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Using the EUNIS habitat classification system in broadscale regional mapping: some problems and potential solutions from case studies in the English Channel.

Roger Coggan, Ceri James, Bryony Pearce and Jennifer Plim

Abstract
The EUNIS habitat classification system provides a standard for recording European marine habitats and biotopes. Its hierarchical structure introduces physical, environmental and biological parameters at different levels, making it attractive for use in broadscale predictive mapping. We have developed a modelled EUNIS map for an area of 12,755 sq km in the eastern English Channel, but in doing so met two difficulties which stem from the structure of the EUNIS classification system. Firstly, it includes only two major substrate classes, 'rock' and 'sediment', so provides no solution for areas where rock is covered by a thin (<1.0 m) sediment layer. Geophysical surveys indicate such areas as rock but grab surveys show them as sediment, and the communities they support can be distinct from those in pure rock or sediment habitats. Secondly, there is an inconsistency in the level at which EUNIS introduces biological zones into the hierarchy. For rock habitats the littoral, infralittoral and circalittoral zones are introduced at EUNIS level 2, but the deep circalittoral is only introduced at level 4. For sediment habitats, level 2 only differentiates littoral from sublittoral; the infralittoral, circalittoral and deep circalittoral zones are all introduced at level 4. As a result, broadscale maps classified at EUNIS levels 2 or 3 are internally inconsistent, showing some but not all sublittoral zonation for rock habitats and no sublittoral zonation for sediment habitats. This can be greatly misleading to the end-user of the maps. Our case study offers solutions to these problems by making some modifications to the EUNIS system, introducing a new substrate class of 'rock and thin sediment' and allowing biological zones to be represented more equitably.

Keywords: biological zone, thin sediment, habitat mapping, English Channel

Roger Coggan, Cefas, Pakefield Road, Lowestoft NR33 7PB, UK.
Tel: +44 (0)1502-524532. Fax: +44 (0)1502-513865. email: roger.coggan@cefas.co.uk.

Ceri James, British Geological Survey, Nicker Hill, Keyworth, Nottingham NG12 5GG, UK
Tel: +44 (0)1159-363467. Fax: +44 (0)1159-363437. email: jwcj@bgs.ac.uk

Bryony Pearce, Marine Ecological Surveys Ltd, 24a Monmouth Place, Bath, BA1 2AY, UK
Tel: +44 (0)1225-442211. Fax: +44 (0)1225-444411. email: bryony@seasurveys.co.uk

Jennifer Plim, British Geological Survey, Nicker Hill, Keyworth, Nottingham NG12 5GG, UK
Tel: +44 (0)1159-363473. Fax: +44 (0)1159-363437. email: jenn@bgs.ac.uk

Introduction

A common system of classifying habitats has been developed within Europe by the European Nature Information Service (EUNIS) with a view to promoting harmonisation and interoperability of both terrestrial and marine habitat studies among EU member states; a desirable position which will support the development of common policy objectives and management plans. The marine section of the EUNIS classification system (Davies & Moss, 2000, 2004) has adopted and further developed the British classification system developed over the ten year period of the Marine Nature Conservation Review (MNCR) undertaken in the 1980/90s (Connor et al, 2004). The EUNIS system is now widely applied in marine habitat mapping projects across Europe. National projects include the UKSeaMap, the Irish INFOMAR project and the French REBENT programme while international work within Europe includes the MESH and MeshAtlantic projects, the BALANCE project in the Baltic and the EUSeaMap project (for further information see also the annual reports of the ICES Working Group on Marine Habitat Mapping, WG-MHM).

The EUNIS classification system is hierarchical in that different physical characteristics of the environment that are important in charcaterising marine habitats are introduced at different levels in the hierarchy. In theory this is attractive to those constructing broadscale habitat maps as the widespread availability of observational or modelled physical environmental data allows a predictive habitat map to be built simply by overlaying the relevant physical layers in a GIS according to the sequence in which they appear in the classification hierarchy. However in practice this has not proved so easy, for reasons that will be explored in this paper.

Over the past eight years we have been engaged in several associated projects mapping the seabed habitats in the central and eastern English Channel (Coggan & Diesing, 2011, Coggan et al., 2009, Diesing et al, 2009, James et al, 2007, 2008, 2010, 2011). The methodology followed has been similar across projects, firstly using acoustic and seismic, geophysical survey methods and/or digital terrain models to develop base-maps of seabed features and characteristics, and secondly analysing ground-truth samples collected by grabs, trawls and seabed imagery (video and still images) to assign point locations to a EUNIS habitat/biotope class. These two sets of information were then brought together in an integrated analysis, using expert judgement to produce a full coverage map of the area classified according to the EUNIS scheme.

During the course of this work we have met with two significant difficulties which arise because of the current structure of the EUNIS system. The first stems from the fact that EUNIS recognises only rock or sediment habitats (Table 1), conflicts arise in the integrated analysis when information from remote sensing (acoustic or seismic surveys) indicates the seabed to be of a rocky nature but the ground-truth samples indicate a predominantly sediment habitat. Both observations are correct but there is currently no way of representing this on a map using the present EUNIS system.

