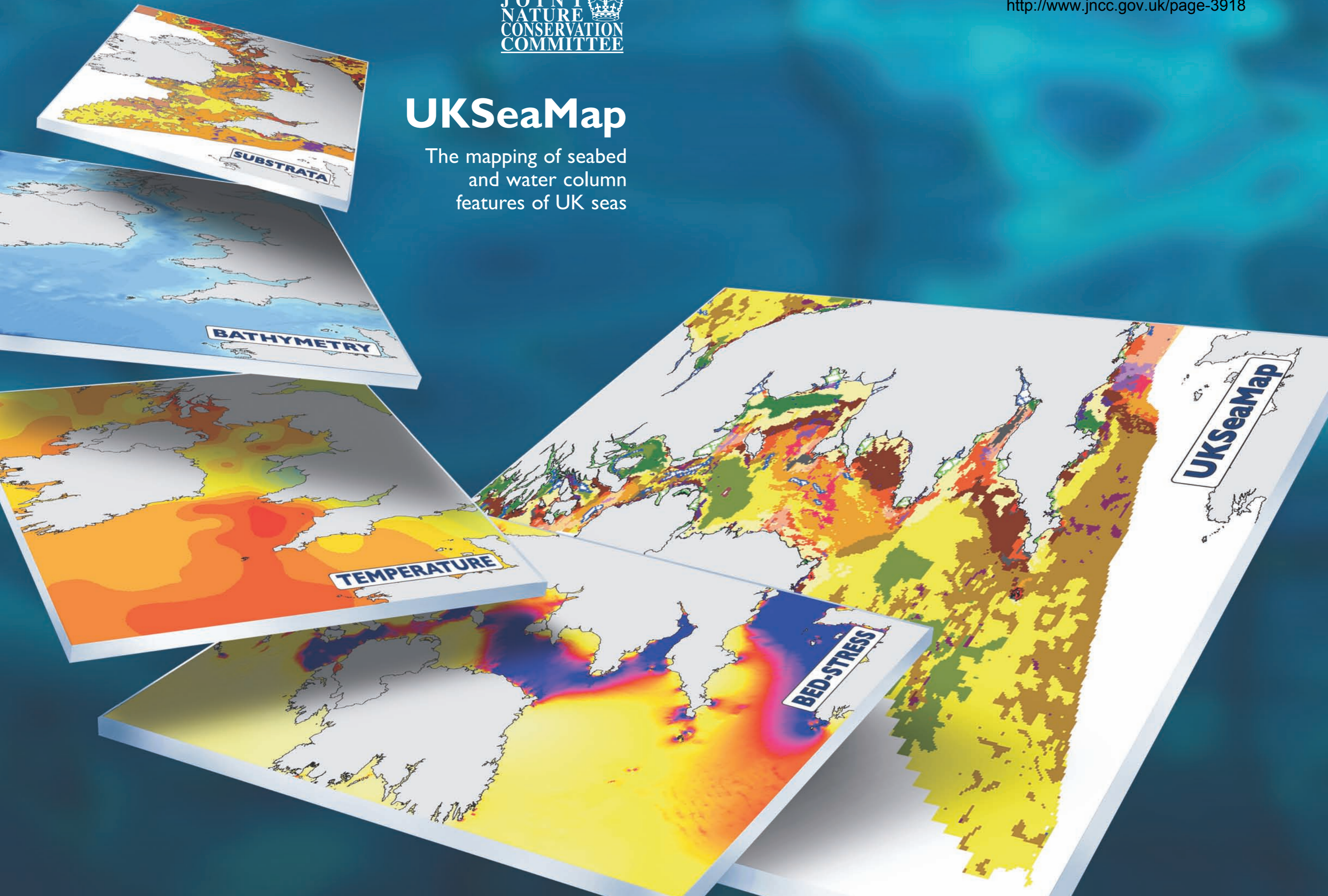


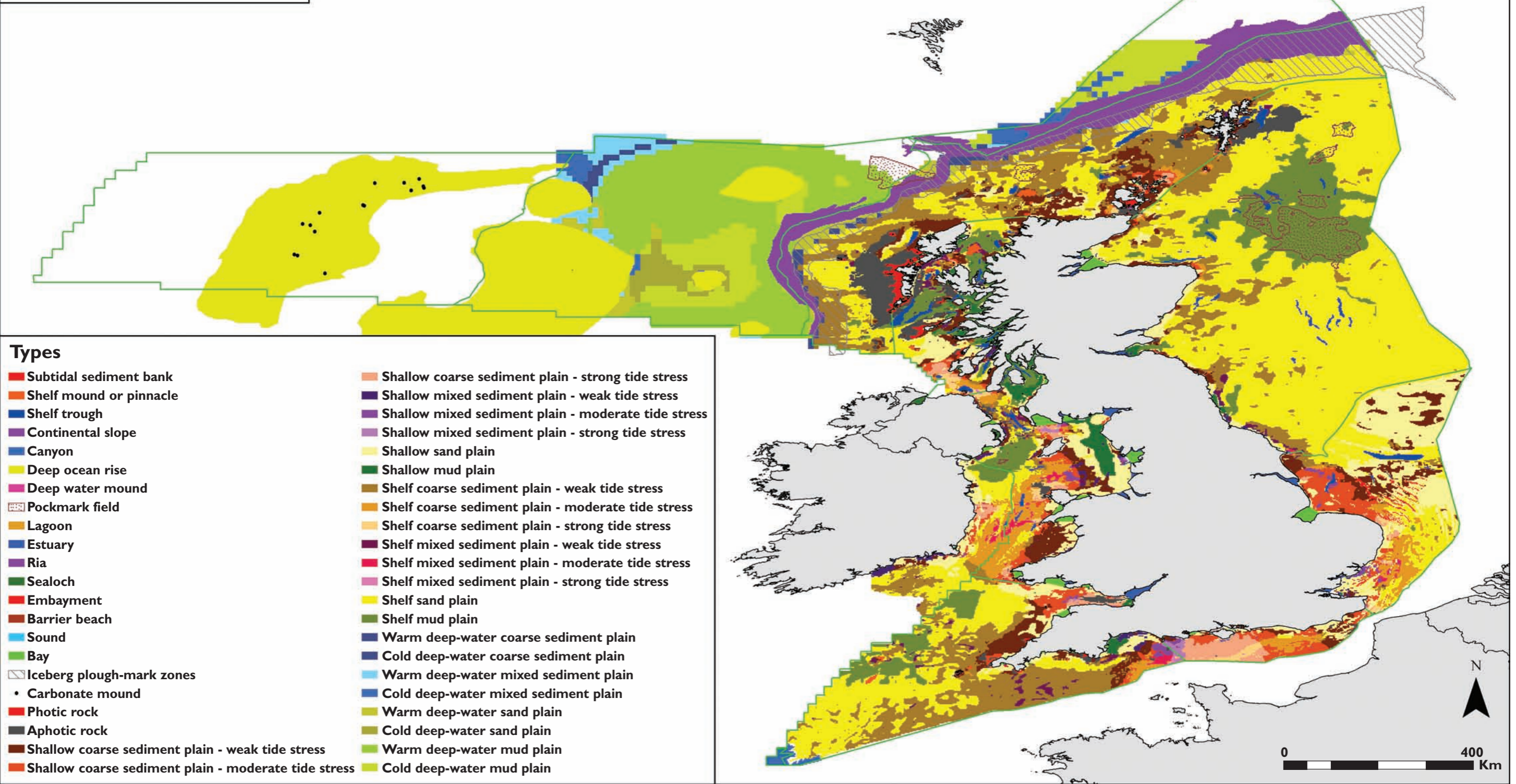
UKSeaMap

The mapping of seabed
and water column
features of UK seas



UKSeaMap

Seabed landscapes



JOINT NATURE CONSERVATION COMMITTEE

UKSeaMap

The mapping of seabed and water column features of UK seas

October 2006

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SCOTTISH EXECUTIVE



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Annex 1: Examples of the need for, and potential benefits of, UKSeaMap outputs

A geophysical spatially-based approach to marine ecosystems, available in the short to medium term, is necessary because, for example:

- Enhanced stewardship of the marine environment based on an ecosystem approach would be impossible without a basic understanding of the physical location and scale of major components of marine ecosystems, on the seabed and in the water column;
- It enables a move to be made away from reactive management to proactive management of marine ecosystem components;
- It provides a framework to improve the capacity to address and manage risk and uncertainty associated with the marine environment;
- It rapidly provides an essential part of the framework needed to support the implementation of internationally agreed commitments and targets, such as halting decline in biodiversity by 2010, applying the ecosystem approach by 2010, implementing MPA networks by 2012, and recovering and sustaining fish stocks by 2015;
- Through information on the distribution of marine ecosystem components, it provides a fundamental basis for marine spatial planning and the benefits this could provide, such as more effective reduction in conflict between different activities and between activities and the environment. It is important that such information is available in the short term to support likely pilot projects to explore the role of marine spatial planning. Spatial planning is recognised at UK, OSPAR and EU levels as a potentially key tool to achieve better integration and regulation in the management of human activities;
- It provides an essential spatial context for assessment of rapidly evolving sectors of use, such as aggregate extraction and wind farms, and cumulative effects across all sectors. It also provides an essential layer of information to support implementation of the Strategic Environmental Assessment Directive (being considered now but required from 2004) and potentially the Environmental Liability Directive;
- It rapidly provides a more informed basis to help focus future spatially-based research and survey requirements, and in so doing helps to maximise cost-effectiveness and reduce possible replication of effort.

