004). EUNIS Habitat Classification revised. Report to the European Topic Centre on Nature Protection and Biodiversity, European Environment Agency. October 2004. 310 pp.

European Commission, (2008). Roadmap for Maritime Spatial Planning: Achieving Common Principles in the EU. Communication from the Commission. Brussels, 25.11.2008. COM(2008) 791 final. 12 pp.

Fontán, A., M. González, N. Wells, M. Collins, J. Mader, L. Ferrer, G. Esnaola, A. Uriarte, (2009). Tidal and wind-induced circulation within the Southeastern limit of the Bay of Biscay: Pasaia Bay, Basque Coast. Cont Shelf Res 29: 998-1007.

Galparsoro, I., (2011). Estudio morfológico y bentónico, de la plataforma continental vasca, mediante sensores remotos y la modelización de hábitats: establecimiento de las bases para la Planificación Espacial Marina / Morphologic and benthic study of the Basque continental shelf, using remote sensing techniques and habitat modelling: establishing the basis for Marine Spatial Planning. Universidad de Vigo / University of Vigo, Vigo. 195 pp.

Galparsoro, I., Á. Borja, J. Germán Rodríguez, I. Muxika, M. Pascual, I. Legorburu, (2012). Rocky Reef and Sedimentary Habitats Within the Continental Shelf of the Southeastern Bay of Biscay. Seafloor Geomorphology as Benthic Habitat. Pages 493-507 in. Elsevier, London.

Galparsoro, I., Á. Borja, V. Kostylev, I. Legorburu, G. Rodríguez, I. Muxika, P. Liria, M. Pascual, (Submitted). Process-driven characterization and benthic soft-bottom habitat modelling, for marine spatial planning and environmental status assessment, within the Basque continental shelf (Bay of Biscay).

Galparsoro, I., Á. Borja, I. Legorburu, C. Hernández, G. Chust, P. Liria, A. Uriarte, (2010). Morphological characteristics of the Basque continental shelf (Bay of Biscay, northern Spain); their implications for Integrated Coastal Zone Management. Geomorphology, 118: 314-329.

Galparsoro, I., G. Rodríguez, Á. Borja, (2009). Elaboración de mapas de hábitats y caracterización de fondos marinos de la plataforma continental vasca. Informe inédito elaborado por AZTI-Tecnalia para el Dirección de Biodiversidad; Viceconsejería de Medio Ambiente; Departamento de Medio Ambiente, Planificación Territorial, Agricultura y Pesca del Gobierno Vasco. 74 pp.

Pascual, M., A. Borja, S. V. Eede, K. Deneudt, M. Vincx, I. Galparsoro, I. Legorburu, (2011). Marine biological valuation mapping of the Basque continental shelf (Bay of Biscay), within the context of marine spatial planning. East Coast Shelf Sci 95: 186-198.

Salomidi, M., S. Katsanevakis, Á. Borja, U. Braeckman, D. Damalas, I. Galparsoro, R. Mifsud, S. Mirto, M. Pascual, C. Pipitone, M. Rabaut, V. Todorova, V. Vassilopoulou, T. V. Fernández, (2012). A ssessment of goods and services, vulnerability, and conservation status of European seabed biotopes: a stepping stone towards ecosystem-based marine spatial management. Med Mar Sci 13: In press.

Valencia, V., J. Franco, A. Borja, A. Fontán, (2004). Hydrography of the southeastern Bay of Biscay. Borja, A. and Collins, M. (Eds.) Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series, 70: 159-194.

EUNIS and main benthic habitats classification systems analysis toward mapping proposals: Application to Brittany Region

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Introduction

The classifications currently used are still heterogeneous according to the sources of the publications that define them, the application framework and national or local practices. The EUNIS classification, initially formulated using data and experience from the UK is being gradually expanded to include all European habitats with a fine-grain definition. Its application to cartography could however prove problematic. At the French level, the implementation of the Habitat Directive has resulted in breaking down the directive's generic habitats into elementary habitats that are not always easily referenced to EUNIS. They remain insufficient to thoroughly describe a given site or to adhere to the OSPAR requirements.

The goal of the present study is to propose a habitat classification which references a known descriptive system and adheres to regulatory mandates, while remaining accessible in the operational framework of cartography. Based on experience acquired during the multi-partner Rebent and Natura 2000 projects coordinated in Brittany by IFREMER, this study also has a European scope by way of the MESH project and frequent exchanges with JNCC in the UK.

Comparison of current standards

The various classifications adopted by the European Directives or international conventions, the guidelines issued at European and national levels (1 to 6), the EUNIS classification (7) were analyzed and compared in the light of regional mapping studies. The most salient points resulting from this analysis are the following:

- The generic habitats listed in the Habitat Directive only target selected habitats and are therefore insufficient for full sites descriptions. Their derived elementary habitats in the 'Cahiers d'habitats' also have the same limitation and difficulties when applied to mapping projects.
- The EUNIS classification tends to represent a greater and more widely shared standard at European level. Relatively exhaustive, its highly granular descriptions presents a number of difficulties :
  - It is extremely rich and complex and hard to use by non-specialists;
  - The units are defined by analysing suite of species taken from samples without worrying about how feasible the spatial delimitation of these units will be;
  - The hierarchy of levels takes account of parameters which in practice can be difficult to delineate at different scales;
  - The habitats of the biogeographic zone surrounding Brittany are not sufficiently taken into account;
  - Different existing versions have introduced modifications to habitats codes. The various documents which refer to EUNIS don't always specify the version number used, whence some errors and ambiguities;
  - Other errors come from nomenclature issues due to practice and interpretation that vary from one language and nation to another, introducing translation and transposition errors (e.g. divergence around the concept of supralittoral and the upper limit of the sublittoral).
- Among the sixteen habitats listed as threatened or declining by OSPAR, seven of them may be found in the Natura 2000 sites in the Brittany region. This selection, which targets priority habitats only, is obviously insufficient to describe the entire sites.
- The American CMECS classification (6) distinguishes three components which are mapped independently: 'Benthic cover' (geologic and biotic cover), the 'Geoform' (structure of the coastline and sea floor at multiple scales) and The 'Water Column' component. Although it is quite incomplete and focused on environments which are different from those found on our coasts, it introduces a general approach of interest for mapping applications. Its standard terminology for descriptive parameters and the ranking of variables (biotic cover, etc.) was very useful for this study.
- A census of the main habitats mentioned in available cartographic documents was conducted. This analysis made it possible to identify new habitats of regional significance. It also made possible to better assess the feasibility of discriminations in cartographic terms.

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Proposal to formulate a classification for mapping applications

Guidelines

In formulating a practical classification for mapping applications, the following guidelines were established:

- For all habitats, reference has been made to a description system as exhaustive as possible and shared by European authors, with possible additions when needed. The EUNIS 2004 edition has been selected.
- An effort has been made to systematically identify the OSPAR 'Priority habitats' and the Natura 2000 'Generic habitats'. The 'Elementary habitats' defined in the Cahiers d'habitats are preserved as far as possible. Missing habitats were also underlined.
- Habitats functional characteristics, such as expansion/ regression phenomena, were taken into account for habitats that risk significant evolution.
- Technical mapping possibilities and the reliability of discriminations made and contours traced were considered.
- The ability to formulate a hierarchy for mapping habitats must be suitable for use at relevant scales for site management and monitoring. Technical feasibility must take cost/benefit into account.
- Broad scale mapping constraints were taken into consideration. In areas of difficult access and in deep areas, modeling can be a useful tool for habitats prediction.

Summary of the new proposals

The new proposals (8,9) concentrate on regional habitats in Brittany that are widely diverse, among those habitats present in the Channel and Atlantic coasts. Fully saline and estuarine tidal and subtidal zones were equally taken into consideration.

A total of 160 habitats were distinguished with full correspondence with EUNIS 2004 habitats (or habitats groups), Natura 2000 generic habitats, elementary habitats of the Cahiers d'habitats, and OSPAR priority habitats. The 'zone' column indicates whether the habitat is found in tidal and/or subtidal zones, which require different technical procedures.

Four hierarchical levels are proposed, enabling adjustment in the data detail to be sought according to the objectives, the site characteristics and the available resources. It is understood that it is always possible to go to greater detail by using the listed EUNIS habitats.

In the sedimentary domain, sub-classes are identified according to classic descriptors (depth zone, particle size, sediment mobility, salinity and easily observable fauna). Marine and estuarine mud are defined in concordance with the OSPAR guidelines and zones with invasive perennial seaweeds are identified.

In the rocky domain, the criterion of exposure has been abandoned in favour of dominance of coverage by vegetal or animal species (for example fucoids or mussels), which is easily observable on site or via remote sensing. This type of reproducible approach enables monitoring significant evolution over the last few decades. On subtidal rocky substrate, similar reasoning led to stressing the identification of kelp forests and sparse kelp meadows which are separated in EUNIS into multiple categories that are difficult to apply at the mapping level. This distinction is compatible with acoustic identification capabilities.

There is a marked vertical zonation of the communities. This zonation is generally much less evident in the sediment habitat than the rocky shores. Thus, the concept of depth zone appears at the second level for the hard substrate while it occurs only at the fourth one for the soft substrate.

For particular habitats, special attention was given to specific habitats related to structuring species which modify the environment:

- Some of them are identified in the OSPAR high-priority habitats such as seagrass and maerl beds, flat oyster beds, Sabellaria reefs or Horse mussel grounds that are unknown to date in this region.
- Others have been added because of their ecological significance: for example *Lanice conchilega* beds (a petition for recognition is under consideration) and boulder fields, rightly recognised in the Cahiers d'habitats but not explicitly mentioned in EUNIS have been retained.
- Others are invasive: either an older proliferation such as *Crepidula fornicata* invaded seabed or a more recent one such as oyster reefs on rock or tidal flats.

Conclusions

This study has clarified a certain number of concepts and resulted in pragmatic proposals that address fundamental concerns. The proposals are also consistent with mapping survey capabilities to meet most inventories and monitoring requirements. The various levels proposed enable adaptations to the site features, scale or objectives set. A correspondence table makes it possible to go down to the most detailed EUNIS levels. The proposal was incorporated into the mapping specifications of Natura 2000 coastal sites (Fig. 1). This study is now being used at the national level for deeper sites. There still remains to characterize some habitats more accurately and to ask for lacking habitats to be created in EUNIS.

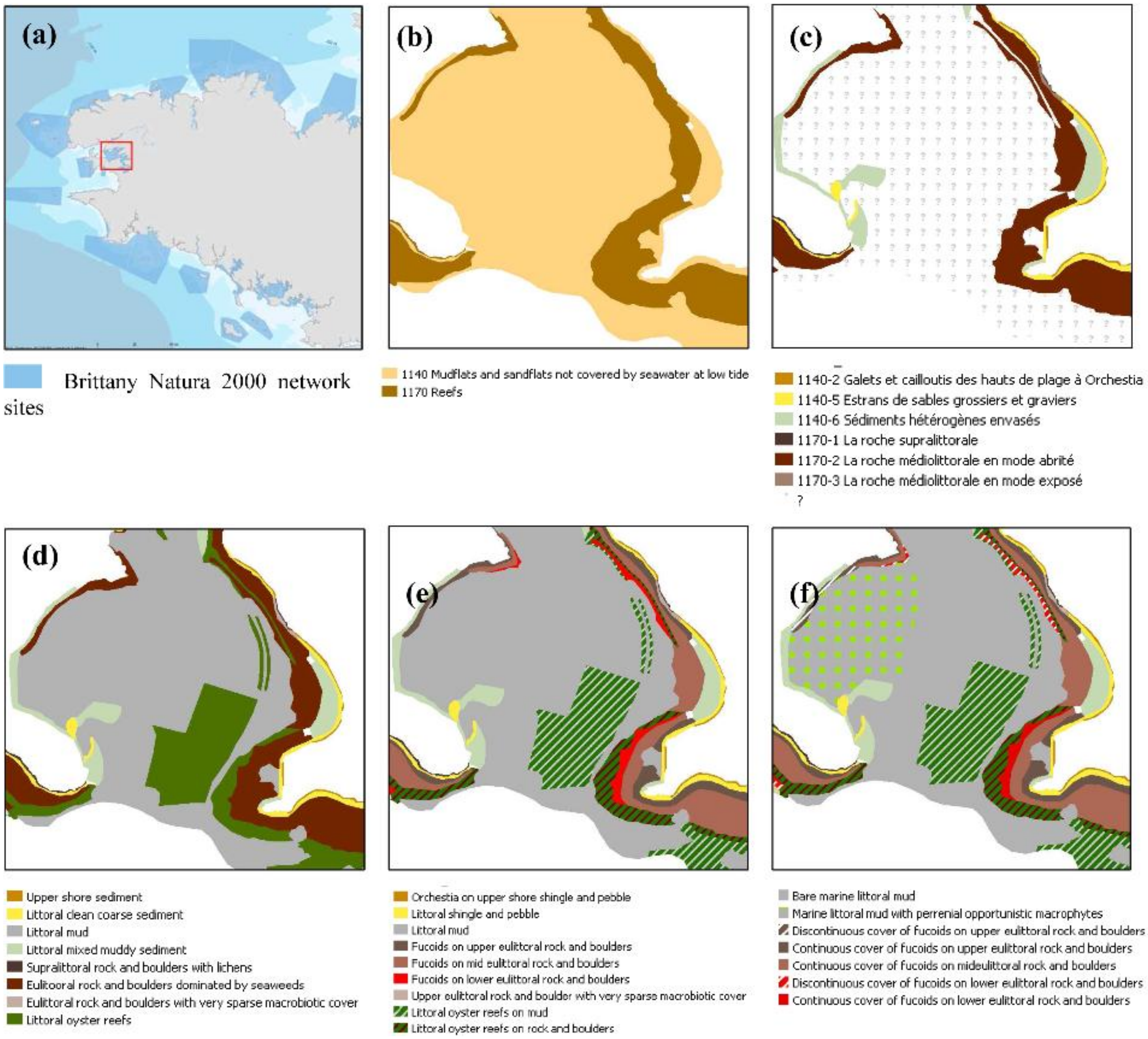

Figure 1. Zoom of Rade the Brest (a) habitat mapping using different classification systems : Habitats directive mapping (b), Cahier d'habitats (c), New propositions for mapping level 1 (d), level2 (e) and level 3 (f)

References

CONSLEG, 2004. Directive 92/43/CEE DU CONSEIL du 21 mai 1992 concernant la conservation des habitats naturels ainsi que de la faune et de la flore sauvages. Réf. 1992L0043 - FR - 01.05.2004. 57p.