The second difficulty arises from the fact that the EUNIS system relies heavily on classic biological zones (Table 2) to discriminate among major habitat/biotope classes, but instead of introducing all the zones at a single level in the hierarchy, some are introduced at level 2 and some at level 4, and this is done differently for rock and sediment habitats. Hence a map produced at EUNIS level 3 can show some, but not all, of the biological zones. A level 3 map will discriminate between the infralittoral and circalittoral zones for the rock habitats but not for the sediment habitats presented on the same map. This internal inconsistency in the map can be considerably misleading to the non-expert observer, yet policy makers continue to request 'EUNIS Level 3' maps to support their management decisions.

The purpose of this paper is to highlight these issues among a wider audience and to present some potential interim solutions, demonstrating how they work through the presentation of a case study based on our work in the English Channel.

Table 1. Extract from the EUNIS hierarchy showing levels 1 to 3 and illustrating the structure used for sublittoral rock and sediment habitats (A3, A4 and A5). The MNCR style code provides a more intuitive abbreviation of the habitat type than the alphanumeric EUNIS code, being derived principally from the capitalised letters in the habitat name

Level	EUNIS Code	EUNIS name	MNCR-style code
1	A	Marine Habitats	
2	A1	Littoral Rock	LR
2	A2	Littoral Sediment	LS
2	A3	Infralittoral Rock	IR
3	A3.1	High energy Infralittoral Rock	IR.HIR
3	A3.2	Moderate energy Infralittoral Rock	IR.MIR
3	A3.3	Low energy Infralittoral Rock	IR.LIR
2	A4	Circalittoral Rock	CR
3	A4.1	High energy Circalittoral Rock	CR.HCR
3	A4.2	Moderate energy Circalittoral Rock	CR.MCR
3	A4.3	Low energy Circalittoral Rock	CR.LCR
2	A5	Sublittoral Sediment	SS
3	A5.1	Sublittoral Coarse sediment	SS.SCo
3	A5.2	Sublittoral Sand	SS.Sa
3	A5.3	Sublittoral Mud	SS.Mu
3	A5.4	Sublittoral Mixed sediment	SS.Mx

Table 2. Definition of biological zones used in this paper.

Biological Zone	**Description**
Littoral	areas exposed at low tide.
Infralittoral	the area below low tide where there is sufficient light to support algal growth (i.e. the permanently submerged part of the photic zone).
Circalittoral	from the bottom of the infralittoral to the maximum depth at which waves disturb the seabed (i.e. the wave-base).
Deep Circalittoral	below the wave-base

Problems and potential solutions relating to substrate classification in EUNIS

The marine section of the EUNIS classification recognises either rock or sediment habitats. Our studies in the English Channel recognise these too, having some areas where bedrock emerges from the seabed and is characterised by sessile attached fauna and others where there are thick sediment deposits of gravel, sand or mixed sediment characterised by interstitial and/or burrowing organisms. However, over a large part of the area bedrock occurs at or near the seabed surface and is covered by a thin layer of sediment. Acoustic and seismic surveys of such areas suggest they should be classified as rock habitats because broad scale geomorphic features consistent with rock bedforms are present. However grab samples at point locations typically return sediments that support infaunal communities, suggesting the area should be classified as a sediment habitat. The conflicting interpretations highlight the issue of scale difference between the two survey methods, the geophysical techniques showing the broadscale structure while the grabs show the finer scale, local detail.

The fact is that the latter can exist within the former, and when intermediate scale observation are made using towed underwater video cameras the truth of the situation becomes clear. Epifauna tend to be more abundant than on pure sediment habitats and are clearly able to attach to solid material just below the sediment surface. In some places there is a patchwork of exposed bedrock among thin mobile sheets of sediment. In others, significant amounts of sediment bank up against low lying rock ridges and scarps, sometimes overtopping them. The total faunal assemblage in the area is different to that in either pure rock or pure sediment habitats. The dilemma in producing a broadscale map is that it is equally incorrect to classify the area as a rock or sediment habitat, but these are the only choices so far available in the EUNIS system. Our interim solution has been to introduce a new substrate class called 'Rock and thin Sediment', abbreviated to 'RthS'.

In order to be able to use this in a EUNIS map, the new substrate class had to be integrated into the existing EUNIS system. We elected to create new classes within the section of the classification that deals with rock habitat, as biological zonation is introduced earlier in the hierarchy for rock habitats than for sediment habitats (see later) and such zonation is an important characteristic of the RthS habitats. Energy/exposure level is also important, and could not have been accommodated if the RthS habitats were encoded among the existing sediment habitats. So, for each existing level 3 class of rock habitat we created an equivalent level 3 habitat for rock and thin sediment; hence 'High energy Infralittoral Rock' (HIR) is now partnered by 'High energy Infralittoral Rock and thin Sediment' (HIRthS) and so on.