Annex 2: Recommendations from the RMNC and Irish Sea Pilot

The Irish Sea Pilot (Vincent *et al.* 2004) included the following recommendations:

- R14 The marine landscape approach should be adopted as a key element for marine nature conservation and utilised in the spatial planning and the management of the marine environment. The approach should take account of broadscale marine habitat information, as this information becomes available over time. In coastal and estuarine waters the approach should seek to complement that taken under the Water Framework Directive (in relation to typology and reference conditions) at a more detailed level.
- R15 A list of internationally-agreed marine landscapes for the North-East Atlantic should be developed. It is suggested that the list identified for the Irish Sea be expanded to include landscapes not found in the Irish Sea and further refined as necessary. Work to complete the mapping of these marine landscapes in the North-East Atlantic should be undertaken in collaboration with other countries.

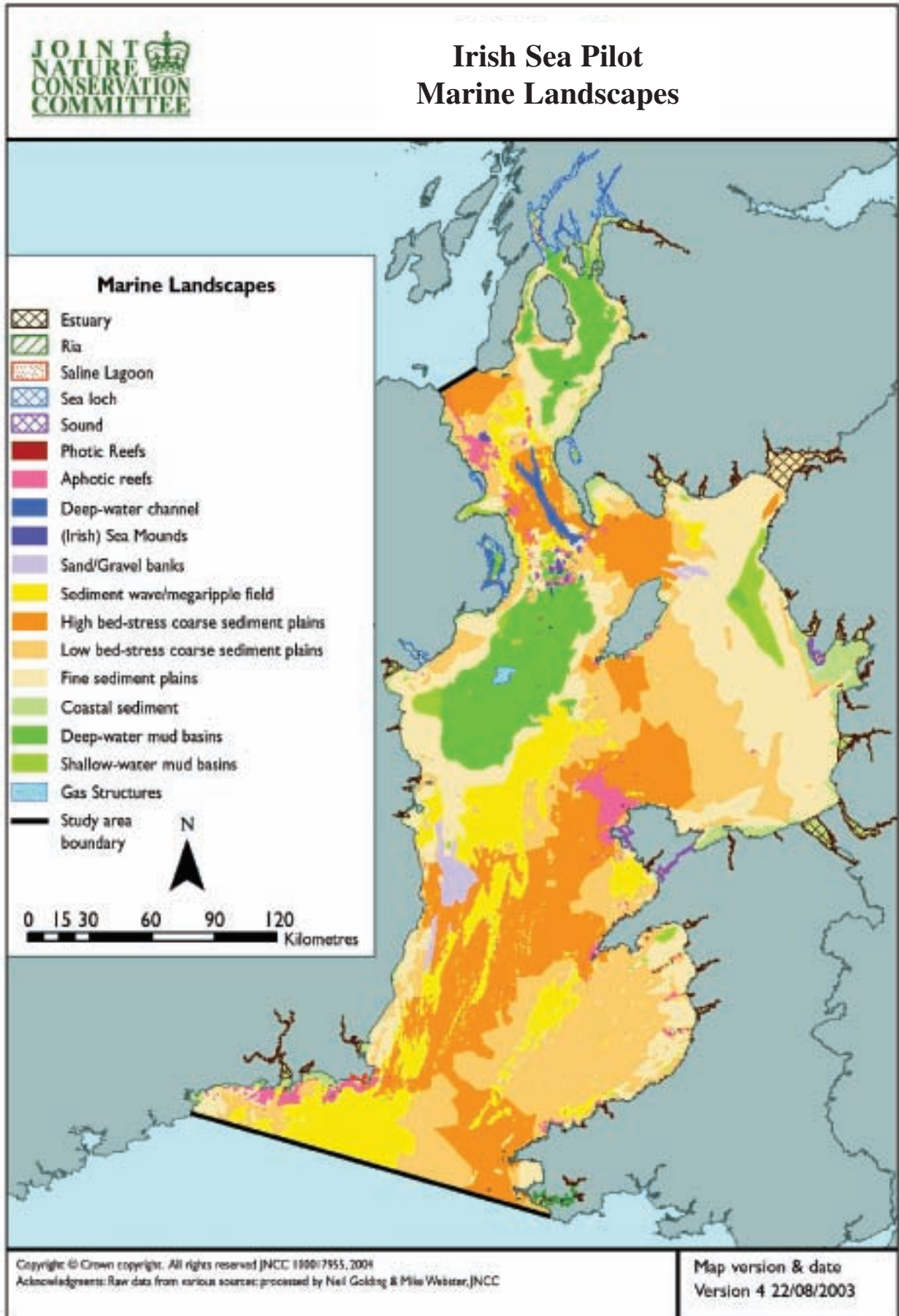
The Review of Marine Nature Conservation (Defra 2004) included the following recommendations:

Key recommendation 3:

Government should refine the process for identifying Marine Landscapes, and agree and map them in all UK waters.

Supporting recommendations:

- 3.1 A list of agreed Marine Landscapes should be developed for UK waters. The list identified for the Irish Sea should be expanded to include landscapes not found in the Irish Sea and further refined as necessary, in particular in relation to the water column. Work should be initiated to complete the mapping of these Marine Landscapes for UK waters.
- 3.2 Further work should be undertaken to determine the degree of correlation between Marine Landscapes and adult populations of vertebrate (i.e. pelagic fish, seabirds and sea mammals) and invertebrate species.
- 3.3 Work should be initiated to develop a list of internationally agreed landscapes for the North-east Atlantic and work to map these should be undertaken in collaboration with other countries.
- 3.4 The methodology for sensitivity and vulnerability of Marine Landscapes should be further developed and refined.



Analysis process

Unsupervised classification approach

An unsupervised approach uses algorithms to cluster multivariate data based solely on the values of the inputs, without any training. Clusters produced by the analysis must then be related to real world features in order to be described. The advantage of this method is that almost all subjectivity is removed from the process. However, the disadvantage of using this method is that it could produce a very 'messy' picture (because of the large number of possible combinations, based on the number of data sets and the number of categories within each), which could need significant additional scientific interpretation into suitable mapping units (classes). A commonly used algorithm for this type of analysis is a Maximum Likelihood Classifier (MLC) and the use of this was investigated. The MLC, however, assumes a normal distribution of data values whilst the inputs for the seabed analysis (see Section 4.3) are a combination of continuous and categorical data types, thus making the MLC an inappropriate technique for the project. Non-parametric unsupervised techniques are also available within the field of data mining. Software to carry out such methods, developed by the University of Waikato, New Zealand, were examined but it was not considered feasible to use this technique within the current project timescale.

Supervised classification approach

A supervised approach relies on a degree of guidance being provided by the mapping scientist. This guidance draws upon expert judgement and prior knowledge, which means that the process, and often the output, can be more intuitive and less abstract in nature. Although this method may be criticised on the basis of being subjective, it would seem short sighted to not apply the wealth of knowledge and understanding we have about marine ecosystems to the classification process in this project. This method relies on developing broad definitions for each marine landscape type prior to the data analysis stage (i.e. supervising the classification of marine landscape types), recognising that criteria used to define each landscape type have ecological relevance. After applying these criteria to the data sets, the validity of the resulting units can be tested with biological data.

GIS data type

Vector

Vector data type refers to the storage of spatial data in the form of points, lines and polygons. All of these are specific locations, or nodes, which in the case of lines and polygons are joined together by arcs. Vector data types were used to develop the Marine Landscapes classification for the Irish Sea Pilot, so it is a valid method to adopt. In order to do this all the input data sets need to be converted to polygons, representing areas of each class, and then overlaid. Problems created by this approach include the creation of very small sliver polygons, which must be dealt with in a consistent way, and also if the situation were to arise that thresholds need to be changed then the input data set must be recreated and the analysis re-run. Running the 'union' command in ArcGIS (the command that overlays data sets) is also very time consuming and demanding on computer processor power.