Commission Européenne, 1999. Manuel d'interprétation des habitats de l'Union Européenne. EUR 15/2. 132 p.

European Commission, 2007. Guidelines for the establishment of the Natura 2000 network in the marine environment. Application of the Habitats and Birds Directives. 112 p.

Bensettiti F. et al., 2004. Connaissance et gestion des habitats et des espèces d'intérêt communautaire. Cahiers d'habitats Natura 2000. Habitats côtiers - Tome 2

OSPAR list of threatened and/or declining species and habitats (2008). Référence number OSPAR 2008-07

Madden, Goodin, C.K., Allee, B., Finkbeiner, M. and Bamford, D. (2008) Coastal and marine ecological classification standard. NOAA & N. Serve), p. 77.

European Environment Agency, 2004. European Nature Information System (EUNIS), Version 2004. http://unis.eea.europa.eu/habitats.jsp.

Guillaumont B., Bajjouk T., Rollet., Hily C., Gentil F., (2008). Typologie d'habitats marins benthiques : analyse de l'existant et propositions pour la cartographie (Habitats côtiers de la région Bretagne) – Note de synthèse, Projets REBENT-Bretagne et Natura-Bretagne, RST/IFREMER/DYNECO/AG/08-06/REBENT

Bajjouk T., Derrien S., Gentil, F., Hily C. & Grall J., 2011. Typologie d'habitats marins benthiques : analyse de l'existant et propositions pour la cartographie. Habitats côtiers de la région Bretagne - Note de synthèse n° 2, Habitats du circalittoral. Projets REBENT-Bretagne et Natura 2000-Bretagne. RST/IFREMER/DYNECO/AG/11-03/TB. 24 p.

Mediterranean benthic EUNIS habitats: structural considerations and lessons learned from mapping

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Abstract

The EUNIS habitat classification system was designed to cover all European habitats and substantial efforts have been made to contain information on marine benthic habitats from different regions, such as the Mediterranean sea, thereby advancing the system's exhaustivity in terms of its geographical coverage of European seas (Davies *et al*., 2004). The importance of a univocal habitat classification system is confirmed by the fact that numerous EU initiatives aimed at marine mapping, assessment and reporting are increasingly using EUNIS habitat categories and respective codes so as to guarantee a common shared path and technical terminology amongst Member States. We hereby present a series of considerations on the structural hierarchy of this habitat classification system and suggest modifications and additions, based on our experience of incorporating Mediterranean benthic habitats into EUNIS as well as those derived from the EUSeaMap broad scale mapping process based on a modeling approach using abiotic variables.

According to the Mediterranean school of thought on benthic bionomy, biocenoses develop within specific zones belonging to two main systems distinguished as a function of the vertical light gradient: the phytal system, where all types of flora can survive, and the aphytal system where autotrophic flora are unable to survive except for sparse algae thriving in very dim light conditions. These two systems host biological zones characterized by different substrate typologies and whose limits are determined by abiotic parameters such as: exposure to tides and waves (for the shallow superficial supralittoral and mediolittoral zones), amount of light reaching the seabottom (for the infralittoral zone and partially for the circalittoral – phytal system), and bottom slope angle trend and pressure (deep circalittoral, bathyal and abyssal – aphytal system) (Peres & Picard, 1964; Carpine, 1970). Since community distribution is dependent on biological zone partitioning and substrate type, it follows that community description and classification follows a sequential order based on such aspects. This ordering is present in the marine habitat classification list revised under the framework of the SPA/BIO protocol of UNEP/MAP's Barcelona Convention (UNEP, 2006). Mediterranean habitats (biocenosis, facies and associations) as defined by the benthic manuals (Peres & Picard, 1964; Augier 1982) and by UNEP/MAP (2006) were inserted into the EUNIS hierarchical system based on an analysis of their known biological characteristics with respect to a specific EUNIS template (depth zone, substrate type, energy, characteristic and accompanying species etc.) and based on the EUNIS classification principles (Tunesi *et al*., 2006). The EUNIS classification approach differentiates the first level of division (level -2) according to depth zone and seabottom mobility, thus creating six broad habitat categories that are alphanumerically coded: A1 – A6 (see Figure 1a). The subsequent level-3 habitat

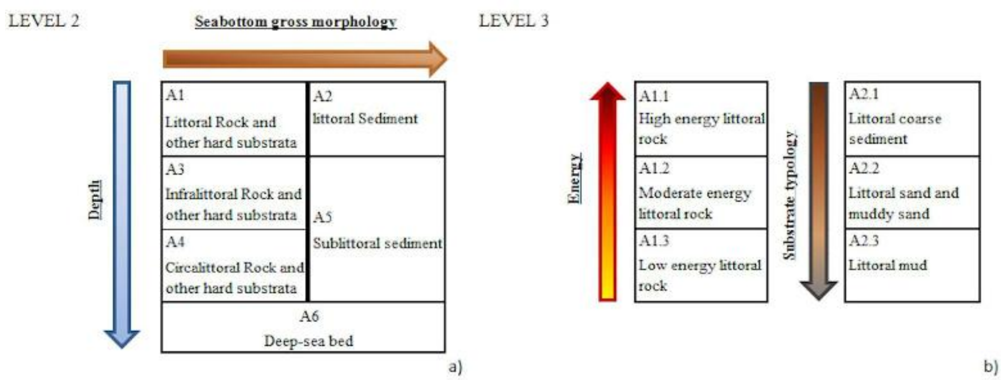

Figure 1. The Eunis hierarchical classification parameters guiding each habitat level partitioning (main abiotic parameters affecting the bionomic differentiation for Mediterranean habitats are underlined in bold)

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partitioning is carried out on the basis of other abiotic parameters (finer detail substrate typology, energy, light etc. see example in Figure 1b), while specific biological features (i.e. dominance of vegetal or animal communities) further differentiate the level 4 and 5 habitat groupings. A comparative cross check was carried out between the marine EUNIS positioning of each Mediterranean community type with respect to the Mediterranean benthic classification approach.

Broad scale maps based on modeling approaches of abiotic parameters have provided Europe with useful tools to quantify the spatial extent of many broad scale habitats (Coltman *et al*., 2008; Leth, 2008; Cameron & Askew, 2011). The habitats indicated by such maps are classified and reported following the EUNIS classification. The broad scale map of the Western Mediterranean was modelled through the intersection of 3 abiotic parameters (estimated % light reaching the seabottom, substrate type, bathymetry combined with slope angle change). The modeled habitat types were analysed with respect to their EUNIS codes to verify for consistency in terms of the resulting level distribution of the modelled habitat types and to check for repetitions and gaps.

Some structural caveats and discrepancies are observed in the way Mediterranean benthic communities are classified in the EUNIS system (see figure 2) especially in consideration of the general principle that level 2 habitat partitioning should occur according to differences in biological zone and substrate mobility. In particular, it is evident that the habitat category "A5-sublittoral sediments" encompasses soft bottom communities of two distinct Mediterranean biological zones: the infralittoral and the circalittoral. In a similar manner, category "A6-deep sea bed" encompasses communities of bathyal and abyssal zones of both hard and soft bottoms.

This aspect is also observed in the results of the EUSeaMap modelled habitats (see Table 1). Modelled rocky bottom habitats belong to EUNIS habitats coded in sequentially increasing order (i.e. A3, A4, A6 respectively for infralittoral rock, circalittoral rock and deep sea rock) but soft bottom habitats of the infralittoral and circalittoral all share the same A5 coding (highlighted in italics in the table). Moreover, infralittoral and circalittoral modelled habitats correspond to a level-4 coding definition while bathyal and abyssal modelled habitats only reach a level- 3 coding due to the aggregation of all bathyal and abyssal soft and hard bottom communities under the broad category A6. This also leads to duplication of habitats with the same EUNIS number codes (highlighted in bold in the table) regardless of whether they belong to an abyssal or bathyal zone, thereby confirming that the system does not allow for separation according to depth zones in the deeper part of the sea.

The EUSeaMap also suggested the existence of new habitat categories in the bathyal and abyssal zones previously not described in Mediterranean habitat classifications, namely the

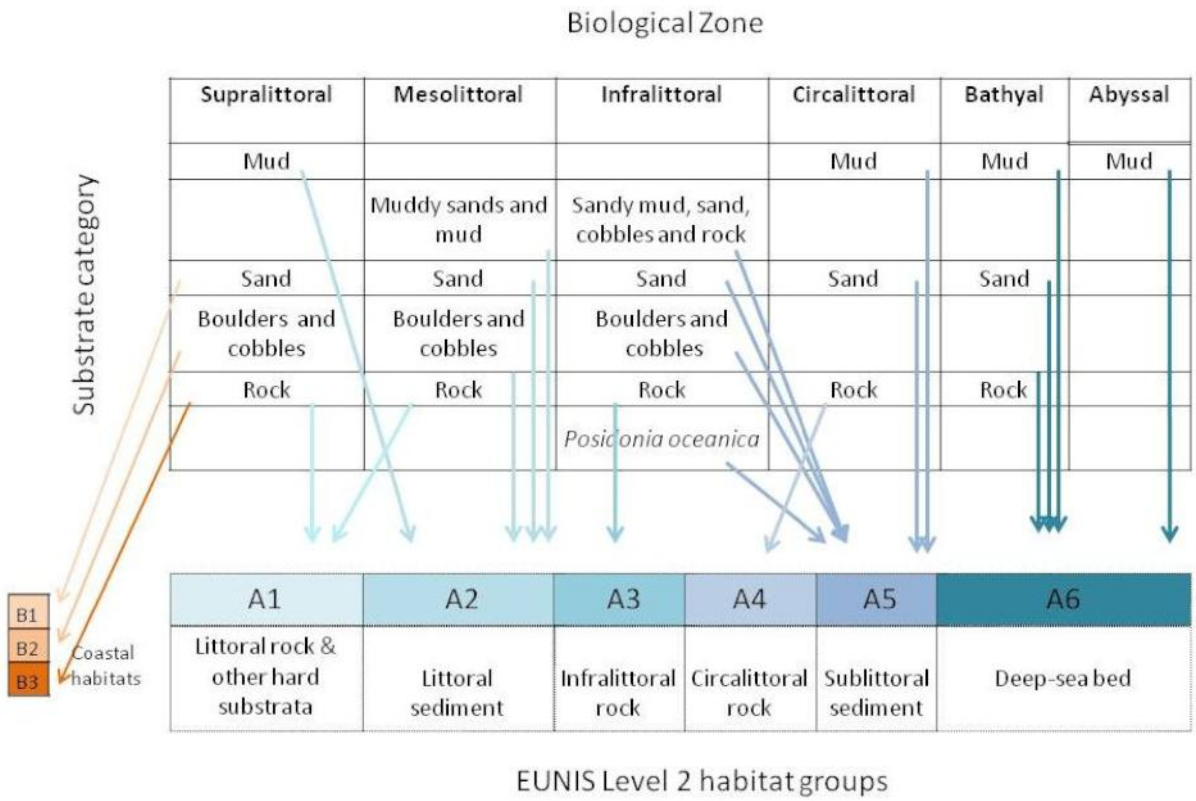

Figure 2. Repartitioning of EUNIS Mediterranean benthic communities (upper table) into the EUNIS level 2 categories (lower table).