To avoid a complete revision to the EUNIS coding, we elected to use vacant alphanumeric codes (i.e. those not already utilised in the current published edition of EUNIS) and to provide consistency across level 2 classes (A3 and A4, and later A4D for deep circalittoral (see later)) we have used consistent suffix codings, such that A3.8 and A4.8 refer to High energy Infralittoral Rock and thin Sediment (HIRthS) and High energy Circalittoral Rock and thin Sediment (HCRthS) respectively while A3.9 and A4.9 refer to Moderate energy Infralittoral Rock and thin Sediment (MIRthS) and Moderate energy Circalittoral Rock and thin Sediment (MCRthS) respectively. Lastly, we adopted the convention that all the EUNIS codes that we create were written in parentheses (brackets) so they can be clearly identified as being ‘unofficial’. Table 3 shows the new codes incorporated into level 3 of the EUNIS hierarchy for rock habitats.

Table 3. Interim development of EUNIS system to incorporate Rock and thin Sediment (RthS) substrate (see text. Subsequent sections of this paper explain the origin of the A4D group for Deep-circalittoral rock).

Level	EUNIS Code	EUNIS name	MNCR-style code
1	A	Marine Habitats	
2	A3	Infralittoral Rock	IR
3	A3.1	High energy Infralittoral Rock	IR.HIR
3	A3.2	Moderate energy Infralittoral Rock	IR.MIR
3	A3.3	Low energy Infralittoral Rock	IR.LIR
3	(A3.8)	High energy Infralittoral Rock and thin Sediment	IR.HIRthS
3	(A3.9)	Moderate energy Infralittoral Rock and thin Sediment	IR.MIRthS
3	(A3.A)	Low energy Infralittoral Rock and thin Sediment	IR.LIRthS
2	A4	Circalittoral Rock	CR
3	A4.1	High energy Circalittoral Rock	CR.HCR
3	A4.2	Moderate energy Circalittoral Rock	CR.MCR
3	A4.3	Low energy Circalittoral Rock	CR.LCR
3	(A4.8)	High energy Circalittoral Rock and thin Sediment	CR.HCRthS
3	(A4.9)	Moderate energy Circalittoral Rock and thin Sediment	CR.MCRthS
3	(A4.A)	Low energy Circalittoral Rock and thin Sediment	CR.LCRthS
2	(A4D)	Deep-circalittoral rock	DR
3	(A4D.1)	High energy Deep-circalittoral Rock	DR.HDR
3	(A4D.2)	Moderate energy Deep-circalittoral Rock	DR.MDR
3	(A4D.3)	Low energy Deep-circalittoral Rock	DR.LDR
3	(A4D.8)	High energy Deep-circalittoral Rock and thin Sediment	DR.HDRthS
3	(A4D.9)	Moderate energy Deep-circalittoral Rock and thin Sediment	DR.HDRthS
3	(A4D.A)	Low energy Deep-circalittoral Rock and thin Sediment	DR.HDRthS

Table 4. Interim development of EUNIS system to incorporate different types of sediment at level 4 in the Rock and thin Sediment (RthS) substrate (see text).

Level	EUNIS Code	EUNIS name	MNCR-style code
3	(A3.8)	High energy Infralittoral Rock and thin Sediment	IR.HIRthS
4	(A3.81)	+ thin Coarse sediment	IR.HIRthS.Cs
4	(A3.82)	+ thin Sandy sediment	IR.HIRthS.Sa
4	(A3.83)	+ thin Muddy sediment	IR.HIRthS.Mu
4	(A3.84)	+ thin Mixed sediment	IR.HIRthS.Mx
3	(A3.9)	Moderate energy Infralittoral Rock and thin Sediment	IR.MIRthS
4	(A3.91)	+ thin Coarse sediment	IR.MIRthS.Cs
4	(A3.92)	+ thin Sandy sediment	IR.MIRthS.Sa
4	(A3.93)	+ thin Muddy sediment	IR.MIRthS.Mu
4	(A3.94)	+ thin Mixed sediment	IR.MIRthS.Mx
3	(A3.A)	Low energy Infralittoral Rock and thin Sediment	IR.LIRthS
4	(A3.A1)	+ thin Coarse sediment	IR.LIRthS.Cs
4	(A3.A2)	+ thin Sandy sediment	IR.LIRthS.Sa
4	(A3.A3)	+ thin Muddy sediment	IR.LIRthS.Mu
4	(A3.A4)	+ thin Mixed sediment	IR.LIRthS.Mx

As the EUNIS system recognises four sediment types, namely coarse, sand, mud and mixed sediment, it was desirable to be able to specify which sediment type was associated with the RthS substrate. Hence level 4 of the hierarchy has been used to introduce the various combinations, as illustrated in Table 4. For example (A3.81) is High energy Infralittoral Rock and thin Coarse sediments (HIRthS.Cs) and (A3.82) is High energy Infralittoral Rock and thin Sandy Sediment - Sand (HIRthS.Sa) and so on.