Raster

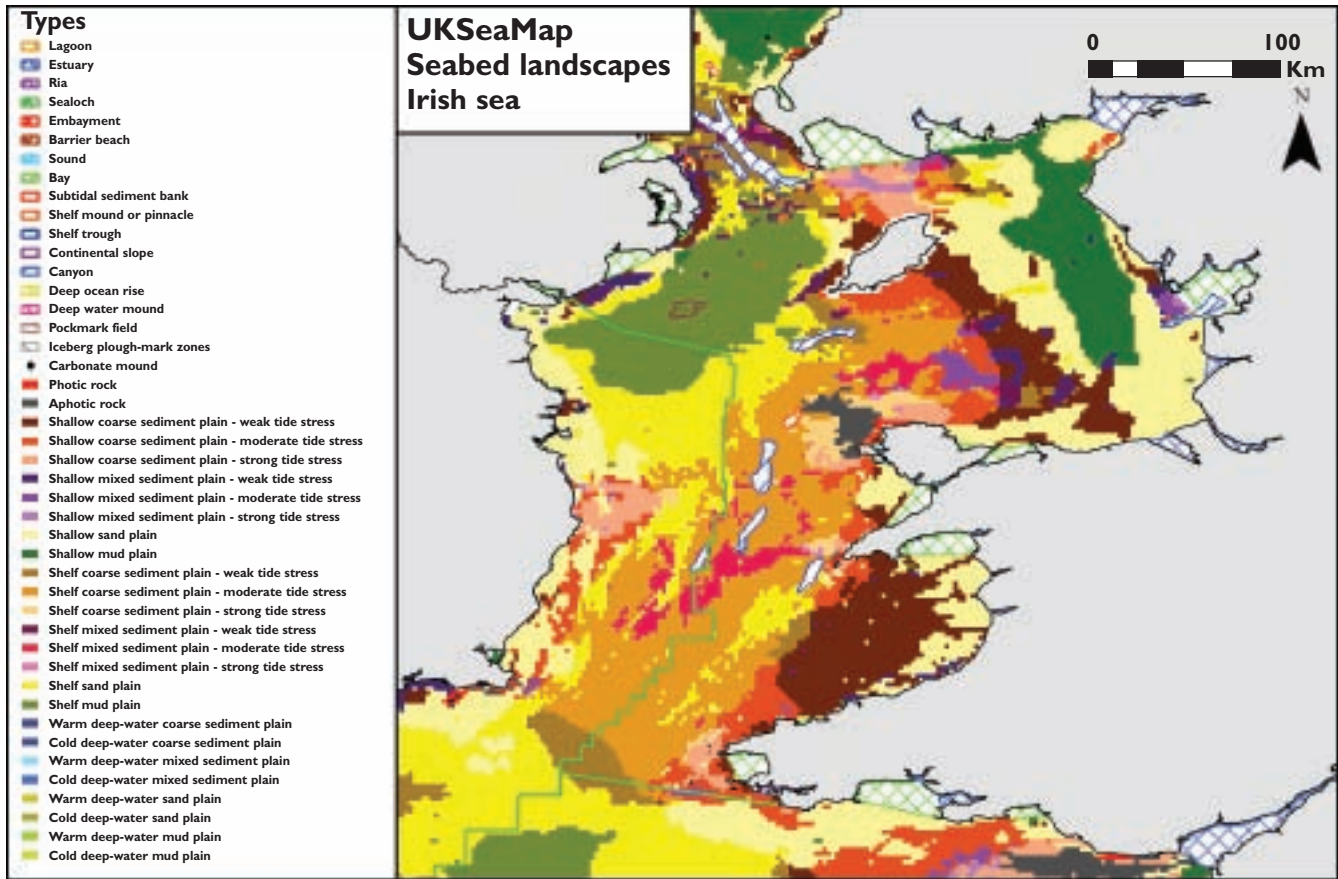
Raster data refers to the storage of spatial data in the form of a continuous field of uniform cells (i.e. a grid layer), each with an associated value. Although analysing and combining raster data in ArcGIS is quicker than vector data, it has the disadvantage of not containing any attribute information, which can store additional information about the data layer.

Annex 5: Identification of coastal physiographic types in a GIS

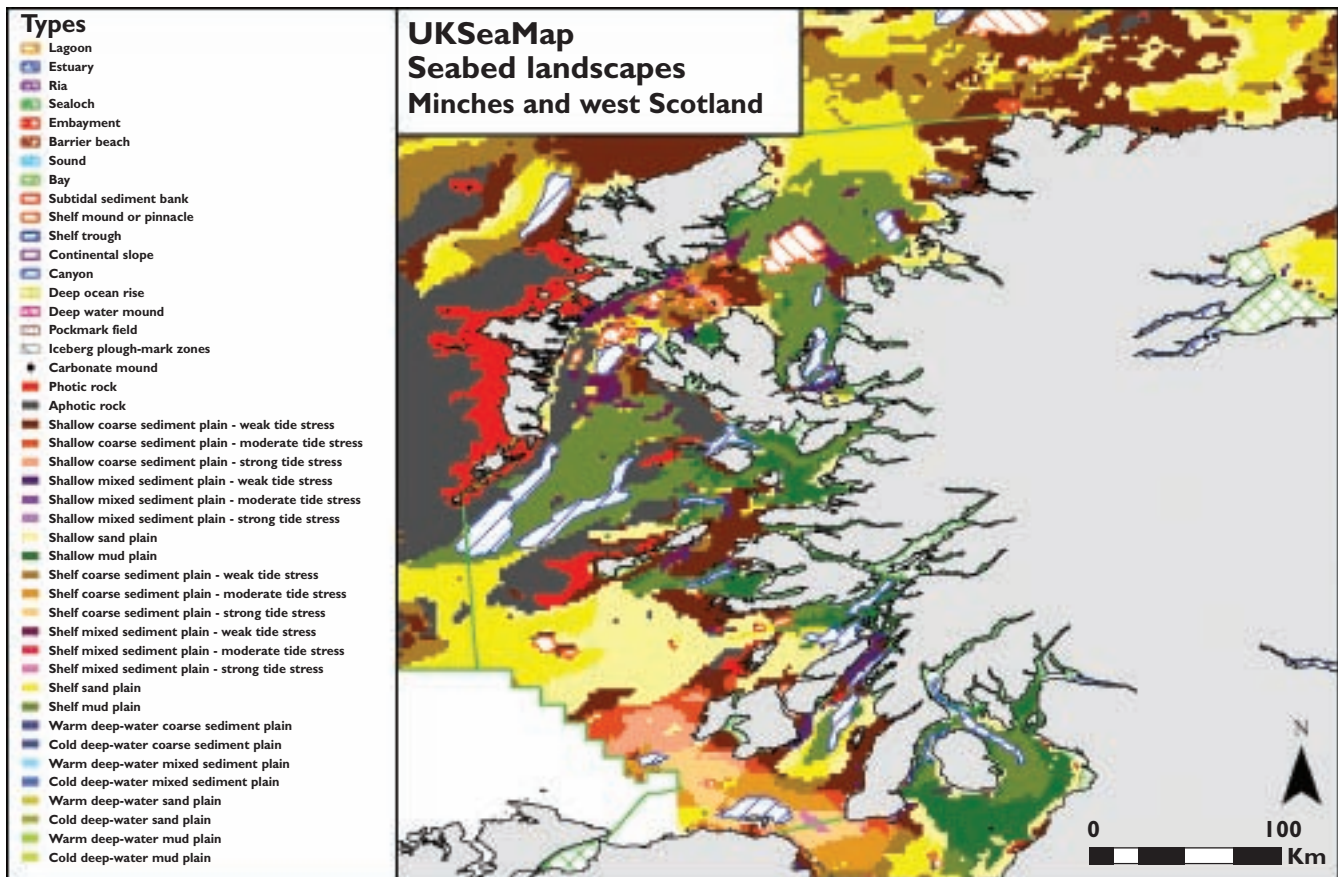
To define, in a GIS, which parts of the coast could be classified as a coastal physiographic feature, a set of rules was established which were used to distinguish the features from the adjacent 'open coast'. These rules were applied to an Ordnance Survey 1:25,000 coast line. As lagoons are generally very small features, these have mostly been identified from specific studies (e.g. MNCR survey of Scottish lagoons) rather than via the following approach.

	Application
Landward Seaward	Normal Tidal Limit, as indicated on the OS map. Some rias and bays may have an estuary on their boundary landward side.
Seaward boundary	Line between headlands at the mouth of the estuary, inlet or bay (if necessary, including islands in the boundary mouth) where it opens to open coast (or into a bay). Where several estuaries, inlets or bays share a mouth, the outer-most limit was used to encompass a 'system'. Where unclear (i.e. there are no distinct headlands), a line was drawn from the point on the coast where orientation changes to predominantly an open coast aspect.
Height boundary	OS High Water.
Physiographic type	<p>Separated according to overall shape and depth profile characteristics, exposure to onshore winds and salinity input:</p> <p>Estuaries (coastal plain, bar-built and complex, as defined by Davidson <i>et al.</i> 1991). Marine features which generally have a large riverine input (from one or several rivers). Rias in south-west Britain (excluding significant estuarine areas at their heads).</p> <p>Embayments – predominantly enclosed features, lacking large riverine input and the typical elongated estuary structure (typically broad inside a narrow entrance).</p> <p>Sealochs and Shetland voes – glacially-derived features.</p> <p>Bays – indentations of the open coast, bounded by headlands which provide some shelter from along-shore winds (but which are predominantly open to onshore winds). Generally length (from mouth to head of bay) at least half width (at mouth).</p>
Depth	No depth limit; vary from predominantly intertidal to over 200m deep. Specific coastal types, however, have typical depth profiles.
Size	<p>Upper limit – The Wash (62,000 ha)</p> <p>Lower limit – 200 ha for open coast bays; 100 ha for enclosed coast rias, voes, embayments and sealochs. Very small estuaries sometimes included as part of larger bay/inlet. Note that no lower size limit has been applied to lagoons.</p> <p>Working size limits have been adopted to exclude both very small and very large areas of (open) coast that might, at some scales, be considered to meet the definitions applied above (e.g. for bays).</p>