Table 1. Eunis codes of broad scale modelled habitats of the Western Mediterranean Sea present in EUSeaMap (partially modified from Cameron and Askew, 2011)

Biological zone Substrate	Infralittoral	Upper Circalittoral	Deep Circalittoral	Deep Sea Bathyal	Deep Sea Abyssal
Rock (or other hard substrata)	A3	A4.26	A4.27	A6.1	A6.1
Coarse & mixed sediments (detritic)	A5.13	A5.46	A5.47	A6.2	A6.2
Muddy detritic			A5.38		
Sand	A5.23			A6.3	A.6.3
Muddy sand				A6.4	A6.4
Sandy mud	A5.33			A6.511	
Mud	A5.34	A5.39		A6.51	A6.52

presence of mixed sediments and muddy sands in the bathyal zones and mixed sediments, sand and muddy sand in the abyssal zone. Though such considerations are only based on the modeling of substrate and biological zone parameters, and no information is available on the associated biological assemblage, the modelled map clearly indicates to the existence of such habitats from an abiotic point of view.

In light of the above it would seem appropriate that structural changes be made in the level 2 partitioning of EUNIS to accommodate for distinct subdivision at this level of hard and soft bottom communities for all biological zones as defined in benthic Mediterranean manuals. This would allow adequate differentiation of soft bottom communities of the infralittoral and circalittoral zones and recognition of the new emergent deep sea soft bottom habitats.

References

Augier, H (1982) Inventory and classification of marine benthic biocenoses of the Mediterranean. Nature and Environment Series25. Council of Europe, Strasbourg. 57pp

Carpine C (1970) Ecologie de l'étage bathyal dans la Méditerranée occidentale. Mém Inst Océanogr (Monaco) 2: 1-146

Cameron A , Askew N (eds.) (2011) EUSeaMap - Preparatory Action for development and assessment of a European broad-scale seabed habitat map final report. Available at http://jncc.gov.uk/euseamap

Coltman N, Golding N, Verling E (2008) Developing a broad-scale predictive EUNIS habitat map for the MESH study area. In: MESH Guide to Marine Habitat Mapping, www.searchMESH.net.

Davies CE, Moss D, Hill Mo (2004) EUNIS Habitat Classification. Report to the European Topic Centre on Nature Protection and Biodiversity, Paris for European Environment Agency, Copenhagen. October 2004. http://EUNIS.eea.eu.int/habitats.jsp

Leth JO (editor) (2008) Baltic Sea marine landscapes and habitats: Mapping and modelling. BALANCE Technical Summary Report, part 2/4: 45pp

Pérès JM and Picard JC (1964) Nouveau manuel de bionomie benthique de la mer Méditerranée. Rec. Trav. Stat. Mar. Endoume, 31(47): 5-137

Tunesi L, Moss D, Evans D, Mo G, Di Martino V (2006) The Mediterranean marine habitats in the "E.U.N.I.S." system. Biol Mar Mediterr 13 (2): 224-225

UNEP (2006) Classification of benthic marine Habitat types for the Mediterranean Region. UNEP (OCA)/MED WG 149/5 Rev. 1

Marine habitats inventory in Spain: classification, modelling and mapping

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Introduction

Identification, classification, and mapping habitats are key tools aiming to describe and manage marine ecosystems. Habitat degradation, destruction, fragmentation, and loss are impacts to be evaluated need of complete marine habitats lists and maps.

In Spain, three parallel working programmes, coordinated by the Ministry of Agriculture, Food and Environment, have highlighted the necessity to have a common list of marine habitat types of Spanish waters: the Marine Inventory of Species and Habitats (Natural Heritage and Biodiversity Act), the Marine Strategy Framework Directive, and the Natura 2000 Network (INDEMARES project). These three programmes have used EUNIS classification, but modified to be more representative of Spanish seas and feasible to be used in management.

Remarks and discussion

Marine Inventory of habitat types: a working-group of more than 30 experts on Spanish marine habitats has faced the challenge of developping a common list of habitats based on EUNIS, but modified to reflect regional peculiarities. Two criteria used in this task were 1) expertise, 2) bibliography. A list of near 1000 habitats, equivalent to EUNIS level 6, is now in the correction stage

Marine Strategy Framework Directive: the European Commission establishes the criteria in the Commission Decision on *Criteria and methodological standards on good environmental status of marine waters* (2010/477/UE). Habitat are monitorised mainly by Descriptor 1 (Biological diversity is maintained), where several criterion and indicators deal with habitat distribution and condition, and Descriptor 6 (Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected) with indicators on impact of pressures in habitats and extent of biogenic habitats. All data on habitats and pressures have been pooled in a GIS by the Spanish Institute of Oceanography (IEO). Habitat information came from several sources: research organizations, national and regional governments (for example WFD monitoring), NGOs, etc, with different spatial and temporal coverage and with different methodology and precision. Intertidal and infralittoral habitats (Figure 1) studies are numerous but very heterogeneous and disperse, hence there are not a continuous spatial and temporal coverage. Circalittoral and upper bathyal sedimentary habitats are yearly monitored in all Spanish shelf fthe IEO bottom trawl surveys. This data have been very useful to develop reference levels of indicators. Finally rocky circalittoral and bathyal data (Figure 2) are also scarce, although projects as INDEMARES have improved a lot of the knowledge of these environments.

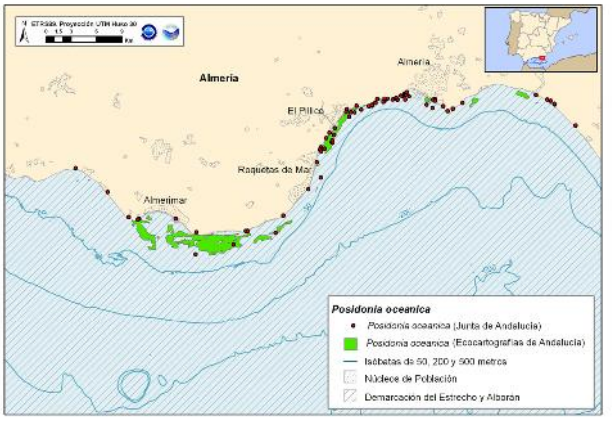

Figure 1. Map of Posidonia oceanica habitat obtained from different sources to the MSFD

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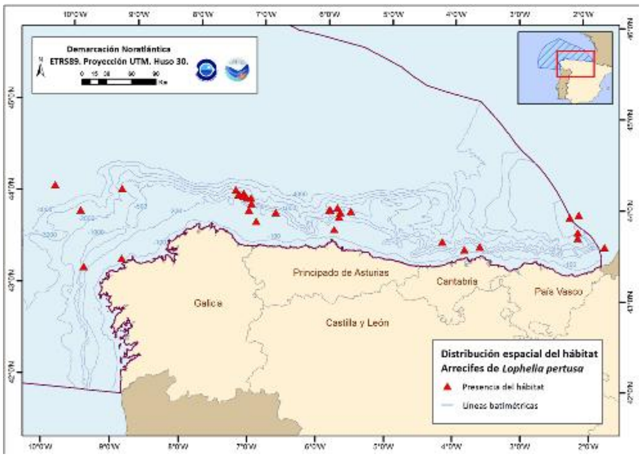

Figure 2. Map of Lophelia pertusa habitat obtained from different sources to the MSFD

Natura 2000 Network: in the marine environment, the Natura 2000 Network is in a very early stage. In order to obtain this information and begin the conservation and management actions, it is necessary to make a big effort to identify the marine ecosystems. It is here where the LIFE+ project "Inventory and designation of marine Natura 2000 areas in the Spanish jurisdictional waters" was born. The main objective of this project is to contribute to the protection and sustainable use of biodiversity in the Spanish seas through the identification of valuable areas for the Natura 2000 Network. The INDEMARES Project deals with the study of 11 marine areas.

One of the main problems that we must face in the development of projects as INDEMARES or the implementation of the Marine Strategy Framework Directive is the necessity of habitat mapping. In this sense, and in spite of both projects have different problematic and scales, the niche ecological modeling is a very useful tool. These type of statistical analysis allow convert punctual information about the presence of habitats, to continuous mapping of habitat suitability, an essential information in the Directive indicator developing or in the establishment of protected areas. The new techniques of habitat suitability modeling as the Ecological niche factor analysis (ENFA) or the maximum entropy analysis (MAXENT) based in presence data are being combined with more ordinary algorithms as GLMS, GAM or neuronal networks with the aim of developing grid habitat suitability maps for vulnerable and key species.

In the three programmes described, EUNIS classification has been the basis for habitat lists. This classification provide several advantages as the unification of criteria at a paneuropean level and the hierarchical system, which allow to generate maps and metrics at different levels of aggregation. Nevertheless, their use has shown the existence of several problems. One of them is that is not really hierarchical. Examples of this are these cases: 1) circalittoral and infralittoral at level 2 together in sedimentary grounds and split in two groups in rocky ones. 2) Substrate is the key factor at level 2 in rock and at level 3 in sediments. 3) Energy is only included as factor in rocky grounds; 4) Role of biogeography is uneven along the classification (when must be included only in the higher levels); 5) different levels of aggregation (in the level 5 are included "Canyons, channels, slope failures and slumps on the continental slope" and "Kelp with cushion fauna and/or foliose red seaweeds"; 6) different levels of detail (20 types of *Laminaria spp* and only one of *Cystoseira*).

Conclusions

- EUNIS is a valuable classification in habitat studies, and has been used in the current habitat conservation programmes in Spain.
- Nevertheless, we faced with several problems when EUNIS habitat types have been applied in Spanish ecosystems
- A work have to be done to adapt EUNIS to the final users as are European monitoring and conservation programmes and national inventories.

Acknowledgements

We have to thank to all experts of the "Working group on Spanish marine habitats", to the three groups working in the MSFD in the Ministry of Agriculture, Food and Environment, Spanish Institute of Oceanography IEO and CEDEX, and finally to the groups working in the INDEMARES project (EC contract INDEMARES-LIFE (07/NAT /E/000732). The authors also thank to the TRAGSA group working on technical support of IEO researchers in the MSFD.

EUSeaMap: predicting broad-scale EUNIS habitats for 2,000,000 km^2 of European seabed

Helen Ellwood[1*], on behalf of the EUSeaMap consortium[2]

Abstract

A consortium of agencies and research institutions from across four European marine regions (Baltic, North, Celtic and western Mediterranean Seas) joined together to deliver the requirements for the European Commission Tender MARE/2008/07 to develop and apply a consistent methodology to mapping seabed habitats across the partnership, taking into account the diverse range of seabed habitats found in different regions. The project is part of the wider EMODnet (European Marine Observations and Data Network) project and built upon the INTERREG-funded MESH[1] and BALANCE[2] projects, by harmonising and improving methods used to produce the MESH EUNIS predictive seabed habitat map for the North Sea and Celtic Sea and the BALANCE marine landscape map of the Baltic Sea, and extending the methodology to the western Mediterranean basin.

The technique relies on the hierarchical nature of EUNIS, which describes only the broad physical environment at its high levels – down to level 3 for rock habitats, and level 4 for sediment habitats. This allows the prediction of EUNIS level 3 and 4 habitats by overlaying full-coverage physical data layers, such as substrate type, energy at the seabed and light penetration. For example, where there is rock, high energy and high light penetration, the habitat is named *A3.1 high energy infralittoral rock*. Spatial data were prepared for a suite of environmental variables including data provided by EMODnet geology and hydrography projects[3]. Biological data were incorporated into the modelling process through the development of ecologically-relevant thresholds, where possible. For example, determining the proportion of light reaching the seabed that is required for photosynthetic algae to grow (thus defining the lower boundary of the infralittoral, or photic, zone).

Producing a harmonised map for such a large area – over 2,000,000 km^2 – and for three different sea basins without a fully developed classification systems posed some problems. The marine section of EUNIS was initially based on the Marine Habitat Classification for Britain and Ireland, which was most developed in coastal regions where the majority of the available data was found. Recent updates to EUNIS have included some Mediterranean- and Black Seas-specific biotopes at levels 4, 5 and 6. However, the Baltic is currently poorly represented within the Baltic region with only a few specific biotopes and the broad-scale variation in salinity – a particularly important parameter driving species distribution within the region – largely unnacounted for. It was also recognised that the deep-sea section (A6) of the classification system may not adequately address the variation in sea-bed habitats beyond 200 metres below sea-level.

Therefore for the Baltic and deep-sea areas, EUSeaMap had to identify biologically relevant combinations of physical variables without the guidance of a pre-defined classification scheme. This involves answering a number of questions, such as:

1. Do certain combinations of physical variables occur in nature, e.g. muddy sediment and high energy?
2. If they do, are these combinations relevant for distinguishing biological communities, e.g. do changes in salinity result in different biological communities or is there no effect?
3. How should these relevant habitat types be arranged into a hierarchy, e.g. at which level in the scheme should each physical variable be introduced?