The new system was successfully applied to the broadscale habitat map for the UK sector of the central and eastern English Channel published by James et al (2011) and is reproduced in the case study below. Combined with a bespoke, logical symbology it allows the map user to see immediately the distinction between pure rock and pure sediment habitats as well as the extensive areas where the two substrates combine to provide a new type of habitat previously not described in the EUNIS classification.

Problems and potential solutions relating to Biological Zonation in EUNIS

The EUNIS system is inconsistent in the way it introduces biological zones (as defined in Table 2) to the hierarchy. Not only are they introduced at different hierarchical levels, but the level at which specific biological zones are introduced differs between rock and sediment habitats. As biological zonation is fundamental to our understanding and mapping of marine habitats, this introduces notable inconsistencies in maps produced to a specific level in the EUNIS hierarchy.

In the rock section of the EUNIS classification the littoral, infralittoral and circalittoral biological zones are introduced at level 2, but the deep circalittoral (i.e. below the wave-base) is introduced at level 4 (see Table 5). The intermediate level, level 3, is used to differentiate between energy regimes to which the rock is exposed (high, moderate and low energy), which is an important environmental characteristic for rock habitats as stronger forces tend to dislodge the 'weaker' animals and plants.

Table 5. Extracts from the EUNIS classification to illustrate that for rock habitats the littoral, infralittoral and circalittoral zones are introduced at level 2 in the hierarchy, whilst the deep circalittoral first appears at level 4 (*cf* sediment habitats in Table 3).

Level	EUNIS Code	EUNIS name	MNCR style code
2	A1	Littoral Rock	LR
2	A3	Infralittoral Rock	IR
3	A3.1	High energy Infralittoral Rock	IR.HIR
3	A3.2	Moderate energy Infralittoral Rock	IR.MIR
3	A3.3	Low energy Infralittoral Rock	IR.LIR
2	A4	Circalittoral Rock	CR
3	A4.1	High energy Circalittoral Rock	CR.HCR
4	A4.12	Sponge communities on deep Circalittoral Rock	CR.HCR.Sp
3	A4.2	Moderate energy Circalittoral Rock	CR.MCR
4	A4.27	Faunal communities on Deep Moderate energy Circalittoral Rock	CR.MCR.DFa
3	A4.3	Low energy Circalittoral Rock	CR.LCR
4	A4.33	Faunal communities on Deep Low energy Circalittoral Rock	CR.LCR.DFa

In contrast, the sediment part of the classification introduces a ‘sublittoral’ class at level 2, a class that is not used at all in the rock hierarchy, and again splits the introduction of the biological zones between levels 2 and 4 (Table 6). This time the littoral zone alone is introduced at level 2 and the infralittoral, circalittoral and deep circalittoral zones are all introduced at level 4. Level 3 is used to differentiate between sediment types, which is an important environmental characteristic in determining benthic community composition.

Table 6. Extracts from parts of the EUNIS classification illustrating that for sediment habitats the littoral zone is introduced at level 2 in the hierarchy, while the infralittoral, circalittoral and deep circalittoral zones are all introduced at level 4 (*cf* rock habitats in Table 5).

Level	EUNIS Code	EUNIS name	MNCR style code
2	A2	Littoral Sediments	LS
2	A5	Sublittoral Sediments	SS
3	A5.1	Sublittoral Coarse Sediments	SS.SCS
4	A5.13	Infralittoral Coarse	SS.SCS.ICs
4	A5.14	Circalittoral Coarse	SS.SCS.CCs
4	A5.15	Deep circalittoral Coarse	SS.SCS.DCs
3	A5.2	Sublittoral Sand	SS.SSa
4	A5.23	Infralittoral Fine Sand	SS.SSa.IFiSa
4	A5.24	Infralittoral Muddy Sand	SS.SSa.IMuSa
4	A5.25	Circalittoral Fine Sand	SS.SSa.CFiSa
4	A5.26	Circalittoral Muddy Sand	SS.SSa.CMuSa
4	A5.27	Deep circalittoral Sand	SS.SSa.DSa
3	A5.3	Sublittoral Mud	SS.SMu
4	A5.33	Infralittoral Sandy Mud	SS.SSa.ISaMu
4	A5.34	Infralittoral Fine Mud	SS.SSa.IFiMu
4	A5.35	Circalittoral Sandy Mud	SS.SSa.CSaMu
4	A5.36	Circalittoral Fine Mud	SS.SSa.CFiMu
4	A5.37	Deep circalittoral Mud	SS.SSa.DMu
3	A5.4	Sublittoral Mixed sediments	SS.SMx
4	A5.43	Infralittoral Mixed sediment	SS.SMx. IMx
4	A5.44	Circalittoral Mixed sediment	SS.SMx.CMx
4	A5.45	Deep circalittoral Mixed sediment	SS.SMx.DMx