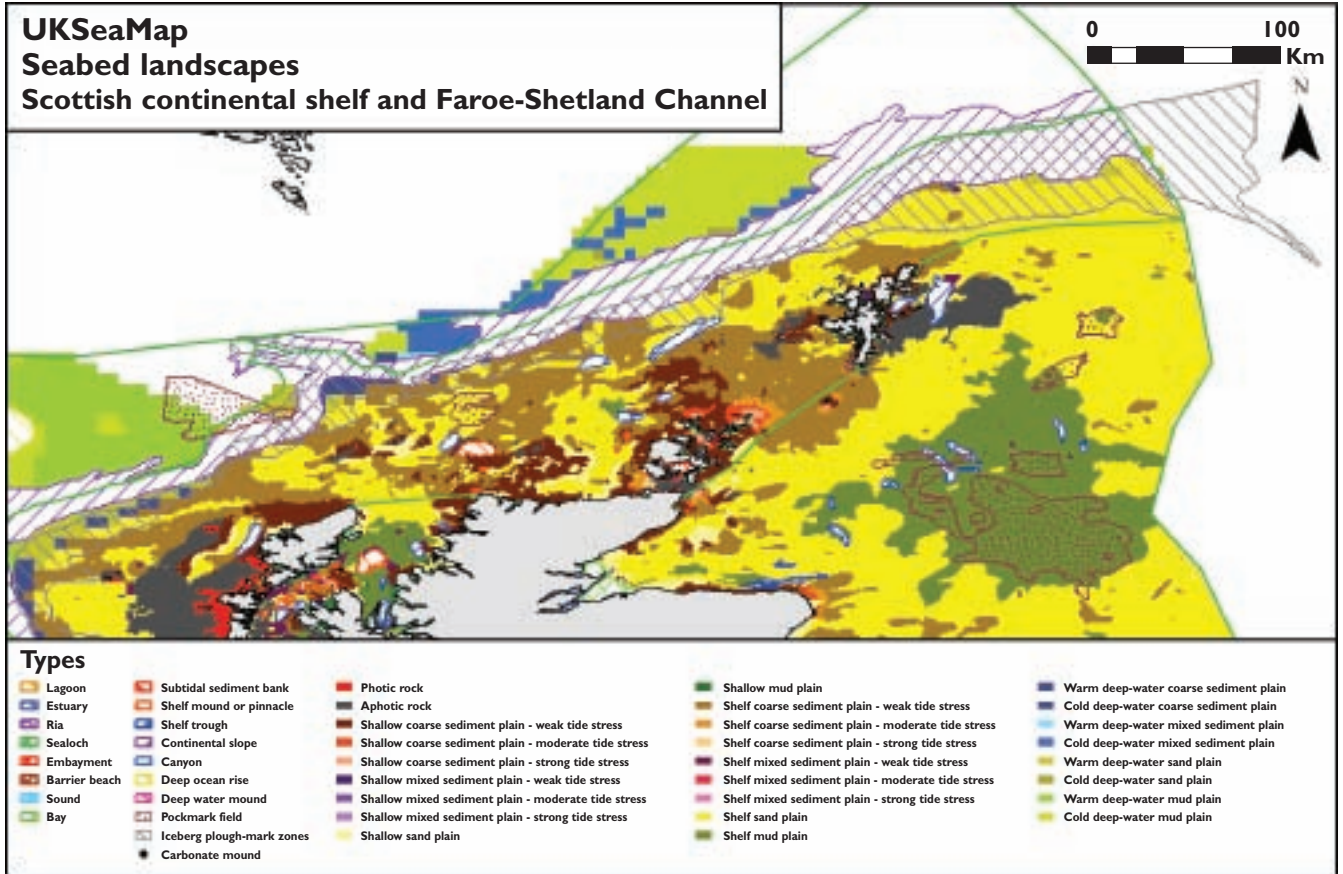
Annex 6: Seabed landscape maps for UK regions



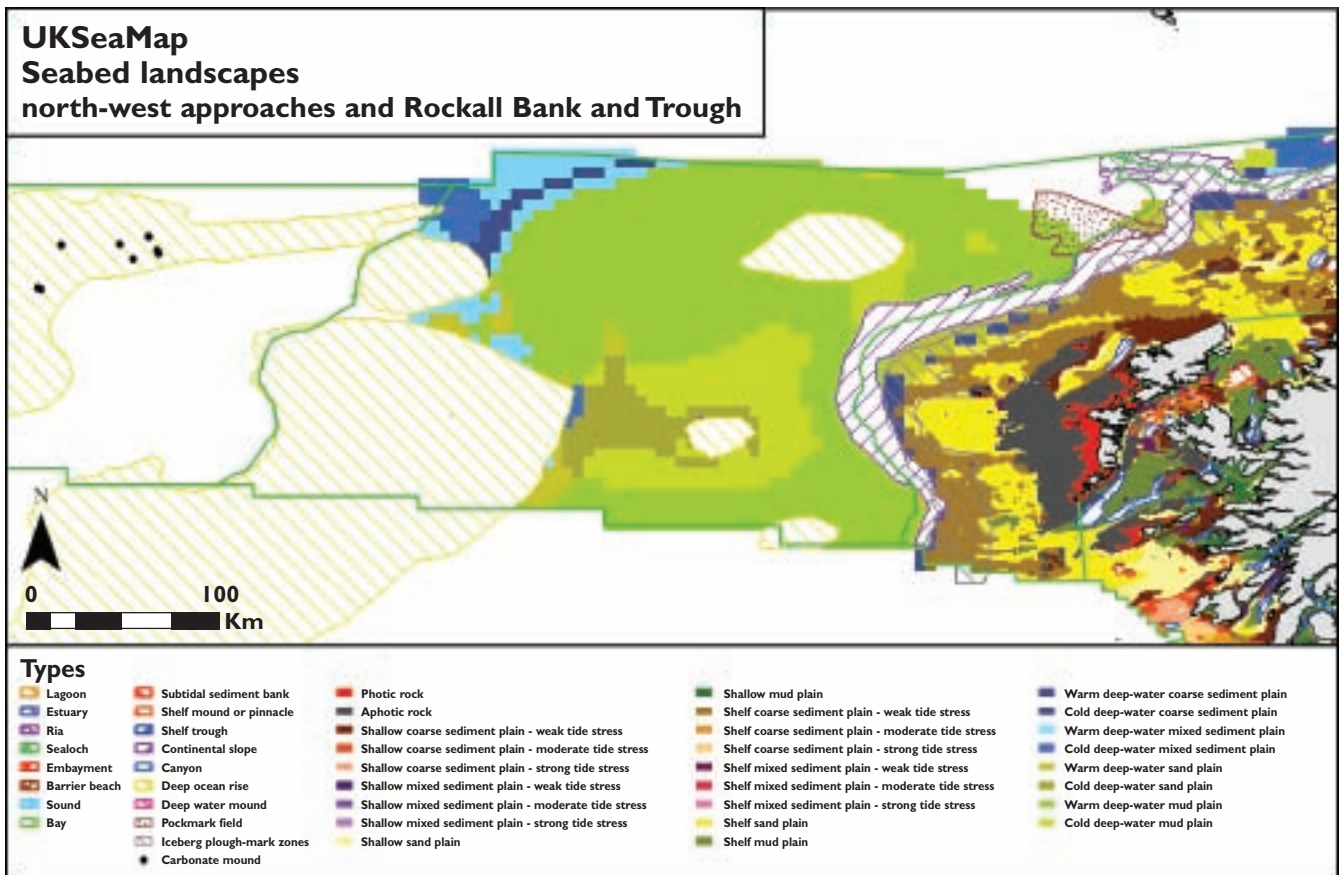
Marine landscape map for the Irish Sea



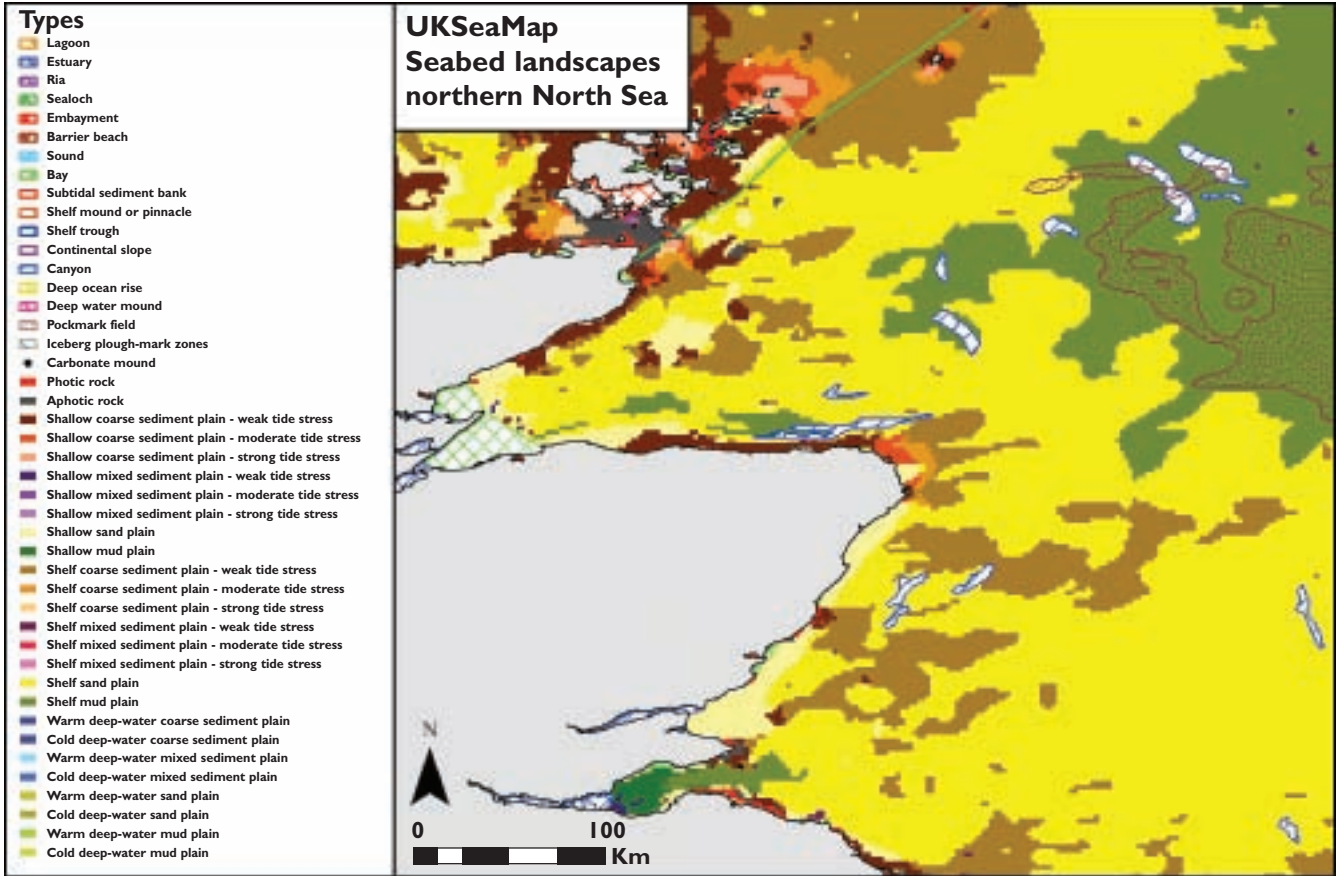
Marine landscape map for the Minches and west Scotland