The latter question relates to the issue of biogeography – at what stage should biogeography be considered in the classification? There are two approaches to this, and the best solution may be a combination of both:

- Refer to biogeographic regions only where relevant, as is the case for many Mediterranean biotopes, e.g. *A5.28 Mediterranean communities of superficial muddy sands in sheltered waters*, which appears below the generic *A5.2 Sublittoral sand.* This allows habitats formed by similar conditions to be grouped together under the same 'parent' habitat; however, there can sometimes be a risk of grouping

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[1] Development of a Framework for Mapping European Seabed Habitats (www.searchMESH.net)
[2] Baltic Sea Management – Nature Conservation and Sustainable Development of the Ecosystem through Spatial Planning (www.balance-eu.org)
[3] Preparatory Actions for European Marine Observation and Data Network, No. MARE/2008/03, Lots 1 & 2

biotopes that appear to be driven by the same environmental factors, as described in the parent habitat, when they are in fact driven by unrelated factors that sometimes occur together.
- Separate a biogeographic region at the top levels of EUNIS, effectively leading to a separate classification system for the region. There is the danger here of duplicating many habitats and biotopes that are equivalent but exist in other sections of the classification system leading to an inability to identify similar areas across basins. However, if a region is substantially different in terms of the main controls on the broad habitat types, then it may be sensible to use this approach.

This was an important question to answer in order to model Baltic habitats in EUSeaMap. The Baltic Sea region differs from the Celtic, North and Mediterranean Seas due to its isolation from the wider ocean and its high latitudes; for example, salinity is reduced, it is very turbid, there is a lack of tidal currents and it is partially covered with ice in winter. It was decided that both approaches described above would be investigated, and two differently classified maps were produced by EUSeaMap:
- The first classified habitats in a similar way to the current classification system: in terms of biological zone, energy and substrate type; however it differed in that energy was considered for sediment as well as rock, and an additional substrate type "mixed hard sediment" was introduced to account for glacial till. This would allow some integration with the current EUNIS system.
- The second classified habitats with salinity regime (oligohaline/mesohaline) at the highest level, as well as biological zone and substrate; "mixed hard sediment" was also included here. Incorporating salinity at such a high level would mean a separate Baltic EUNIS section would be formed from EUNIS level 2 onwards.

Importantly, these two combinations of physical factors were made with limited biological information; therefore further work was required to identify the most biologically-relevant habitats. Since EUSeaMap, the Helsinki Commission (HELCOM) Red List project has investigated this issue further. On analysis of biological data it was found that neither of the proposed structures was the most appropriate approach if duplication was to be avoided at the more detailed biotope levels. The Red List Biotopes team are currently working on the levels 5 and 6 of the Baltic classification on the basis that the Baltic habitats and biotopes will form a new section of the EUNIS classification. The development of the seabed habitat classification for the Baltic Sea will be discussed further in the talk by J. Haldin, entitled "The Red List project at the Helsinki Commission – HELCOM".

The biogeography issue is also relevant for the deep-sea bed (beyond 200m), which occurs in the North, Celtic and western Mediterranean Sea regions, but not the relatively shallow Baltic. The classification used by EUSeaMap uses the suggestions of Howell (2010) for five deep-sea zones defined by depth as a proxy for other environmental variables: Upper Slope, Upper bathyal, Mid bathyal, Lower bathyal and Abyssal. After these zones, the five usual EUNIS substrate types are defined. The same deep-sea zones were used across the Celtic, North and Mediterranean Seas; however, the Mediterranean deep-sea zones are relatively isolated from the Atlantic ocean as a result of the shallower depths in the Strait of Gibraltar. It may therefore be argued that the biogeography differs so greatly in the Mediterranean that EUNIS should divide Mediterranean from Atlantic deep-sea habitats at a high level. This would be a less drastic division than the draft Baltic classification; however, because the Mediterranean would retain common habitat types in the intertidal, infralittoral and circalittoral zones. The deep-sea classification and related biogeographic issues will be discussed further in the talk by C. Jenkins, entitled "Changing the deep-sea structure of the 'Marine Habitat Classification for Britain and Ireland'".

The EUSeaMap project produced the first harmonised broad-scale habitat map for over 2,000,000 km^2 of European seabed. During the process, several obstacles were met, which has led to further research in these areas. In late 2012, the next phase of the EMODnet project will begin. It is hoped that current and future developments in the EUNIS classification system will lead to improved predictive habitat maps. This new phase will potentially include new sea areas, which may present new problems, providing the opportunity to further improve the EUNIS classification system until it is truly a European system.

References

Cameron A, Askew N (eds.) (2011) EUSeaMap - Preparatory Action for development and assessment of a European broad-scale seabed habitat map final report. Available online at http://jncc.defra.gov.uk/page-5020

Howell KL (2010) A benthic classification system to aid in the implementation of marine protected area networks in the deep/high seas of the NE Atlantic. Biological Conservation 143: 1041-56.

EUNIS: Issues with application to broadscale habitat mapping

Roger Coggan[1*], Bryony Pearce[2], Ceri James[3]

Abstract

Experience of trying to use the EUNIS classification scheme for broadscale habitat mapping studies has revealed three features of the existing system that make it difficult to apply in practice. These stem from a) inconsistencies in the hierarchical structure, b) the dichotomy between rock and sediment substrates and c) infidelity of communities to nominated sediment classes. This paper examines these problems and presents potential solutions.

Inconsistencies in the hierarchical structure:

The EUNIS system uses substrate, energy (exposure) and biological zone to characterise physical habitat types, but it introduces these factors at inconsistent levels in the hierarchy which causes internal inconsistencies in maps classified at EUNIS level 3 which is commonly used in many broadscale studies. Rock and sediment substrates are differentiated at EUNIS level 2; however the scheme introduces the littoral, infralittoral and circalittoral biological zones at level 2 for rock habitats but only at level 4 for sediment habitats. The practical outcome of this is that a level 3 EUNIS map will discriminate biological zones for rock habitats but not for sediment habitats (Figure 1a), so some parts do show biological zones whilst others do not (Figure 1b). A level 3 map can show potential kelp habitat but cannot show potential *Zostera* habitat, yet both are in the infralittoral zone. The level 3 map significantly under represents the infralittoral zone. Another anomaly is that the deep-circalittoral zone (i.e. below the wave-base) is introduced for sediment habitats (at level 4) but is never formally introduced for rock habitats; instead some level 4 rock habitats include 'deep' in their title. In order to represent the biological zones equitably within a single map, rock habitats should be classed to level 3, sediment habitats to level 4, and a new class made for deep circalittoral rock at level 3.

Code	EUNIS name
A1	Littoral Rock
A2	Littoral Sediment
A3	Infralittoral Rock
A3.1	High energy Infralittoral Rock
A3.2	Moderate energy Infralittoral Rock
A3.3	Low energy Infralittoral Rock
A4	Circalittoral Rock
A4.1	High energy Circalittoral Rock
A4.2	Moderate energy Circalittoral Rock
A4.3	Low energy Circalittoral Rock
A5	Sublittoral Sediment
A5.1	Sublittoral Coarse sediment
A5.2	Sublittoral Sand
A5.3	Sublittoral Mud
A5.4	Sublittoral Mixed sediment

Figure.1a. EUNIS levels 2 & 3

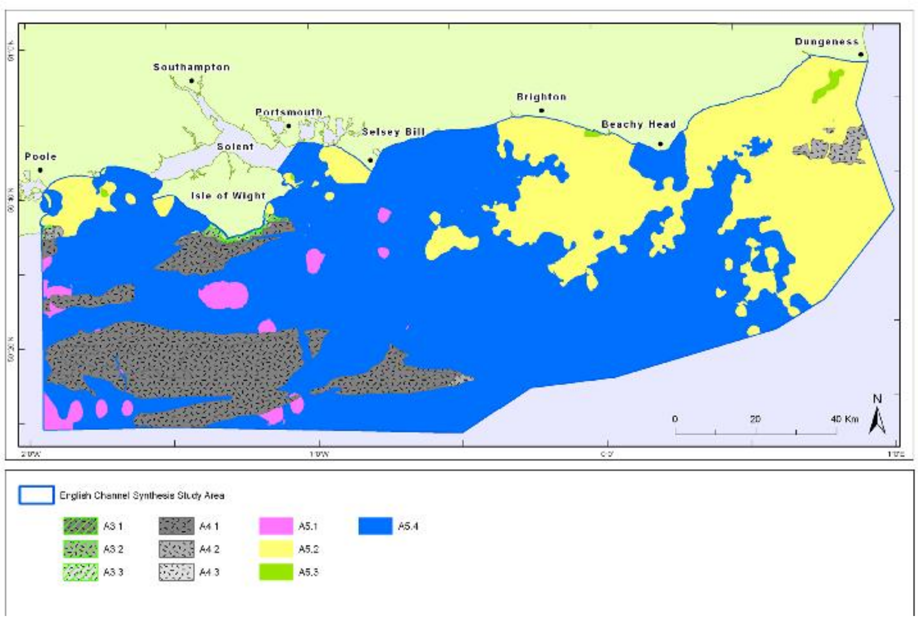

Figure.1b. EUNIS level 3 map, illustrating severe under representation of the infralittoral zone (green hatching) along the coast (from James *et al*, 2011)

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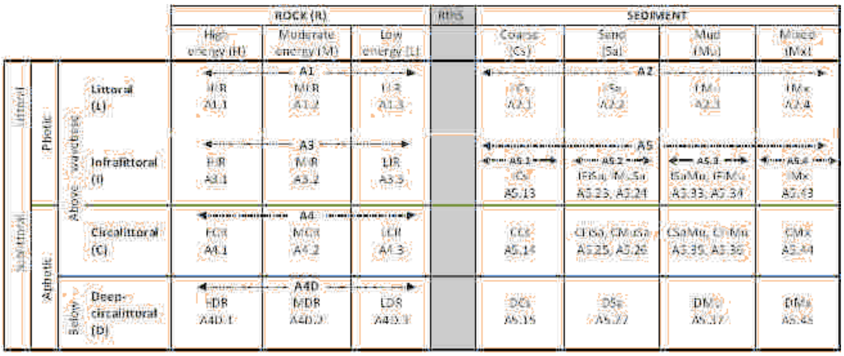

Figure 2. Substrate x Biological Zone matrix giving the EUNIS and MNCR-style codes for each matrix cell. Rock habitats coded to EUNIS level 3; sublittoral sediment habitats coded to EUNIS level 4. MNCR codes are derived from feature abbreviations, such that MIR = Moderate energy Infralittoral Rocked. In addition, FiSa = fine sand, MuSa = muddy sand, SaMu = sandy mud, FiMu = fine mud. RthS = Rock and thin Sediment (see text).

The dichotomy between rock and sediment substrates:

The EUNIS system recognises two main types of substrate, namely rock and sediment, so mapped areas have to be classified as either rock or sediment. However, there are significant areas of the seabed where bedrock occurs at the seabed surface in association with a thin (<0.5 metre), often discontinuous covering of sediment, leading to a mosaic of rock and sediment habitats. The benthic community in these areas includes species characteristic of both rock and sediment habitats, so it does not match well to the existing biotope descriptions. It is equally wrong to describe the area as a rock or sediment habitat, because it displays characteristics of both. However, this can not be represented using the current EUNIS classification system as it only recognises separate rock or sediment habitats. Our solution to this problem has been to introduce a third substrate class called 'Rock and thin Sediment', coded as 'RthS'. It sits between the rock and sediment habitats. A modified schema for the classification system is presented in Figure 2, incorporating both the 'RthS' class of substrate and introducing a deep-circalittoral class at level 3 (as described above).

Infidelity of communities to nominated sediment classes

The EUNIS classification system recognises four sediment classes, namely coarse sediments, sand, mud and mixed sediments. These have been mapped to the standard Folk trigon (Folk, 1954) to apportion the more familiar Folk sediment classes to EUNIS sediment classes (Long, 2006), as illustrated in Figure 3. However, although infaunal communities can be quite distinct in their species composition (and so be considered a biotope), they rarely show fidelity one of these four sediment classes and can typically be found in two or more of the classes.