So, while the infralittoral and circalittoral zones are introduced at level 2 for rock habitats they are only introduced at level 4 for sediment habitats. The practical upshot of this variability in the system becomes clear when one considers what can be illustrated by a map drawn at a particular EUNIS level, a task frequently requested by policy makers and/or those involved with spatial planning or environmental assessment. For example, a map at EUNIS level 2 can only show the first three biological zones for rock habitats (littoral, infralittoral, circalittoral) and would erroneously classify deep circalittoral rock as ‘circalittoral rock’. For sediments, it would only discriminate between littoral sediments and all others (sublittoral). Though the infralittoral and circalittoral zones would be shown for rock, they would not be shown for sediments; hence the map is internally inconsistent.

At EUNIS level 3 the map will still show just three of the four biological zones for rock habitats and only one zone proper (the littoral) for sediments. However it will now differentiate between the energy/exposure regimes for rock habitats and between the different types of sediment. The map will still miss-classify any deep circalittoral rock. In addition, it will give the impression that there is no biological zonality among the different sediment classes, because the zonation that is illustrated for rock habitats is absent from the sediment classes at this level in the EUNIS hierarchy. Such internal inconsistency is effectively misleading the map user.

At EUNIS level 4 these internal inconsistencies are mostly resolved as it is now possible to illustrate all four of the biological zones in both rock and sediment habitats along with the energy/exposure regimes for rock habitats and the substrate types for sediment habitats. However at level 4, characterising biological species are employed in the classification of rock habitats but these do not appear until level 5 for the sediment habitats.

It is usually the case that lay-interpreters of such maps are not aware that the inconsistencies in the EUNIS hierarchy impose such limitations on what the maps can and can not show, and it is unlikely that those limitations are properly conveyed to the layman by the map makers. The inconsistencies make the task of producing modelled habitat maps a great deal more complicated which has time and cost implications. They also unduly affect confidence in the modelled map, as the biotope classes assigned to ground truth samples (level 5/6) appear to be inconsistent with the classes shown on the broadscale map.

The ultimate solution to this problem is to revise the entire EUNIS hierarchy to provide consistency in the way it introduces biological zonation. However this would be a major work and is beyond the scope of this paper. Instead we offer an interim solution to remove the inconsistency in the biological zones for rock habitats by introducing a class for deep circalittoral rock at level 2. To fit in with the existing EUNIS coding system we assign this a code of A4D (Table 3 & Figure 1), A4 being circalittoral rock and the D denoting deep circalittoral. This will at least provide consistency in the presentation of biological zones for the rock habitats, but maps drawn at EUNIS levels 2 or 3 would still need to advise the user that biological zonation is not illustrated consistently across rock and sediment habitats. Provision of a schematic such as that presented in Figure 1 would help inform such lay-users. Map makers can themselves enforce consistency in broadscale habitats maps by presenting rock habitats at level 3 and sediment habitats at level 4.

Example from a case study in the English Channel.

We have applied this revised schema to a modelled habitat map for the UK part of the central and eastern English Channel (James et al, 2011) which uses EUNIS level 3 for rock (R) habitats and EUNIS level 4 for both rock and thin sediment (RthS) and Sediment (S) habitats. To highlight the differences this makes, we compare this with a 'standard' EUNIS level 3 map classified using the existing EUNIS classes and opting to assign sediment rather than rock classes to areas of rock and thin sediment.

The standard EUNIS level 3 habitat map is presented in Figure 2 and depicts the area to be dominated by mixed sediments (A5.4), with outcropping rock (A3.x & A4.x) and coarse sediment (A5.1) generally restricted to the west while sand (A5.2) is dominant in the east. The rock habitats are differentiated into infralittoral and circalittoral rock (A3.x and A4.x respectively), the infralittoral being depicted by a green hatching on the symbols. There is also a differentiation between high, moderate and low energy habitats depicted by dark, mid and light background shading in the symbols for A3.x and A4.x. The infralittoral zone appears to be extremely limited in its spatial extent to an area on the southern part of the Isle of Wight, as the level 3 map is not capable of displaying the infralittoral zone for sediment habitats. The deep circalittoral zone is not shown at all.

In contrast, the map that uses the revised schema (Figure 3) is more informative and consistent. The infralittoral, circalittoral and deep circalittoral zones (red hatching) are now prominently represented across all habitat types. The infralittoral zone is seen to extend significant distances from the shore-line across most of the area but at the southern tip of the Isle of Wight the zonation changes abruptly from infralittoral through circalittoral to deep circalittoral, the latter marking the area of St Catherine's Deep which reaches depths in excess of 70 metres. Further offshore the deep circalittoral zone marks the course of a deepened area of the English Channel known as the Northern Palaeovalley which existed during the last glaciation when this area was a terrestrial environment, prior to the latest marine transgression (see James et al, 2010 & 2011 for more detail).