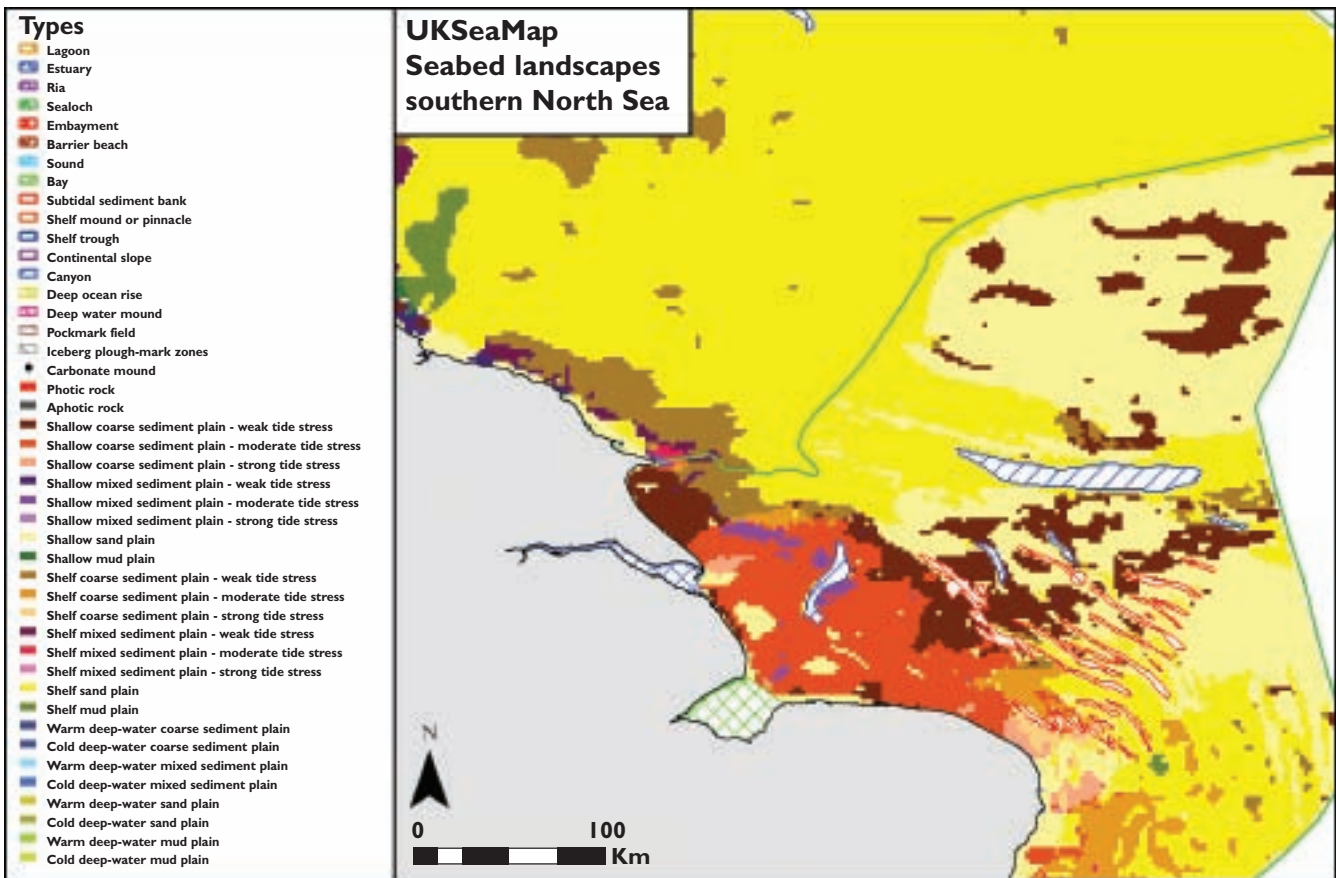
Marine landscape map for the Scottish Continental Shelf and the Faroe-Shetland Channel