Unfortunately, the EUNIS system assigns a particular community type to one and only one sediment class, so while sediment composition of a grab sample may indicate that it should be assigned to a mixed sediment class (A5.4), its faunal composition may force that sample to be assigned to a biotope that falls under the sand class (A5.2), simply because that community type is only listed under the 'sand' class of substrate in the EUNIS classification. This can cause a tremendous amount of patchiness when trying to draw EUNIS maps using just empirical data, and significant disagreements between EUNIS classes derived from broadscale modelled maps and those derived from point sampling at a given location. We frequently found that many of the communities listed under EUNIS 'sand' biotopes were also found in mixed, coarse and muddy substrates, and concluded that

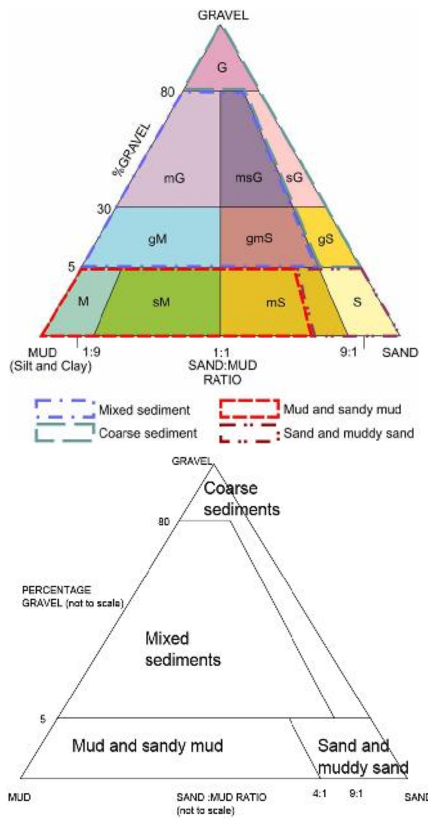

Figure 3. Folk trigon (left) showing the classification used by the UK SeaMap and MESH projects to assign Folk sediment classes to the four broader sediment classes used in the EUNIS habitat classification scheme (after Long, 2006)

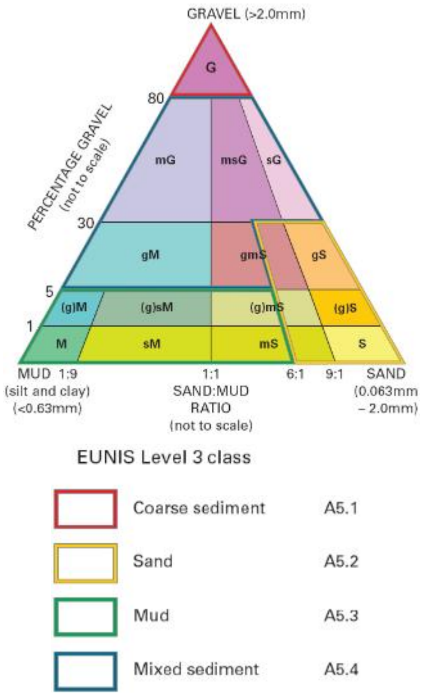

Figure 4. Modification of the schema shown in Figure 1, adjusting how EUNIS classes are mapped to the Folk trigon, in an attempt to improve matching between modelled EUNIS habitat maps and ground-truth observations of benthic communities (from James *et al*., 2010)

the original mapping of EUNIS substrate types to the Folk trigon had restricted the EUNIS sand class to too small an area of the trigon. Hence we have trialled a revised division, expanding the sand class and reducing the gravel and mud classes to give the partitioning shown in Figure 4. This has significantly reduced the mismatch between EUNIS classes determined from grab samples and broadscale modelled EUNIS maps.

We have found that the structure and underlying assumptions of the current EUNIS classification system make it difficult to apply when producing mapped outputs and that some of those outputs are potentially misleading to the non-expert. We have demonstrated that several opportunities exist for modifying the system in order to make it more fit-for-purpose for habitat mapping and consequently for marine management and spatial planning.

References

James JWC, Pearce B, Coggan RA, Arnott SHL, Clark R, Plim JF, Pinnion J, Barrio-Frójan C, Gardiner JP, Morando A, Baggaley PA, Scott G, Bigourdan, N (2010) The South Coast Regional Environmental Characterisation. British Geological Survey Open Report OR/09/51. 249 pp

James JWC, Pearce B, Coggan RA, Leivers M, Clark RWE, Plim JF, Hill JM, Arnott SHL, Bateson L, De-Burgh Thomas A, Baggaley PA (2011) The MALSF synthesis study in the central and eastern English Channel. British Geological Survey Open Report OR/11/01. 158pp.

Long D (2006). BGS detailed explanation of seabed sediment modified folk classification. MESH project document available online at http://www.searchmesh.net/PDF/GMHM3_Detailed_explanation_of_seabed_sediment_classification.pdf

Challenges and confidence levels associated with modelling EUNIS level 5 biotopes: Case study from the North Sea

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Abstract

A Regional Environmental Characterisation (REC) study of the Outer Humber region was commissioned by the British Government in 2008, through the Marine Environmental Protection Fund (MEPF). The primary objective of this study was to produce a broad scale characterisation of seabed habitats, providing a regional context to the development of specific Environmental Impact Assessments (EIAs). It is anticipated that this broadscale characterisation will also be used in future marine planning and to help facilitate the development of an ecologically coherent network of Marine Protected Areas (MPAs).

A top-down / bottom up approach to habitat modelling was used in the Humber REC to develop a biotope model (Pearce *et al*, 2011), broadly equivalent to Level 5 in the European Nature Information Service (EUNIS) classification scheme. The modelling processes adopted a modified approach to those used in BIOMOR 5 / HABMAP (Robinson *et al*, 2009). However the categorisations used to inform the EUNIS classifications were not related to HABMAP.

The Humber REC model was based on a recently developed alternate interpretation of the Folk triangle, for determination of EUNIS sediment categories at level 4. Originally developed for the South Coast REC this has been proven to produce better alignment between EUNIS classes determined from grab samples and broadscale modelled EUNIS maps (James *et al*, 2010). The biotope model developed in the Humber REC further applied Level 5 sediment classification, not previously defined for EUNIS seabed habitats. The resuling biotopes predicted were assigned descriptions through careful consultation of the 2006 EUNIS classification scheme. Where a match was not possible, new Level 5 biotopes were proposed.

The Humber REC biotope model is considered to offer the most accurate prediction of biotopes given i) the vast datasets incorporated from both within the project survey programme and from previous national datasets, e.g. British Geological Society Seabed Sediments; and ii) the proven increase in accuracy given by the categorisations used. However the resultant maps would have differed significantly had these not been adopted. Therefore this paper aims to present a range of model outputs that could have been provided had these steps not been followed, and to compare these visually.

The alternate model outputs will consider how biotopes sampled in the field, that do not have a formal categorisation in EUNIS, may at times be forced into the closest matching category. The Humber REC model will be adapted fit to the EUNIS classification as closely as possible without assigning new categories and comparison made to the actual published model. Other comparisons will be shown for Level 4 EUNIS habitats, using each of the sediment categorisations available from UKSeaMap, EUSeaMap and the South Coast REC. In addition, these maps will be compared to habitats predicted without use of the REC data as provided through MESH, UKSeaMap 2010 and EUSeaMap.

References

James, J W C, Pearce, B, Coggan, R A, Arnott, S H L, Clark, R, Plim, J F, Pinnion, J, Barrio Frójan, C, Gardiner, J P, Morando, A, Baggaley, P A, Scott, G, and Bigourdan, N. 2010. The South Coast Regional Environmental Characterisation. British Geological Survey Open Report OR/09/51. 249 pp

Pearce, B., Chambers, C., Hill, J., Tappin, D. & Dove, D. (2011). Ecological Gymnastics - Combining a top-down and bottom-up approach to Biotope Modeling. 10th International Conference GEOHAB 2011 Marine Geological and Biological Habitat Mapping, Geological Society of Finland, Espoo, Helsinki.

Robinson, K. A., Ramsay, K., Lindendaum, C., Frost, N., Moore, J., Petrey, D., & Darbyshire, T. (2009). BIOMÔR 5: Habitat Mapping for Conservation and Management of the Southern Irish Sea (HABMAP) II: Modelling & Mapping.

Tappin,D.R., Pearce,B., Fitch,S., Dove,D., Geary,B., Hill,J.M., Chambers,C., Bates,R., Pinnion,J., Green,M., Gallyot,J., Georgiou,L., Brutto,D., Marzialetti,S., Hopla,E., Ramsay,E., Fielding,H. (2011). The Humber Regional Environmental Characterisation, Marine Aggregate Levy Sustainability Fund (MALSF), British Geological Survey Open Report OR/10/54. 317pp.

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Changing the deep-sea structure of the 'Marine Habitat Classification for Britain and Ireland'

Chris Jenkins[1]

Abstract

As part of the JNCC's responsibilities for the Marine Habitat Classification for Britain and Ireland (Connor *et al*, 2004), work has been undertaken to update and develop the deep-sea component. A large amount of work has been undertaken in regard to this classification and its application to EUNIS. The deep-sea element has, however, been highlighted as an underdeveloped region and fresh thinking has suggested several possible sources for advancement. The JNCC is proposing these changes to its own UK based 'Marine habitat classification for Britain and Ireland' but working towards integration with the wider European community and the current EUNIS classification system

The current deep-sea classification covers the upper slope to hadal depths. Environmental conditions over these depths vary greatly and the classification should be developed to better represent this heterogeneity. Howell *et al* (2010) discuss biogeographic diversity within the deep-sea, not only in relation to environmental conditions but also the diversity related to the life history of regions.

Depth zones will be discussed, but it is important to note that they have been based on UK deep-sea investigations and further analysis would be required to depict depth bands in other regions across EUNIS. A structural change to the deep-sea classification would likely cause difficulty for future mapping exercises and thought must be given to how best to minimise discontinuity between the deeper and shallower regions. Environmental parameters that define coastal and shallower waters are not particularly applicable to deep-sea communities however, and clear thought must be given to how to best define deep-sea regions.

The deep-sea component currently encompasses a wide range of habitat types at a range of depths, from 200m at the top of the slope down to the abyssal slopes at depths of 5,000m (in UK waters). Depth itself is not the primary factor within the classification but can be better looked at as a surrogate for other environmental factors associated with depth, light attenuation being the clearest. It could be argued that since the deep-sea is clearly at a depth greater than the photic zone there is no requirement for further division. However, it is becoming apparent that there are still other factors that can be associated with depth in the deep-sea; temperature, water density, slope and topography to name but a few (Dinter, 2001). Howell *et al*. (2010) propose five zones defined by depth for the deep-sea that we support here. These zonations have already been used to great effect in mapping exercises (UK SeaMap and EU SeaMap) and are a strong basis for better defining some of the environmental variability.

1. Upper Slope/ Bathyal margin (name to be confirmed)
2. Upper bathyal zone
3. Mid bathyal zone
4. Lower bathyal zone
5. Abyssal

A full discussion of these depth zones can be found in Howell *et al*. (2010) and their relationships with the primary environmental factors that will be affecting faunal communities. The main discussion topic is that even though depth is used throughout the classification system, it is important to understand that it is used as a proxy for other factors and, therefore, should not be assumed that different regions, at comparable depths and sediment types, display an ubiquitous environment.

Within the deep-sea classification, biogeography takes a relatively low priority and is currently introduced at level 4, more specifically as 'Mediterranean communities of bathyal muds'. It could be argued that this relatively low prioritisation could result in similar biological communities surviving in relatively distinct environments to be classified as the same biotope. Within the deep sea, using depth alone as a surrogate for other environmental factors may lead to misinterpretations of habitats. Equally, communities that are similar but are found under different environmental conditions should not be considered as the same biotope and a means to distinguish between them, that is not reliant on depth and sediment type, should be introduced. The introduction of a biogeographic zonation has been considered contentious in the past, due to it reducing the classification's capability to compare biotopes in isolated geographic locations with similar biotopes on a broader scale. Though this is true it is also worth considering that the biogeographic dissimilarities in the deep sea are related to water properties, i.e. temperature, density, salinity etc. that will vary greatly on a geographic scale due to the nature of deeper water, and thus impacting on communities more than would be expected in shallower locations within the photic zone.

Options for restructuring the deep sea portion of the marine classification are fairly complex and there are many ways to

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do this. Thought and discussion on some of the more practical options is needed with a, hopefully, wide consensus to be achieved. There will be positives and negatives to a restructuring exercise but a credible and effective way to classify the deep sea is necessary.