The dominance of grey shading in Figure 3 shows that most of the area is characterised by rock and thin sediment. The different colours used for the superficial pattern in the symbols for rock and thin sediment habitats indicates the type of sediment found (coarse = pink, sand = yellow, mixed = blue) and is consistent with the colouring used for the 'pure' sediment habitats so, for example, the sand sheet extending southwest of Dungeness is seen to grade into rock and thin sands (A3.92 & A4.92) and ultimately to rock and thin mixed sediment (A3.94 & A4.94) around Beachy Head. Other prominent features that were not visible in the level 3 map are the in-filled palaeochannels that trend southwards on either side of the Isle of Wight; another one is visible between Selsey Bill and Brighton. These areas mark the course of ancient river channels that are now in-filled with sediment and targeted by industry as a source of aggregate.

Conclusion

Broadscale marine habitat maps play an important role in informing policy, planning and management relating to the marine environment. As such it is important that the information provided should be fit-for-purpose and free from inaccuracies, inconsistencies and ambiguities which may mislead those who rely on the maps to inform their decision making. It is the responsibility of the map makers to ensure such quality control and to advise non experts who may commission such maps of the technical specifications required to make the maps fit-for-purpose. At present there is still a tendency for non experts to commission maps at EUNIS level 3, unaware of the inconsistencies that such a specification will impose on the map due to the anomalies of the marine section of the EUNIS classification system. We highlight these anomalies and provide some simple interim measures that improve the information content, quality and consistency of broadscale habitat maps. We recommend that in the long term the EUNIS hierarchy should be revised with a view to removing the anomalies relating to biological zonation and to expand the classification to accommodate the need to present habitat types that are transitional between the classical rock and sediment substrates. In the interim we recommend that the minimum specification for broadscale habitats maps should be to present rock habitats at EUNIS level 3 and sediment habitats at EUNIS level 4.

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List of Acronyms
BALANCE - Baltic Sea Management – Nature Conservation and Sustainable Development of the Ecosystem through Spatial Planning
EUNIS - European Nature Information Service
INFOMAR – Integrated Mapping for the Sustainable Development of Ireland's Marine Resources
MESH - Mapping European Seabed Habitats project
MNCR - Marine Nature Conservation Review
REBENT - Réseau benthique

References
Coggan, R, and Diesing, M. 2011. The seabed habitats of the central English Channel: A generation on from Holme and Cabioch, how do their interpretations match-up to modern mapping techniques? Continental Shelf Research, Vol. 31, Issue 2, Supplement 1, S132-S150.

Coggan, R, Diesing, M and Vanstaen, K. 2009. Mapping Annex I Reefs in the central English Channel: evidence to support the selection of candidate SACs. Scientific Series Technical Report, Cefas Lowestoft, 145: 116pp

Connor, D W, Allen, J H, Golding, N, Howell, K L, Leiberknecht, L M, Northen, K O, and Reker, J B. 2004. The Marine Habitat Classification for Britain and Ireland Version 04.05 JNCC, Peterborough.

Davies C E, and Moss, D. 2000. The EUNIS Habitat Classification. Theme Session on Classification and Mapping of Marine Habitats, CM 2000/T:04. ICES Annual Science Conference 2000, Brugge, Belgium, 27-30 September 2000

Davies, C E and Moss, D. 2004. EUNIS Habitat Classification Marine Habitat Types: Revised Classification and Criteria. C02492NEW. Centre for Ecology and Hydrology, Dorset, UK.

Diesing, M, Coggan, R and Vanstaen K. 2009. Widespread rocky reef occurrence in the central English Channel and the implications for predictive habitat mapping. Estuarine, Coastal and Shelf Science, Vol. 83: 647-658

James, J W C, Coggan, R A, Blyth-skyrme, V J, Morando, A, Birchenough, S N R, Bee, E, Limpenny, D S,Verling, E, Vanstaen, K, Pearce, B, Johnston, C M, Rocks, K F, Philpott, S L, and Rees, H L. 2007. Eastern English Channel Marine Habitat Map. Scientific Series Technical Report, Cefas Lowestoft, 139: 192 pp + map

James, J W C, Coggan, R A, Rocks, K, and Iwanoczko, A P. 2008. Application of sea bed morphology modelled from single beam echo sounder data for habitat mapping in the Eastern English Channel. British Geological Survey Open Report OR/08/016.

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

James, J W C, Pearce, B, Coggan, R A, Leivers, M, Clark, R W E, Plim, J F, Hill, J M, Arnott, S H L, Bateson, L, De-Burgh Thomas, A and Baggaley, P A. 2011. The MALSF synthesis study in the central and eastern English Channel. British Geological Survey Open Report OR/11/01. 158pp.