Marine landscape map for the north west approaches and Rockall Bank and Trough

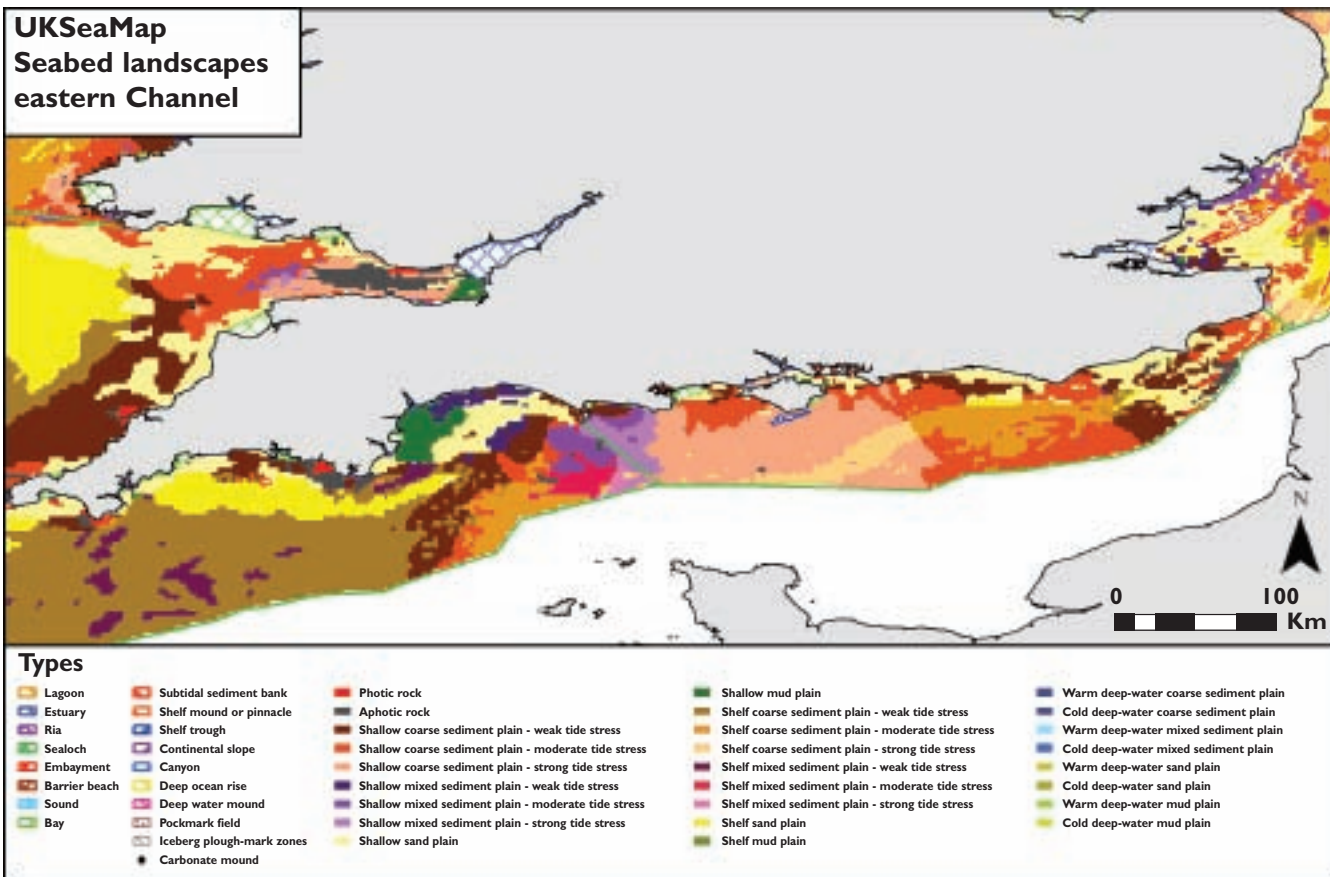


Marine landscape map for the northern North Sea

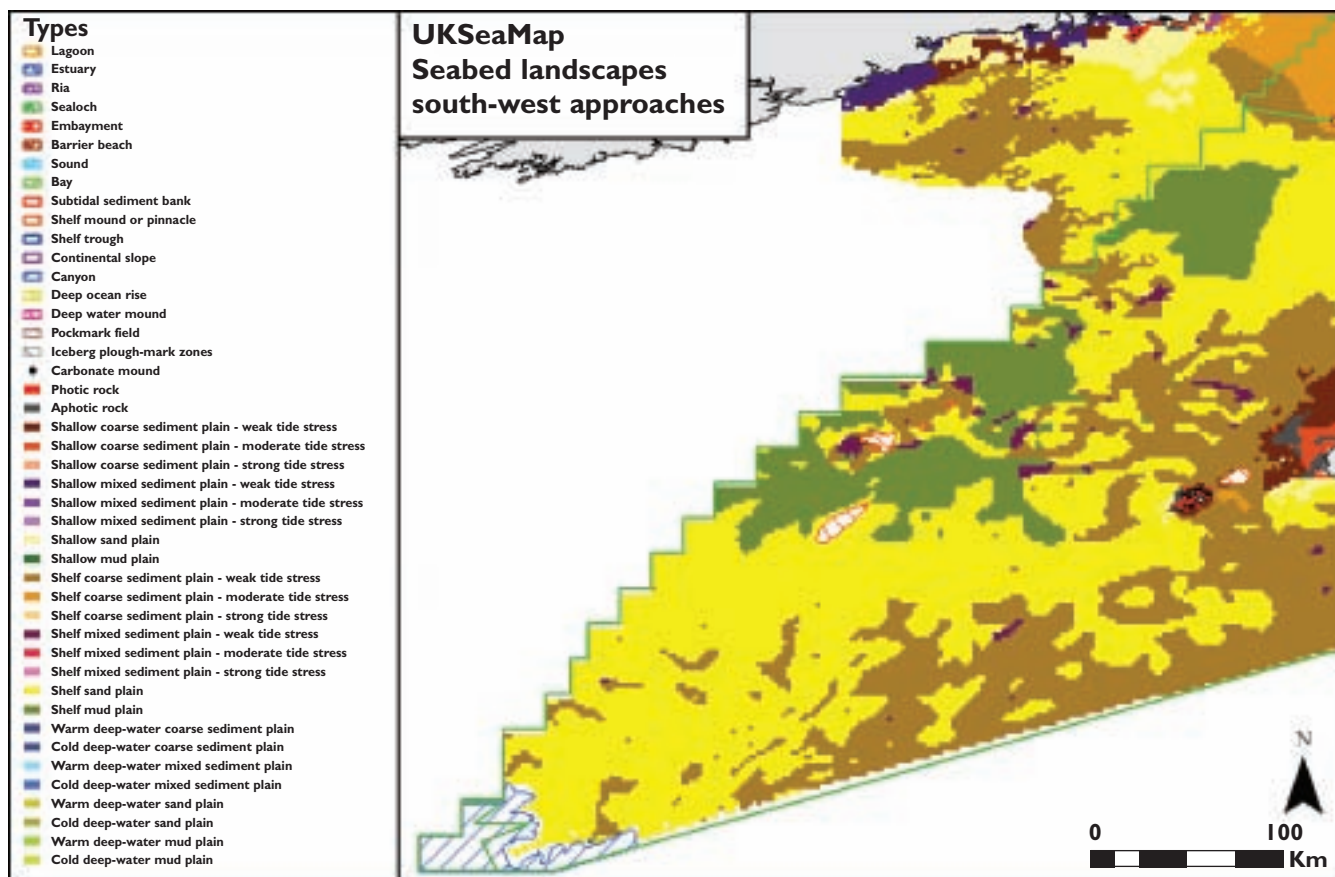


Marine landscape map for the southern North Sea

UKSeaMap Seabed landscapes eastern Channel



Marine landscape map for the eastern Channel



Marine landscape map for the south west approaches

Annex 7: Relationship between marine landscape types and the EUNIS habitat classification

To prepare for the biological analysis, those EUNIS Level 4 habitats that appear to fall within the expected definition of the landscape type were identified. These relationships are based upon the expected character or definition of each modelled seabed type, coastal physiographic feature and topographic feature (particularly substratum and depth zone) and are summarised below within a semantic Look-Up Table (LUT) which is a way to define relationships between two different classification schemes. In this case it is required to define how a marine habitat relates to a marine landscape as these are two different concepts. Three possible relationships were defined:

- 1 = Expected relationship (Samples from Habitat X match Landscape type Y)
- -1 = Unexpected relationship (Samples from Habitat X do not match Landscape type Y)
- 0 = Uncertain relationship (the relationship between Habitat X and Landscape type Y is unclear. In certain circumstances, samples from Habitat X may match Landscape type Y)

A semantic LUT is required to carry out this analysis as the two data sets cannot be compared directly, one data set being landscape features, the other being habitat types. Such a comparison is unavoidable as the concept of marine landscape features is both recent and novel, and as a consequence there are no similar data with which to compare the new map. The only data available for the comparison are point sample biological data, which can be identified to a habitat type (within EUNIS), but it would not be possible to directly assign such a sample to a landscape feature as the latter is a concept related to a broader scale than that represented by a single point. The semantic LUT therefore allows a comparison to be made between the two classification systems based on expert opinion of the relationship between the two classification systems. Such techniques have been used recently with considerable success in research comparing different land cover classification schemes in terrestrial environments (Comber *et al* 2004).

Using three values in the semantic LUT allows the analysis to utilise a rough set approach in comparing the two classifications (Ahlqvist *et al.* 2000). This technique moves away from the more traditional Boolean comparison (where something is either a member of a set or it is not) by allowing an uncertain membership function (given the value 0 above). In a Boolean analysis, the relationship is very clear, such that certain habitats should occur, for example, in the landscape type *Shallow mud plain*, and all others should definitely not. Using a rough set approach, however, there may be other habitats that while not specifically related to a *Shallow mud plain*, could possibly be found in such locations. This technique allows the production of a maximum (including definite and uncertain relationships) and a minimum (including definite relationships only) approximation of the relationship between the two data sets; it also recognises that not all such relationships in biology are clear-cut.

In this way, it was possible to assess whether each sample had an 'expected' 'unexpected' or 'uncertain' relationship with the underlying landscape type and thus both a conservative (minimum) (the proportion of data falling into expected definitions only) and an optimistic (maximum) (the proportion of data falling into either expected or uncertain definitions) estimate of correlation was made for each landscape type.

The following table provides (in two parts) a provisional correlation between EUNIS habitat types (levels 1-3) and the marine landscape types, indicating that many landscape types may include multiple habitat types. Note that the table only shows a summary of the full LUT, showing EUNIS types only down to level 3, whilst the biological sample data were assigned to the more detailed EUNIS level 4 (biotope complex level). Greyed out cells in the table indicate the habitat is not expected to occur in UK waters (as these are defined as Baltic or Mediterranean types).

			Open coast and shelf seas												Coastal and shelf bed-form features													
Enclosed coast			Shallow coastal plain features												Shelf plain features				Coastal and shelf bed-form features									
EUNIS level	EUNIS code	EUNIS name	Lagoon	Estuary	Ria	Sealoch/Voe	Embayment	Barrier beach	Sound or strait	Bay	Photic rock	Aphotic rock	Weak tide stress shallow coarse sediment plain	Moderate tide stress shallow coarse sediment plain	Strong tide stress shallow coarse sediment plain	Weak tide stress shallow mixed sediment plain	Moderate tide stress shelf coarse sediment plain	Strong tide stress shelf coarse sediment plain	Weak tide stress shelf mixed sediment plain	Moderate tide stress shelf mixed sediment plain	Strong tide stress shelf mixed sediment plain	Shelf mud plain	Shelf sand plain	Shelf mud plain	Subtidal sediment bank	Shelf mound or pinnacle	Shelf trough	Pockmark field
2	A4	Circalittoral rock and other hard substrata	1	0	1	1	0	0	1	1	-1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	0	-1
3	A4.1	Atlantic and Mediterranean high energy circalittoral rock	-1	0	0	1	0	0	1	0	-1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	0	-1
3	A4.2	Atlantic and Mediterranean moderate energy circalittoral rock	0	0	0	1	0	0	1	0	-1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	0	-1
3	A4.3	Atlantic and Mediterranean low energy circalittoral rock	1	0	1	1	0	0	0	0	-1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1
3	A4.4	Baltic exposed circalittoral rock																										
3	A4.5	Baltic moderately exposed circalittoral rock																										
3	A4.6	Baltic sheltered circalittoral rock																										
3	A4.7	Features of circalittoral rock	0	0	0	1	0	0	1	1	-1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	-1	-1	
2	A5	Sublittoral sediment	1	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	1	1	
3	A5.1	Sublittoral coarse sediment	1	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	0	-1	
3	A5.2	Sublittoral sand	1	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	1	1	1	
3	A5.3	Sublittoral mud	1	1	1	1	1	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	1	
3	A5.4	Sublittoral mixed sediments	1	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	
3	A5.5	Sublittoral macrophyte-dominated sediment	1	1	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	-1	
3	A5.6	Sublittoral biogenic reefs	0	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
3	A5.7	Features of sublittoral sediments	0	0	0	0	0	0	0	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	0	0	0	
2	A6	Deep-sea bed	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
3	A6.1	Deep-sea rock and artificial hard substrata	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
3	A6.2	Deep-sea mixed substrata	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
3	A6.3	Deep-sea sand	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
3	A6.4	Deep-sea muddy sand	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
3	A6.5	Deep-sea mud	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
3	A6.6	Deep-sea bioherms	-1	-1	-1	0	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