References

Connor D, Gilliland P, Golding N, Robinson P, Todd D, and Verling E (2006) UKSeaMap: The Mapping of Seabed and Water Column Features of UK Seas. 1-104. 1-1-2006

Connor D, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, and Reker J (2004) The Marine Habitat Classification for Britain and Ireland. Version 04.05, Volume 1. Littoral Rock Section. 1-1-2004

Connor D, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, and Reker J (2004) The Marine Habitat Classification for Britain and Ireland. Version 04.05, Volume 2. Sublittoral Sediment Section. 1-1-2004

Connor DW, Dalkin MJ, Hill TO, Holt RHF, and Sanderson WG (1997) Marine Nature Conservation Review: Marine Biotope Classification for Britain and Ireland. Vol. 1. Sublittoral Biotopes. Connor, D. 230 (Version 97.06), 1-448. 1-1-1997

Connor DW, Dalkin MJ, Hill TO, Holt RHF, and Sanderson WG (1997) Marine Nature Conservation Review: Marine Biotope Classification for Britain and Ireland. Vol. 2. Sublittoral Biotopes. Connor, D. 230 (Version 97.06), 1-448. 1-1-1997

Dinter W P (2001) Biogeography of the OSPAR Maritime Area. Ed. Federal Agency for Nature Conservation. Bonn, Germany: Bundesamt fur Naturschutz: 1-167

Howell, K. L., Davies, J. S., and Narayanaswamy, B. E. (2010) Identifying deep-sea megafaunal epibenthic assemblages for use in habitat mapping and marine protected area network design. Journal of the Marine Biological Association of the United Kingdom 90: 33-68

Howell KL (2010) A benthic classification system to aid in the implementation of marine protected area networks in the deep/high seas of the NE Atlantic. Biological Conservation 143: 1041-56

Coastal and Marine Ecological Classification Standard (CMECS) Version 4.0: US Framework

Kathleen L. Goodin[1*], Rebecca J. Allee[2], Giancarlo Cicchetti[3], Mark A. Finkbeiner[2], Lawrence R. Handley[5], Christopher J. Madden[1], Garry F. Mayer[4], Emily Schumchenia[6]

Abstract

The Coastal and Marine Ecological Classification Standard (CMECS) is the United States federal standard for classifying ecological units in coastal and marine systems. It is intended to facilitate the study, monitoring, protection, restoration and management of habitats supporting commercially- and recreationally-important species, vital habitats for protected species, unique biotic assemblages, and key ecosystem features. CMECS was designed as a comprehensive ecological classification, was built on existing classifications, can be easily compatible with mapping, and allows for dynamic content. It is the product of development, testing and validation by experts from multiple federal and state agencies, academia and non-governmental organizations. It is designed for use in North American marine, estuarine, and Great Lakes ecosystems, but the framework is applicable world-wide.

CMECS characterizes marine and coastal environments in terms of two settings and four components (Table 1). Settings offer alternate but complementary approaches for partitioning the marine and coastal world. Components provide specific tools for describing observation (sampling) sites. Settings are applicable to all components.

CMECS provides two broad based, complementary settings within which to partition the coastal and marine world—the Biogeographic Setting (BS) and the Aquatic Setting (AS). These may be used independently or together. The BS identifies ecological units based on species aggregations and features influencing the distribution of organisms. Coastal and marine waters are organized into regional hierarchies composed of realms

Table 1. CMECS Framework.

Biogeographic Setting	Aquatic Setting	Water Column Component	Geoform Component	Substrate Component	Biotic Component
Realm Province Ecoregion	System Subsystem Tidal Zone	**Layer Subcomponent**	**Tectonic Setting Subcomponent**	Substrate Origin Substrate Class Substrate Subclass Substrate Group Substrate Subgroup	Biotic Setting Biotic Class Biotic Subclass Biotic Group Biotic Community
		Salinity Subcomponent	**Physiographic Setting Subcomponent**		
		Temperature Subcomponent	**Level 1 Geoform Subcomponent** Geoform Origin Level 1 Geoform Level 1 Geoform Type		
		Hydroform Subcomponent Hydroform Subform Hydroform Type	**Level 2 Geoform Subcomponent** Geoform Origin Level 2 Geoform Level 2 Geoform Type		
		Biogeochemical Feature Subcomponent			
Biotope					

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(largest), provinces and ecoregions (smallest). CMECS adopts the approach described by Spalding *et al*. (2007) in Marine Ecosystems of the World (MEOW) to characterize Biogeographic Settings occurring in the Estuarine System and in the Marine Nearshore and Marine Offshore Subsystems. MEOW is worldwide in coverage and identifies five realms, eight provinces, and 24 ecoregions in U.S. waters. Representative units include the Gulf of Maine/Bay of Fundy, Carolinian, and Southern California Bight ecoregions. Biogeographic Settings for the CMECS Oceanic Subsystem are defined in the Global Open Ocean and Deep Seabed (GOODS) Biogeographic Classification (UNESCO 2009). As in MEOW, hierarchies composed of regions, provinces, and ecoregions are identified, but separate suites of terms are applied to benthic and water column habitats.

The Aquatic Setting divides the coastal and marine environment into three Systems: marine, estuarine, and lacustrine. These conform to those described in the Classification of Wetlands and Deepwater Habitats in the United States (FGDC 1996). Secondary and tertiary layers of the Aquatic Setting describe Subsystems (e.g., nearshore, offshore, and oceanic) and Tidal Zones (subtidal, intertidal, and supratidal).

CMECS is organized into four components to record and define the attributes of environmental units and biota within each setting--the Water Column Component (WC), the Geoform Component (GC), the Substrate Component (SC), and the Biotic Component (BC). Each component is a stand-alone construct that can be used on its own or in combination with other components or settings. CMECS components include a variety of modifiers to enhance the specificity and detail of resulting descriptions and classifications. Units within the BC and SC are organized into traditional hierarchical frameworks; however, this is not the case for the WC and the GC. Units within each of the latter overlap significantly in nature and do not lend themselves to hierarchies. CMECS organizes the WC and GC into subcomponents that may be used on their own or in combination.

The WC represents a new approach to the ecological classification of open water settings. The component describes the water column in terms of five subcomponents: vertical layering, water temperature, salinity, hydroforms, and biogeochemical features. Vertical layers, temperature and salinity can be combined to create unique descriptors of water column strata. Example strata include “cold euhaline marine nearshore surface layer” and “warm oligohaline estuarine coastal upper water column. Example hydroforms include longshore current, hydrothermal plume, and coastally trapped wave. Example Biogeochemical Features include neustonic layer, and benthic boundary layer.

The GC describes the major geomorphic and structural characteristics of the coast and seafloor. This component is divided into four subcomponents that describe tectonic and physiographic settings and two levels of geoform elements that include geological, biogenic, and anthropogenic geoform features. Representative units include lagoon, ledge, atoll, harbor.

The SC describes the composition and size of estuary bottom and sea bed materials in all CMECS systems. This component is hierarchical and encompasses substrates of geologic, biogenic, and anthropogenic origin. Particle size classes conform to those developed by Wentworth (1922) and substrate mixes suggested by Folk (1954). Representative units include sandy mud, coral sand, and construction rubble.

The BC is a hierarchical classification that identifies (a) the composition of floating and suspended biota and (b) the biological composition of coastal and marine benthos. Representative units include cyanophyte aggregation, massive coral reef, clam bed, filamentous algal bed and soft sediment hydroids, and seagrass bed.

A biotope is defined as the combination of abiotic features and associated species (Connor *et al*., 2003). Using CMECS, biotopes can be derived by identifying repeating BC biotic communities that are consistently associated with combinations of environmental units from any of the other CMECS settings or components. While individual biotope units have not been defined yet for the United States, users can begin to define and describe biotopes as they apply CMECS. As knowledge of biotopes increases, biotope units and descriptions will be added to CMECS.

CMECS incorporates a list of standard modifiers—a consistent set of characteristics and definitions— as part of each component to describe the nature and extent of observed variability within ecological units. Modifiers allow users to customize the application of the classification in a standardized manner.

The Coastal and Marine Ecological Classification Standard (CMECS), Version 4.0, is a catalog of terms that provides a means for classifying ecological units using a simple, standard format and common. CMECS offers a way to organize and interpret data about the marine environment, and it provides a common platform for inter-relating data. It builds upon approaches from published international, national, regional, and local habitat classification procedures, and it offers an umbrella under which a U.S. national coastal and marine ecological classification can grow and evolve.

References

Connor, DW, Allen, JH, Golding, N, Lieberknecht, LM, Northen, KO, and Reker, JB. 2003. “Introductory Text.” In The National Marine Habitat Classification for Britain and Ireland. Version 03.02. Peterborough, UK: Joint Nature Conservation Committee.

FGDC (Federal Geographic Data Committee). 1996. FGDC- STD-004. *Classification of Wetlands and Deepwater Habitats of the United States*. Reston, VA: Federal Geographic Data Committee.

Folk, RL, 1954. “The Distinction between Grain Size and Mineral Composition in Sedimentary-Rock Nomenclature.” *The Journal of Geology* 62: 344-359.

Spalding, MD., Fox, HE Allen, GR, Davidson, N, Ferdana, ZA, Finlayson, M Halpern, BS. 2007. “Marine Ecoregions of the World: A Bioregionalization of Coastal and Shelf Areas.” BioScience 57 (7): 573–583.

UNESCO (United Nations Educational, Scientific and Cultural Organization). 2009. *Global Open Ocean and Deep Seabed (GOODS)-Biogeographic Classification*. UNESCO Intergovernmental Oceanographic Commission. IOC Technical Series No. 84.

Wentworth, C K. 1922. “A Scale of Grade and Class Terms for Clastic Sediments.” *The Journal of Geology* 30: 377–392.

The Coastal and Marine Ecological Classification Standard (CMECS): science and marine spatial planning

Emily Shumchenia[1]

Abstract

Since 2000, the U.S. National Oceanic and Atmospheric Administration (NOAA) has supported the development of a Coastal and Marine Ecological Classification Standard (CMECS). The purpose of CMECS is to document and describe ecologically meaningful units using a "common language" for national resource management, science and conservation (Allee *et al*., 2012). The overall goal of CMECS is "to facilitate assessment, monitoring, protection, restoration, and management of biotic assemblages, harvested and protected species, vital habitats, and important ecosystem components." (Allee *et al*., 2012). CMECS is currently in its 4th version and through a rigorous peer review and editing process, it has become more sensitive to ecological patterns, adaptable to dynamic coastal ecosystems, and more amenable to mapping. At the broadest scales, CMECS uses Biogeographic Setting and Aquatic Setting units to describe marine ecosystems. Within these settings are four components – the Water Column, Geoform, Substrate and Biotic Components. Each component is a stand-alone construct, but only the Substrate and Biotic Components are hierarchical in specificity. The Water Column and Geoform Components consist of sub-components that overlap significantly in spatial and temporal dimensions. The abiotic and biotic information from these components combines to define the characteristics of biotopes at the finest scales. The development of biotopes in CMECS is just beginning and will progress as utilization of the standard increases. Overall, the CMECS structure encourages the incorporation of interdisciplinary data, without requirements related to gear type or frequency of observations. At the University of Rhode Island (USA), CMECS is being used as the classification standard for two types of benthic mapping studies.

In Narragansett Bay, Rhode Island, CMECS is being used to classify seabed habitats as defined by their abiotic and biotic characteristics (Shumchenia & King, 2010). Acoustic classes, sediment and macrofauna samples, and sediment profile images were used to examine the relationships between biological and physical properties of the benthic environment. Physical properties were mapped in a full-coverage continuous gradient framework. A bottom-up methodology was used to integrate abiotic and biotic information in order to generate statistically significant habitat classes using the BEST tool in PRIMER-E software. These classes were then categorized using CMECS unit thresholds in each relevant component (Geoform, Substrate and Biotic Components).

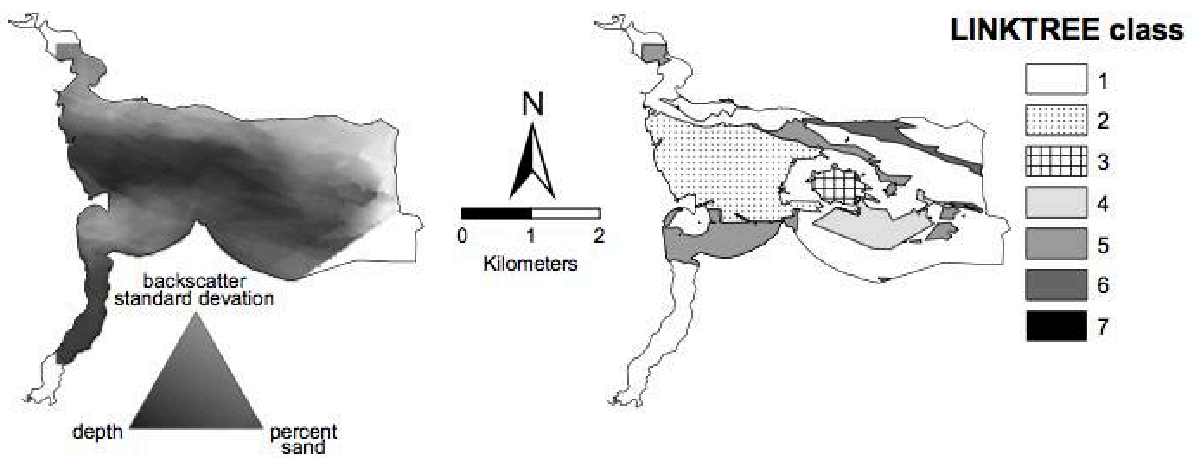

Figure 1. Gradient map of abiotic properties in a sub-embayment of Narragansett Bay, Rhode Island (USA) and a classification of the abiotic-biotic habitat units generated by a multivariate BEST procedure (Shumchenia and King, 2010).