				ROCK (R)			RthS	SEDIMENT			
				High energy (H)	Moderate energy (M)	Low energy (L)		Coarse (Cs)	Sand (Sa)	Mud (Mu)	Mixed (Mx)
Littoral	Photic	Above - wavebase		←	**A1**	→		←	**A2**		→
			Littoral (L)	HLR A1.1	MLR A1.2	LLR A1.3		LCs A2.1	LSa A2.2	LMu A2.3	LMx A2.4
Sublittoral				←	**A3**	→		←	**A5**		→
			Infralittoral (I)	HIR A3.1	MIR A3.2	LIR A3.3		← **A5.1** → ICs A5.13	← **A5.2** → IFiSa, IMuSa A5.23, A5.24	← **A5.3** → ISaMu, IFiMu A5.33, A5.34	← **A5.4** → IMx A5.43
	Aphotic			←	**A4**	→					
			Circalittoral (C)	HCR A4.1	MCR A4.2	LCR A4.3		CCs A5.14	CFiSa, CMuSa A5.25, A5.26	CSaMu, CFiMu A5.35, A5.36	CMx A5.44
		Below - wavebase		←	**A4D**	→					
			Deep-circalittoral (D)	HDR A4D.1	MDR A4D.2	LDR A4D.3		DCs A5.15	DSa A5.27	DMu A5.37	DMx A5.45

Figure 1. 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 = **M**oderate energy **I**nfralittoral **R**ocked. In addition, FiSa = fine sand, MuSa = muddy sand, SaMu = sandy mud, FiMu = fine mud. RthS = Rock and thin Sediment (see text).