		Open coast and shelf seas														Coastal and shelf bed-form features																					
Enclosed coast		Shallow coastal plain features														Shelf plain features				Coastal and shelf bed-form features																	
		Semi-enclosed coastal features				Shallow coastal plain features										Shelf plain features				Coastal and shelf bed-form features																	
EUNIS level	EUNIS code	EUNIS name	Lagoon	Estuary	Ria	Sealoch/Voe	Embayment	Barrier beach	Sound or strait	Bay	Photoc rock	Aphotic rock	Weak tide stress shallow coarse sediment plain	Moderate tide stress shallow coarse sediment plain	Strong tide stress shallow coarse sediment plain	Weak tide stress shallow mixed sediment plain	Moderate tide stress shallow mixed sediment plain	Strong tide stress shallow mixed sediment plain	Shallow sand plain	Shallow mud plain	Weak tide stress shelf coarse sediment plain	Moderate tide stress shelf coarse sediment plain	Strong tide stress shelf coarse sediment plain	Weak tide stress shelf mixed sediment plain	Moderate tide stress shelf mixed sediment plain	Strong tide stress shelf mixed sediment plain	Shelf sand plain	Shelf mud plain	Subtidal sediment bank	Shelf mound or pinnacle	Shelf trough	Pockmark field					
3	A6.7	Raised features of the deep-sea bed	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
3	A6.8	Deep-sea trenches and canyons, channels, slope failures and slumps on the continental slope	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
3	A6.9	Vents, seeps, hypoxic and anoxic habitats of the deep sea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
2	A7	Pelagic water column	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
3	A7.1	Neuston	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
3	A7.2	Completely mixed water column with reduced salinity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
3	A7.3	Completely mixed water column with full salinity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
3	A7.4	Partially mixed water column with reduced salinity and medium or long residence time	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
3	A7.5	Unstratified water column with reduced salinity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
3	A7.6	Vertically stratified water column with reduced salinity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3	A7.7	Fronts in reduced salinity water column	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3	A7.8	Unstratified water column with full salinity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3	A7.9	Vertically stratified water column with full salinity	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3	A7.A	Fronts in full salinity water column	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2	A8	Ice-associated marine habitats	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3	A8.1	Sea ice	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
3	A8.3	Brine channels	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	A8.4	Under-ice habitat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Annex 8: Biological validation of the seabed features

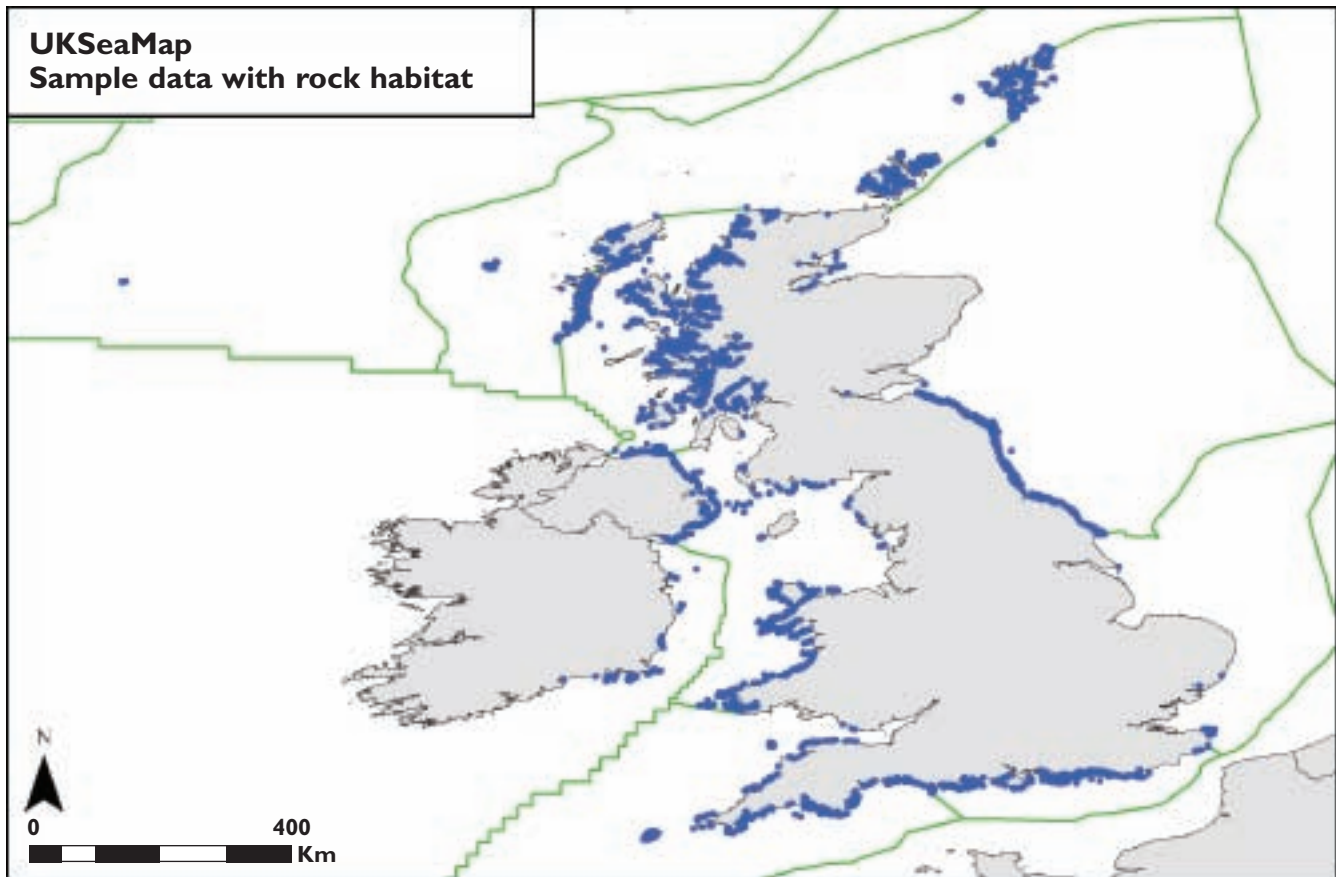
The following table provides further detail on the results of the seabed biological validation process. This information is provided in summary in Table 7.

Landscape type	By Cell				By Landscape type				Expected	Min. % correlation (expected)	Max. % correlation (expected + uncertain)	Habitat types not matching	Comments
	Total no. of cells	No. of cells not validated	No. of cells validated	% cells validated	Total no. of samples	Not expected	Uncertain						
Enclosed coast													
Lagoon	27	2	25	93	137	6	39	92	67	96			
Estuary	539	3	536	99	3697	20	1556	2121	57	99			
Ria	78	2	76	97	965	27	309	629	65	97			
Sealoch	1101		1101	100	6640		449	6191	93	100			
Embayment	138	2	136	99	861	32	423	406	47	96			
Open coast and continental shelf													
Semi-enclosed coastal features													
Barrier Beach	0												
Sound	36		36	100	410	13	199	198	48	97			
Bay	510	1	509	100	1459	10	559	890	61	99			
Shallow coastal plain features													
Photic rock	284	90	194	68	1637	640	5	992	61	61	CR; SS.SMp; SS.SCS	Lack of 'rock' data within BGS data set	
Aphotic rock	51	31	20	39	225	145		80	36	36	IR types	Poor distinction remains between photic/aphotic (infralittoral/circalittoral) despite amendments to light attenuation boundary	
Shallow coarse sediment plain - weak tide stress	793	556	237	30	2747	2126	20	601	22	23	Rock types; SS.SMp; SS.SSa	% Correlation increases when area outside buffer is taken alone	
Shallow coarse sediment plain - moderate tide stress	825	385	440	53	3293	2067	116	1110	34	37	Rock types; SS.SMp; SS.SSa	% Correlation increases when area outside buffer is taken alone	
Shallow coarse sediment plain - strong tide stress	259	150	109	42	1104	820	18	266	24	26	Rock types; SS.SMp; SS.SSa	% Correlation increases when area outside buffer is taken alone	
Shallow mixed sediment plain - weak tide stress	204	153	51	25	653	492	19	142	22	25	Rock types; Infralittoral sands		
Shallow mixed sediment plain - moderate tide stress	39	27	12	31	303	225	6	72	24	26	Rock types; SS.SCS		
Shallow coarse sediment plain - strong tide stress	15	9	6	40	109	88	2	19	17	19	Rock types; SS.SCS		

Landscape type	By Cell				By Landscape type							Comments
	Total no. of cells	No. of cells not validated	No. of cells validated	% cells validated	Total no. of samples	Not expected	Uncertain	Expected	Min. % correlation (expected)	Max. % correlation (expected + uncertain)	Habitat types not matching	
Shallow sand plain	1127	648	479	43	4063	2669	229	1165	29	34	Rock types; SS.SCS	% Correlation improves outside coastal buffer; but still ~350 samples were assigned to SS.SCS
Shallow mud plain	256	132	124	48	658	446	59	153	23	32	Rock types	% validated increases to 80% when the area outside the buffer is examined
Shelf plain features												
Shelf coarse sediment plain - weak tide stress	90	84	6	7	226	219	7		0	3	SS.SCS,ICS	Poor distinction between shallow/shelf landscapes; HMP problem
Shelf coarse sediment plain - moderate tide stress	174	164	10	6	433	420	12	1	0	3	SS.SCS,ICS	Poor distinction between shallow/shelf landscapes; HMP problem
Shelf coarse sediment plain - strong tide stress	19	17	2	11	55	52	3		0	5	SS.SCS,ICS	Poor distinction between shallow/shelf landscapes-HMP problem; very low sample size
Shelf mixed sediment plain - weak tide stress	17	10	7	41	58	50	6	2	3	14		Sample size too low for results to be reliably interpreted
Shelf mixed sediment plain - moderate tide stress	6	3	3	50	7	4	1	2	29	43		Sample size too low for results to be reliably interpreted
Shelf mixed sediment plain - strong tide stress	0											No samples
Shelf sand plain	767	713	54	7	2029	1945	72	12	1	4	Mud types; Sandy muds; SS.SCS	Poor distinction between sand and mud-367 samples are in 'mud' rather than sand.
Shelf mud plain	194	66	128	66	446	199	194	53	12	55	Rock types; Muddy sands; Infralittoral muds	Many rock samples found in mud within coastal buffer - % validated increases to 70% when the area outside the buffer is examined
Coastal and shelf bed-form features												
Subtidal sediment bank	9		9	100	16	2	9	5	31	88		
Shelf mound or pinnacle	13		13	100	53		18	35	66	100		
Shelf trough	33	2	31	94	137	51	58	28	20	63	IR types	
Pockmark field	0											