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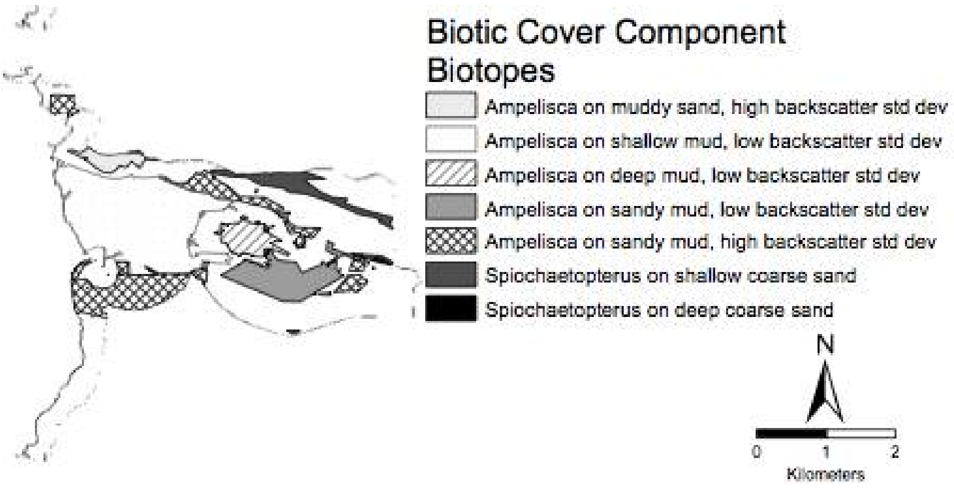

Figure 2. The CMECS biotopes classified from the abiotic-biotic habitat units generated by a multivariate BEST procedure for a sub-embayment of Narragansett Bay, Rhode Island (USA) (Shumchenia & King, 2010).

This bottom-up method generated significant habitat classes based on macrofauna abundance, percent sand, water depth, and backscatter standard deviation (Figure 1; Shumchenia & King, 2010). The strict abiotic habitat criteria generated from the BEST procedure populated about 47% of the study area with biotic predictions. These biotic habitats were ultimately classified into CMECS Biotopes (Figure 2; Shumchenia & King, 2010). The CMECS format allowed abiotic-biotic linkages to be preserved and documented at the biotope level. Further up in the component structure, abiotic and biotic CMECS units are kept separate and unless multiple components are overlaid, only abiotic or biotic maps can be produced.

In Rhode Island Sound, we are using CMECS to characterize marine landscapes in order to support ecosystem valuation, assessment, and marine spatial planning activities related to renewable energy development. By using CMECS as the guiding framework for these applications, an ecosystem-based approach is encouraged. The interdisciplinary raw data layers (e.g., grain size, annual mean sea surface temperature) and many of the second-order interpreted data (e.g., rugosity, stratification index) have been classified within CMECS. Raw data have been placed within the Component structure, and second-order interpreted data are classified as modifier layers. These layers were used to build models such as the Kostylev habitat template (Figure 3), which give another level of ecological meaning to the classified data. The current structure of CMECS enhances these uses and interpretations and even lends itself to an assessment framework. Several of the CMECS modifiers can be used to address assessment questions (e.g., community successional stage, productivity, anthropogenic impact) and it is our goal to utilize these metrics to characterize the baseline conditions of the Rhode Island Sound ecosystem prior to new human use or development. Additionally, ecological valuation exercises will soon be conducted using landscape metrics such as patch size, diversity and connectivity on marine landscapes that were defined using CMECS Geoform and Water Column Components. These metrics will then be used to compare with spatial patterns in biodiversity of marine mammals, birds, and commercially and ecologically important fish and invertebrate species in order to rank the ecological value of various abiotic habitat units.

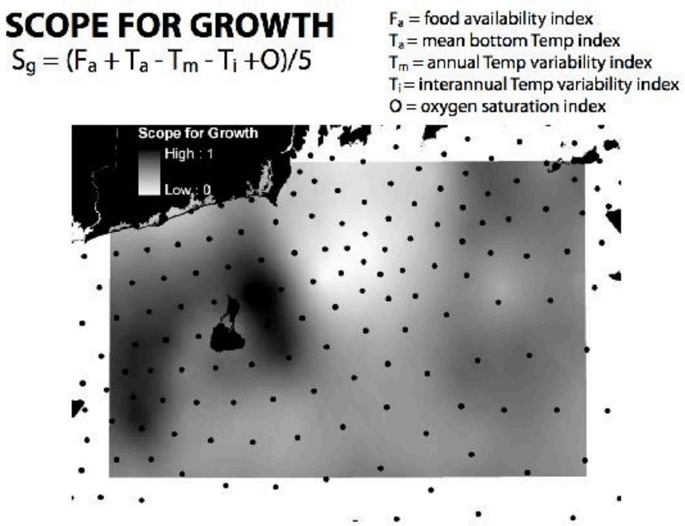

Figure 3. A Scope for Growth map generated from abiotic and biotic data in Rhode Island offshore waters (USA).

The spatial-temporal framework of CMECS (Figure 4) was used to develop guidance for impact assessment and monitoring of renewable energy developments. First, the likely spatial and temporal extent of the impact was identified (Wilhelmsson *et al*., 2010). Second, a rough sampling frequency was determined based on the temporal scale of the impact. The sampling frequency timeline was overlaid with the spatial-temporal CMECS framework in order to determine which relevant CMECS components could inform data collection. Next, we matched the units within CMECS

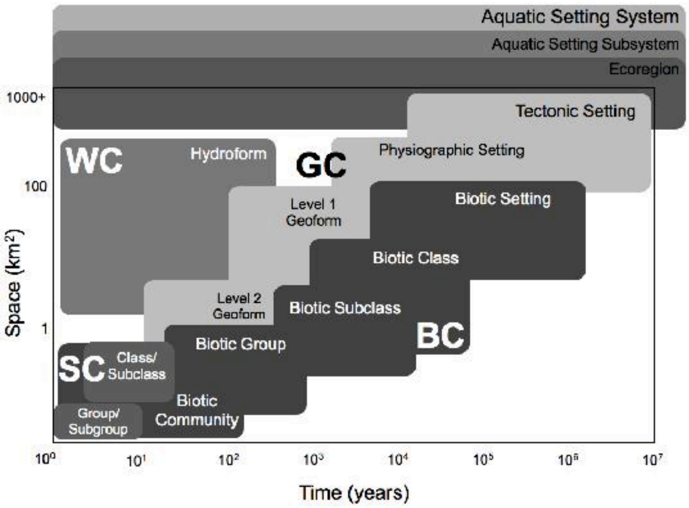

Figure 4. CMECS components in a spatial-temporal framework. Bounding boxes for units are clipped spatially and temporally (on the bottom left) to avoid overlap and confusion between units (Allee *et al*., 2012).

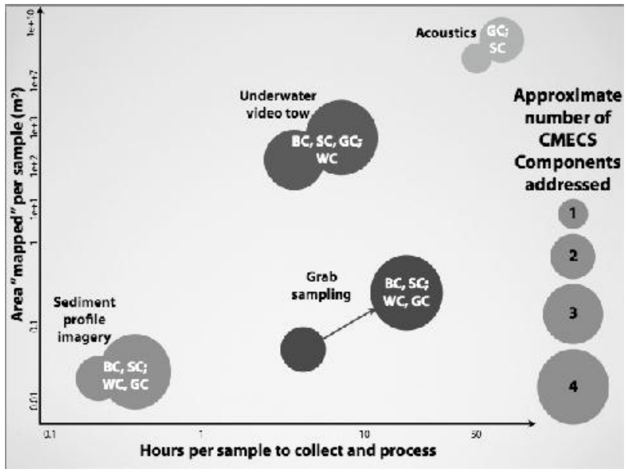

Figure 5. Level of sampling effort required for populating CMECS components using common seafloor sampling tools. BC = Biotic Component, SC = Substrate Component, GC = Geoform Component, WC = Water Column Component.

components to a range of common seafloor sampling tools (e.g., grab sampler, underwater video), and determined the level of effort (area sampled per unit time) required to collect and interpret data from these tools (Figure 5). Level of effort for each tool was plotted with an estimate of the CMECS information that could be derived from each of the tools. From these plots we determined which sampling tools should be used and at what frequency sampling should occur in order to adequately address the spatial and temporal extent of an impact. Several monitoring scenarios were generated for a suite of anticipated impacts to the benthic environment at “high” and “low” levels of funding. This information is currently being synthesized into a decision-tree framework to aid managers and regulators in developing appropriate monitoring protocols for a range of offshore renewable energy impacts.

Consistency in nomenclature is particularly important for describing reference states and ecosystem change. The production of final products, maps, and models can be delayed, or even made impossible, if data is not in an interpretable format. A unified classification scheme can focus data collection and streamline interpretation and integration. CMECS is particularly suited to environmental assessments because of the explicit acknowledgement of ecological features’ spatial extent, temporal persistence, and relationships with other natural and anthropogenic features. Because CMECS can also aid in structuring hypothesis-driven science, we plan to utilize it as the classification standard for abiotic-biotic habitat studies throughout Rhode Island waters.

References

Allee, R.J., Cicchetti, G., Finkbeiner, M., Goodin, K., Handley, L.R., Madden, C.J., Mayer, G.F., Shumchenia, E.J., Soule, J. (eds.) 2012. Coastal and Marine Ecological Classification Standard. NOAA and NatureServe. 339 pp.

Shumchenia, E.J., King, J.W., 2010. Comparison of methods for integrating biological and physical data for marine habitat mapping and classification. Continental Shelf Research. 30, 1717-1729.

Wilhelmsson, D., Malm, T., Thompson, R., Tchou, J., Sarantakos, G., McCormick, N., Luitjens, S., Gullstrom, M., Patterson Edwards, J.K., Amir, O., Dubi, A., 2010. Greening blue energy: Identifying and managing the biodiversity risks and opportunities of offshore renewable energy. Gland, Switzerland, p. 102.

Goods, Services and Sensitivity of European Marine Biotopes: building on the EUNIS database with a view to facilitating Marine Spatial Management

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Abstract

The first two authors coordinated this work; the names of all other contributors appear in alphabetical order

Although many steps have been taken towards the protection of European ecosystems through European, National and International legislation and agreements, there is still a need of further measures to ensure conservation. This is especially true for marine ecosystems, for which difficulties such as inaccessibility and inherent biological complexity have resulted in significant knowledge and management gaps (Fraschetti *et al*., 2011; Brown *et al*., 2011). Moreover, much of the existing conservation efforts for the marine environment have addressed either too small scales (e.g. Marine Protected Areas) or too broad objectives (e.g. the European Habitats Directive 92/43/EEC).

Facing the increasing human pressure and the consequent degradation of the world's oceans, Ecosystem Based Marine Spatial Management (EB-MSM) is an emerging comprehensive approach which calls for an integrated management of all interactions within and across ecosystems (human uses and conflicts included) with the goal of maintaining ecosystem components and their related goods and services in a resilient and sustainable condition (Douvere, 2008; Katsanevakis *et al*., 2011). In this light, understanding and assessing the relative value and vulnerability of seabed biotopes is an important first step towards an effective implementation of EB-MSM. Although much such information exists, so far it has been scattered throughout the scientific literature. Within the frames of the EU FP7 program "Monitoring and Evaluation of Spatially Managed Areas" (MESMA), we reviewed 56 European biotopes and compiled the existing information on the goods and services they provide (sensu Beaumont *et al*., 2007), as well as their sensitivity to major human activities.

All benthic biotopes considered in this review were identified and classified according to the European Nature Information System (EUNIS, 2002). Although several other regional classification systems do exist (see for example Fraschetti *et al*., 2011 and references therein), often allowing for even more refined approaches, the EUNIS strong point lies in that it provides a comprehensive hierarchical pan-European framework, which facilitates the collection of data across Europe. The EUNIS database (http://eunis.eea.europa.eu) comprises, amongst others, a large variety of ecosystem units (from natural to artificial, from terrestrial to freshwater and marine, from coastal to deep waters, etc.) and their associated biotic and abiotic features. In this review, only sublittoral, fully marine EUNIS biotopes at level-4 and beyond (EUNIS, 2002) were considered.