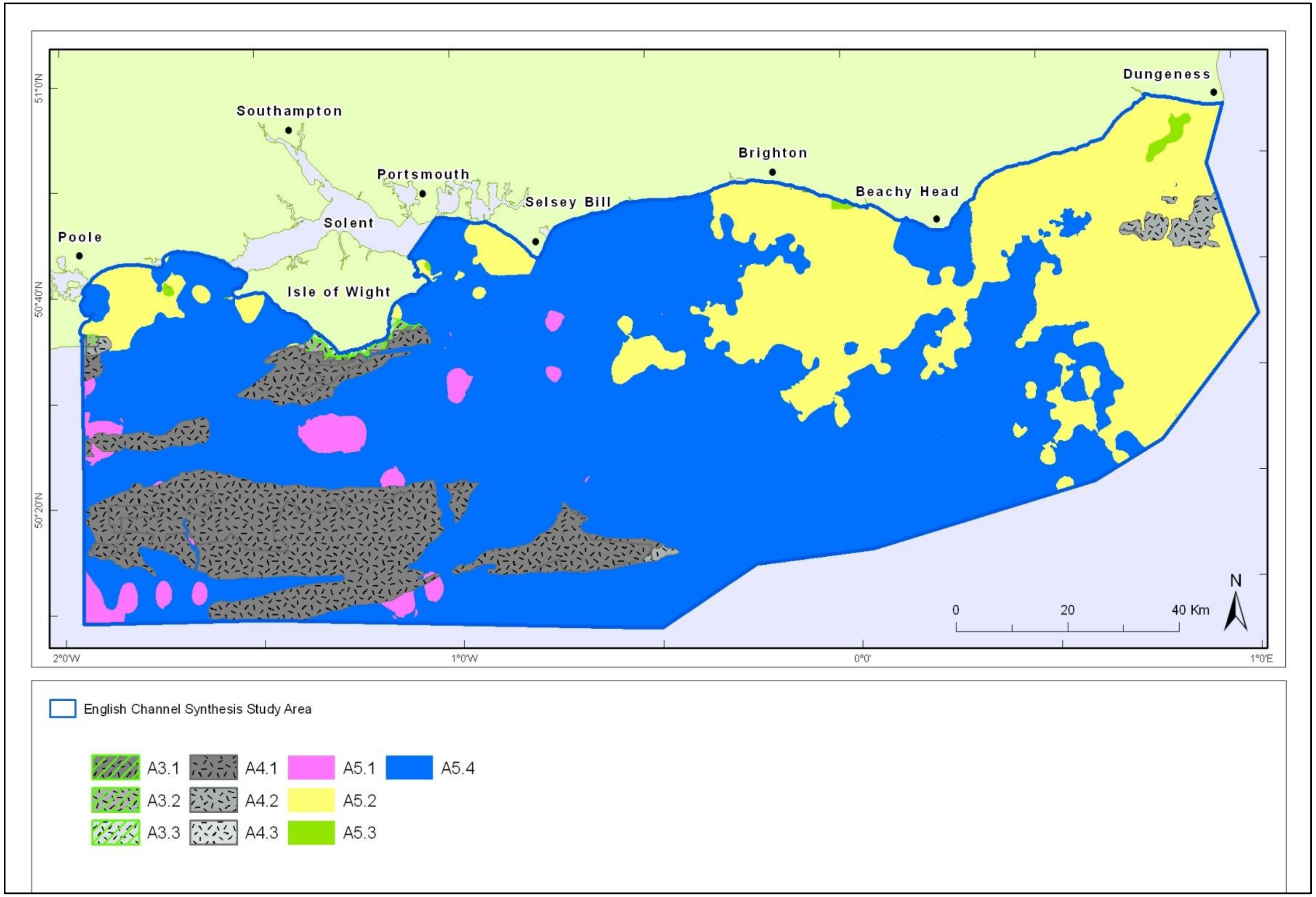

Figure 2. Modelled habitat map for the English Channel study area (James et al, 2011) classified to level 3 in the current published version of EUNIS. Only rock or sediment habitats can be shown and there is a vast under-representation of the infralittoral and deep circalittoral zones (*cf* Figure 3. See Table 1 for definition of EUNIS classes).

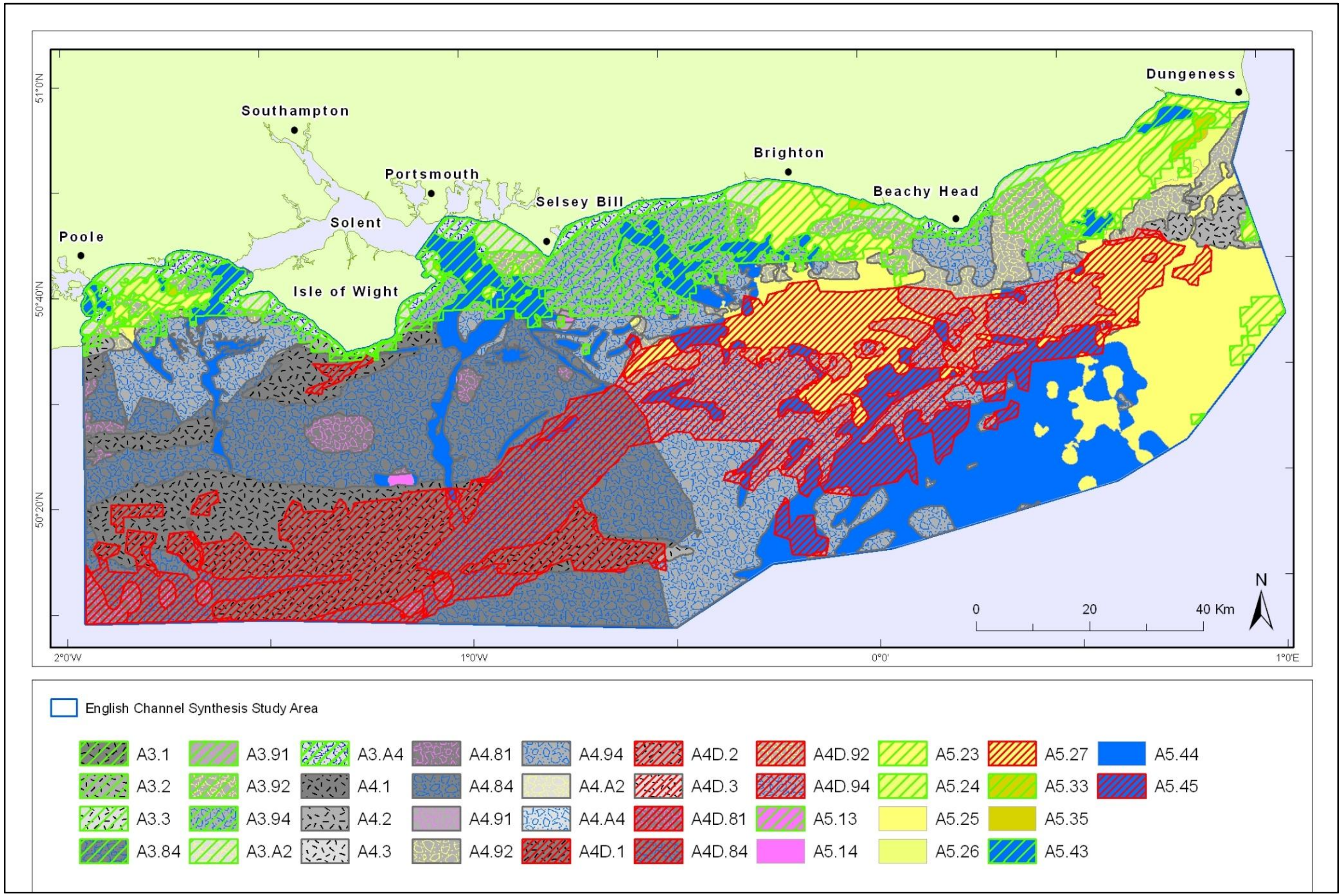

Figure 3. Modelled habitat map for the English Channel study area (James et al, 2011) classified to EUNIS level 3 for rock substrates and level 4 for sediment substrates using the modifications to the classification proposed in this paper (*cf* Figure 2. see Tables 3,4,5 & 6 for definition of EUNIS classes).