Evaluation of the selected marine biotopes, based on the relevant literature and expert judgment, yielded a stunning 91% being assessed as highly important in providing at least one of the following goods and services: food; raw materials; air quality and climate regulation; disturbance and natural hazard prevention; water quality regulation and bioremediation of waste; cognitive benefits; leisure recreation and cultural inspiration; feel good or warm glow; photosynthesis, chemosynthesis and primary production; nutrient cycling; reproduction and nursery areas; and maintenance of biodiversity. Destructive fishing (particularly trawling) and marine pollution were recognized as the main threats affecting most European seabed biotopes, while increased seawater turbidity, mining and aggregate extraction, coastal constructions, biological invasions, shipping-related activities, tourism, hydrocarbon

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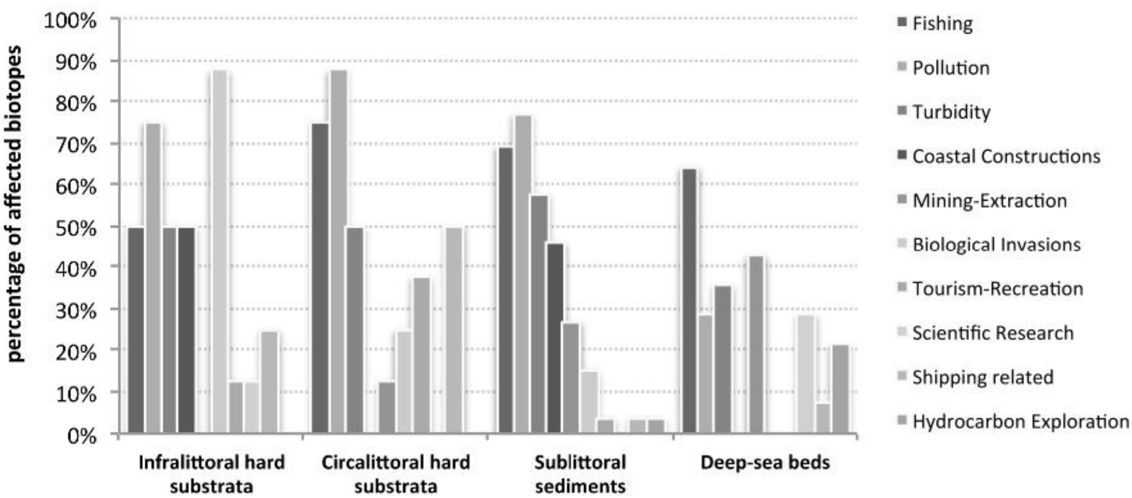

Figure 1. Main human impacts and percentage of affected marine biotopes, grouped in EUNIS level-2 ecological zones.

exploitation, and even some practices of scientific research were also noted to exert substantial pressure (Figure 1). The EUNIS database proved to be a handful tool for identifying and assessing natural ecosystem components, providing a well-defined and adequately fine-scaled classification framework.

As much of our knowledge about marine resources and benefits remains yet unrevealed (even more so in mesophotic and deep water biotopes), this review cannot be considered conclusive. However, we suggest that the hereby presented assignment of evaluation classes to biophysical features of the marine environment can contribute significantly to shaping priorities, assessing management choices and applying marine spatial plans in the European Regional Seas.

Acknowledgements

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References

Beaumont NJ, Austen MC, Atkins JP, Burdon D, Degraer S, Dentinho TP, Derous S, Holm P, Horton T, van Ierland E, Marboe AH, Starkey DJ, Townsend M, Zarzycki T (2007) Identification, definition and quantification of goods and services provided by marine biodiversity: Implications for the ecosystem approach. Mar Poll Bull 54 (3): 253-265

Brown CJ, Smith SJ, Lawton P, Anderson JT (2011) Benthic habitat mapping: A review of progress towards improved understanding of the spatial ecology of the seafloor using acoustic techniques. Estuar Coast Shelf S 92 (3): 502-520

Douvere F (2008) The importance of marine spatial planning in advancing ecosystem-based sea use management. Mar Policy 32:762– 771

EUNIS (2002) EUNIS Habitat Classification. European Environment Agency http://eunis.eea.eu.int

Fraschetti S, Guarnieri G, Bevilacqua S, Terlizzi A, Claudet J, Russo GF, Boero F (2011) Conservation of Mediterranean habitats and biodiversity countdowns: what information do we really need? *Aquatic Conservation*: Mar Freshw Ecosyst 21: 299-306

Katsanevakis S, Stelzenmüller V, South A, Sørensen TK, Jones PJS, Kerr S, Badalamenti F, Anagnostou C, Breen P, Chust G, D'Anna G, Duijn M, Filatova T, Fiorentino F, Hulsman H, Johnson K, Karageorgis AP, Kroencke I, Mirto S, Pipitone C, Portelli S, Qiu W, Reiss H, Sakellariou D, Salomidi M, van Hoof L, Vassilopoulou V, Vega Fernández T, Vöge S, Weber A, Zenetos A, ter Hofstede R (2011) Ecosystem-based marine spatial management: review of concepts, policies, tools, and critical issues. Ocean Coast Manage 54: 807-820

EUNIS Compatible Classification of Baltic Sea Biotopes

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Abstract

The HELCOM RED LIST BIOTOPES project aims at completing a biologically meaningful, EUNIS compatible, Baltic Sea wide classification of Baltic Sea habitats and biotopes by the end of the year 2012. This classification will comprise of two elements- the classification system itself and the accompanying biotope descriptions – both to be published in the Baltic Marine Environment Proceedings series on the HELCOM website.

Due to very particular features driving the biological patterns across the Baltic Sea (such as the lack of tidal zones, the strong salinity gradient, ice scraping, differences in hydrography etc.) the biotope classification of the Atlantic EUNIS could not adequately cover the biotopes found in the Baltic, so a separate but compatible classification system was needed. The first Baltic Sea biotope classification commonly agreed upon was the HELCOM Red List of marine and coastal biotopes and biotope complexes of the Baltic Sea, Belt and Kattegat (HELCOM 1998). This provided a classification and descriptions of Baltic Sea biotopes defined mainly by abiotic factors. More recently, it has been possible to further develop this classification into a EUNIS-compatible classification down to level four within the EUSeaMap project (2009-2010). As a basis of the classification proposal, the Baltic Sea part of EUSeaMap utilized both new data on species and biotopes and new sub-regional classification proposals, not available at the time of the original 1998 Baltic Sea classification.

However, it has been acknowledged that a weakness of the Baltic Sea EUNIS classification (sensu EUSeaMap) is that it contains only little biotic information and that its coverage is insufficient. At the same time, several recent national and international projects in Baltic Sea countries have produced more detailed, biology-driven habitat classifications for sub-regional areas of the Baltic Sea. The need for a Baltic Sea wide classification with more detailed biological components became apparent when the previous Red List of habitats and biotopes needed updating. The HELCOM countries agreed that community level, and in some cases dominant species, of the Baltic Sea EUNIS classification are the most appropriate for the Red List assessment of Baltic Sea biotopes (example down to the community, at level 5, can be found in table 1). This level of detail also serves conservation, management, maritime spatial planning and threat assessment purposes.

The project set by HELCOM to produce the EUNIS compatible classification utilized a two-fold strategy to quickly and reliably achieve the needed results. To allow their effective and transparent participation, a group of national experts from each Baltic Sea country was tasked to gather all the available raw data on species occurrence, coverage (phytobenthos) and biomass (zoobenthos) as well as the coordinates and type of the sample. The bulk of the work (data sorting and analysis, biotope descriptions) was then carried out by expert commercial consultants. The raw data was analyzed according to procedures previously used in the EUSeaMap project (Wikström *et al*. 2010), using the hierarchical classification system BalMar as well as multivariate analyses. The samples where then clustered and the available level 5 biotopes were sorted out based on community and used as base when arranging the classification system (Table 1). The actual designation and grouping of biotopes was then done collectively at three expert workshops by national experts on management, phyto- and zoobenthos.

In theory, the different methods used in gathering the national datasets for the BalMar analyzes do not affect the results, because BalMar classifies each sample separately. However, the results of phytobenthos sample classification are different when the amounts are determined using *visual volume* or biomass (Kiirikki *et al*. 1998). This can be caused by the different densities of species and the human factor affecting all estimations. On the other hand, coverage estimates are generally made from an area of 1-6 m^2, while biomass samples are collected from a much smaller area, typically 0.04 m^2. Although this biology driven method has many strong points, it can alienate the Baltic Sea classification from the current Atlantic EUNIS. Furthermore, the use of dominant species as the defining characteristic may result in omitting of rare biotopes simply because they are very rare in the data. Therefore the analyses should be done with care, taking into consideration the need to have rare biotopes (potential candidates for the biotope red list) represented in the final draft classification system and the need for a simple system, utilizable for management and mapping purposes. Ultimately, all of the Baltic seabed should be mapped and classified according to this commonly agreed EUNIS compatible classification system, and at the level of detail needed for management.

At this point in the process the most saline and diverse parts of the Baltic Sea have been given less attention than they deserve due to the lack of expertise from the areas in question. However, it is well acknowledged that the entrance area to the Baltic Sea is

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crucial for delineating the ecologically relevant border between the area where the North Atlantic EUNIS should be applied and where the Baltic Sea EUNIS should be applied.

At the time of the publication of this abstract the work with the Baltic Sea classification system is still on going and changes to the classification may still occur. However, by the end of 2012, when the finalized classification system and the biotope descriptions are made available, it will greatly facilitate the harmonized and coordinated implementation of the Marine Strategy Framework Directive as far as it concerns the habitats/biotopes of the Baltic Sea. In addition, the EU is increasingly laying out measures related to maritime spatial planning, such as the European Commission's roadmap for maritime spatial planning under the EU Maritime Policy. The aim of this work is that it will be widely used by marine environment authorities of the Baltic Sea countries as well as those implementing the HELCOM Baltic Sea Action Plan, EU Strategy for the Baltic Sea Region, Marine Strategy Framework Directive, and those responsible for maritime spatial planning and all the underlying mapping and monitoring efforts. In order to achieve this, a simple and easily understandable system is crucial.

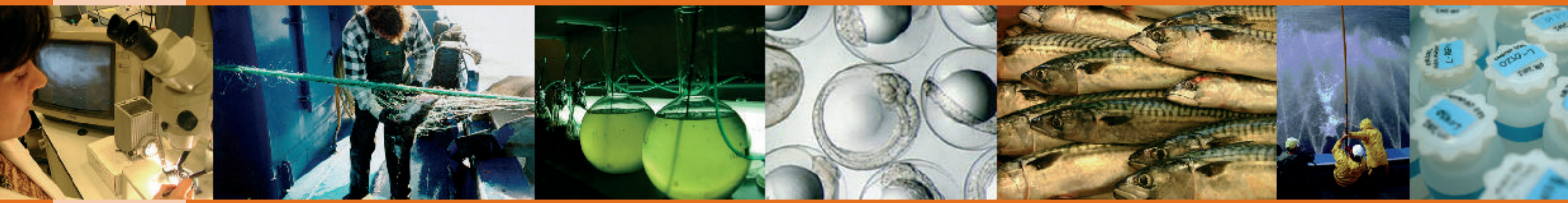
References

Kiirikki M, Haapamäki J, Koponen J, Ruuskanen A, & Sarkkula J 1998: Linking the growth of filamentous algae to the 3D-Ecohydrodynamic model of the Gulf of Finland. Environmental Modelling & Software, 13, 503-509.

Wikström S, Daunys D, and Leinikki J 2010: A proposed biotope classification system for the Baltic Sea. AquaBiota Report 2010:06. ISBN: 978-91-85975-11-2. Electronic document is downloadable at: www.aquabiota.se.

Table 1. EUNIS compatible classification system of the Baltic Sea down to level 5 (biotopes: communities) as suggested by the HELCOM RED LIST BIOTOPES project.

Level 1 Marine area	**Level 2 Vertical zones**	**Level 3 Vegetation**	**Level 4 Substrate**	**Level 5 Community**
Baltic	Photic	Vegetated	Rock and boulders	dominated by annual algae dominated by perennial algae or moss with sparse phytobenthic communities
			Till	dominated by annual algae dominated by perennial algae or moss dominated by perennial algae/moss and rooted plants dominated by stable unattached plants dominated by helophytes dominated by submerged rooted plants with sparse phytobenthic communities
			Coarse sediment	dominated by helophytes dominated by submerged rooted plants dominated by stable unattached perennial algae
			Sand	dominated by helophytes dominated by submerged rooted plants dominated by stable unattached perennial algae
			Muddy sediment	dominated by helophytes dominated by submerged rooted plants dominated by stable unattached perennial algae
Baltic	Photic	Non- vegetated	Rock and boulders	dominated by attached epibenthic fauna dominated by mobile epibenthic fauna
			Till	dominated by attached epibenthic fauna dominated by mobile epibenthic fauna
			Hard clay	dominated by attached epibenthic fauna dominated by mobile epibenthic fauna
			Coarse sediment Sand	with sparse fauna dominated by infauna dominated by unattached epibenthic fauna
			Muddy sediment	dominated by infauna dominated by epibenthic fauna with sparse fauna
			Concretion bottoms Peat bottoms Shell gravel	with sparse fauna with sparse fauna dominated by fauna
Baltic	Aphotic	Non- vegetated	Rock and boulders	dominated by attached epibenthic fauna dominated by mobile epibenthic fauna with sparse fauna
			Till	dominated by attached epibenthic fauna dominated by mobile epibenthic fauna with sparse fauna
			Hard clay	dominated by attached epibenthic fauna dominated by mobile epibenthic fauna with sparse fauna
			Coarse sediment Sand	with sparse epibenthic fauna dominated by infauna dominated by unattached epibenthic fauna with sparse fauna
			Muddy sediment	dominated by infauna dominated by epibenthic fauna with sparse fauna without permanent fauna; more or less permanently anoxic
			Concretion bottoms Shell gravel	with sparse fauna dominated by fauna



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