Landscape type	By Cell			By Landscape type							Comments	
	Total no. of cells	No. of cells not validated	No. of cells validated	% cells validated	Total no. of samples	Not expected	Uncertain	Expected	Min. % correlation (expected)	Max. % correlation (expected + uncertain)		Habitat types not matching
Continental slope and deep sea												
Continental slope and deep sea topographic and bed-form features												
Continental slope	2	2	0	0	17	17			0	0		No types in LUT to validate feature
Iceberg plough mark zone	0											No types in LUT to validate feature
Canyon	0											No samples
Deep ocean rise validate feature	2	2	0	0	27	27			0	0		No types in LUT to validate feature
Carbonate mound	0											No samples
Deep-water mound	0											No samples
Continental slope and deep sea plain features												
Warm deep-water coarse sediment plain	1	1	0	0	1	1			0	0		No types in LUT to validate feature
Cold deep-water coarse sediment plain	0											No samples
Warm deep-water mixed sediment plain	0											No samples
Cold deep-water mixed sediment plain	0											No samples
Warm deep-water sand plain	0											No samples
Cold deep-water sand plain	0											No samples
Warm deep-water mud plain	0											No samples
Cold deep-water mud plain	0											No samples

Annex 9: Map illustrating distribution of benthic sample data for rock habitats



Consideration was given as to whether these data could be used to modify the seabed substratum data set prior to undertaking the modelling analysis. However, the significant differences in scale of the two data sets meant that it was inappropriate to combine the data.

Annex 10: Data sets used in UKSeaMap

Parameter	Data set	Date	Source	Processing	Boundaries (categories)
Bottom temperature	Minimum bottom temperature	1973-1999	ICES	Spline interpolation	4°C isotherm (Warm deep water, Cold deep water)
Fronts	Front probability	10 year simulation of POLCOMS	POL	Inverse distance weighted interpolation	0.15 (Non-frontal and Frontal)
Photic depth	Annual mean light attenuation	1998-2004 for January to August and 1997-2003 for September to December	Data supplied by POL, derived from SeaWiFS.	Inverse distance weighted interpolation	1% of light reaches seabed (Photic and Aphotic zones)
Salinity	Sea surface salinity	10 year simulation of POLCOMS	POL	Inverse distance weighted interpolation	30 ppt, 34 ppt and 35 ppt (Estuarine, ROFI, Shelf and Oceanic)
Seabed disturbance (tides)	Maximum seabed tide stress	2000-2004	POL	Inverse distance weighted interpolation	1.8 Newtons/m ² and 4.0 Newtons/m ² (Weak, Moderate and Strong)
Seabed disturbance (waves)	Maximum wave length	Over 10-year period	POL	Inverse distance weighted interpolation	Wave base (Shallow and Shelf)
Stratification	Surface to seabed temperature difference	10 year simulation of POLCOMS	POL	Inverse distance weighted interpolation	0.5°C and 2.0°C (Well mixed, Frontal and Stratified)
Substrata	DigSBS250 seabed sediments	NA	British Geological Survey	Simplification of the Folk categories; supplemented with other data	Mud and sandy mud, Sand and muddy sand, Mixed sediment, Coarse sediment and Rock
Topography	Digital Elevation Models and bathymetric contour data (DigBath250)	NA	Gebco, SeaZone, BGS	Slope calculation	Various topographic features

Annex 11: Other water column data sets

The following data sets were not used in the water column analysis.

Surface sea temperature

Temperature is an important parameter for many biological processes which ultimately determine biological community characteristics and can be used to describe biogeographic changes. It was considered that maximum and minimum temperatures may be the most biologically meaningful aspect of temperature, as species are influenced by low temperature through mortality and their inability to reproduce and by high temperatures which influence breeding and larval survival. This includes benthic species which often have a larval stage.

Sea surface temperature (SST) data, based on 8-day composites on an equal angle grid (~9km resolution) from the NASA/NOAA pathfinder Advanced High Resolution Radiometer were obtained (see <http://podaac.jpl.nasa.gov/products/product102.html>). The 15 years (1985-1999) of satellite measurements were averaged to give seasonal means and standard deviation.

Unfortunately there is no simple relationship between temperature and biology as some species distributions are influenced by lowest temperature and some by highest. The UK is in the middle of major biogeographic provinces: most species extend further north and south than the British Isles in the north-east Atlantic so there are few clear boundaries.

Stratification data sets

These data are extracted from a 10-year simulation of the Proudman Oceanographic Laboratory Coastal Ocean Modelling System (POLCOMS; Holt and James 2001) applied to the north-west European Shelf. This is the 'Medium Resolution Continental Shelf' domain described by Holt *et al.*, (2005) and run operationally at the Met. Office in a 7-day hind cast mode (see <http://www.metoffice.gov.uk/research/ncof/mrcs/browser.html>).

Stratification probability

The stratification probability density function is defined as the number of days the surface to bed temperature difference at this cell exceeds 0.5°C divided by the number of days in this season over the 10-year run. The stratification data set has not been incorporated into the classification process as the front probability and the surface to bed temperature difference data sets provide a more detailed description of water column stratification.

Potential energy anomaly

The potential energy anomaly is a measure of the energy required to overcome stable stratification and completely mix the water column (see Simpson and Bowers 1981). Potential energy anomaly were not used within the water column classification analysis as both surface to bed temperature difference and front probability have been used to describe the level of stratification in the water column.

Mixed layer depth

Mixed layer depth (i.e. the depth to which surface waters are mixed) replicates categories described above using surface to bed temperature difference data and does not appear to bring anything extra to the water column type classification so it has not been included.

Annex 12: Glossary

ArcGIS Spatial Analyst – A set of spatial modelling and analysis tools produced by ESRI.

Classification Tree – A table of decisions and their possible consequences used to create a plan to reach a goal.

Digital Elevation Model (DEM) – A digital file, usually in raster form, describing the terrain and elevation of a given area.

Data layer – A collection of similar geographic features, such as estuaries, carbonate mounds and rock, referenced together for display on a map.

Geographic Information System (GIS) – A collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. The UKSeaMap project was undertaken using ESRI's ArcGIS 8.3 software application.

Highest Astronomical Tide (HAT) – The highest level to which the tide can be expected to occur under average meteorological conditions.

Inverse distance weighted interpolation - Within ArcGIS data points can be interpolated into continuous raster layers using a set of Spatial Analyst functions that predict values for a surface from a limited number of data points. Inverse distance weighted interpolation estimates values by averaging the values of sample data points in the vicinity of each cell. The closer a point is to the centre of the cell being estimated the more influence it has in the averaging process. A minimum number of measured points, to use within each neighbourhood, need to be defined. When there are fewer measured points than the specified minimum, the search radius will increase until it can encompass the minimum number of points. The power function used in the algorithm controls the weighting of known points on the interpolated values based on their distance from the output point. A power of two was used in UKSeaMap to ensure a balance between weightings of near and distant points, and results in a relatively smooth surface.

Mean High Water Datum – The average of the high water heights over a period.

Metadata – Structured, encoded data that describe characteristics of information-bearing entities to aid in the identification, discovery, assessment, and management of the described entities.

North Atlantic Drift – An ocean current in the North Atlantic, which is a branch of the Gulf Stream.

Photoperiodism – The physiological reaction of organisms to the length of day or night.

Raster Calculator – A Spatial Analyst function that provides a powerful tool for performing mathematical calculation.

Raster Data – Raster data refers to the storage of spatial data in the form of a continuous field of uniform cells, each with an associated value.

Shapefile – A set of files that contain a set of points, arcs, or polygons (or features) that hold tabular data and a spatial location.

Slope Function – The slope function calculates the maximum rate of change between each cell and its neighbour. Every cell in the output raster has a slope value. The lower the slope value, the flatter the terrain; the higher the slope value, the steeper the terrain. The output can be calculated as a percentage or degree.

Spline method - an interpolation method in GIS in which cell values are estimated using a mathematical function that minimizes overall surface curvature, resulting in a smooth surface that passes exactly through the input points.

Supervised Classification – A classification system that allows the specialist to choose and set up discrete classes thus supervising the selection and assigning them category names.

Unsupervised Classification – A classification system that uses algorithms to cluster multivariate data based solely on the values of the inputs, without any training.

Vector Data – Vector data type refers to the storage of spatial data in the form of points, lines and polygons.

JOINT NATURE CONSERVATION COMMITTEE

The Joint Nature Conservation Committee (JNCC) is the statutory adviser to Government on UK and international nature conservation. Its work contributes to maintaining and enriching biological diversity, conserving geological features and sustaining natural systems.

JNCC delivers the UK and international responsibilities of the Council for Nature Conservation and the Countryside (CNCC), the Countryside Council for Wales (CCW), Natural England, and Scottish Natural Heritage (SNH).

The functions that arise from these responsibilities are principally to:

- advise Government on the development and implementation of policies for, or affecting, nature conservation in the UK and internationally;
- provide advice and disseminate knowledge on nature conservation issues affecting the UK and internationally;
- establish common standards throughout the UK for nature conservation, including monitoring, research, and the analysis of results;
- commission or support research which it deems relevant to these functions.

The Committee comprises 14 members: a Chairman and five independent members appointed by the Secretary of State; the Chairman of CNCC; the Chairmen or deputy Chairmen of CCW, Natural England and SNH; and one other member from each of these bodies.

JNCC, originally established under the Environmental Protection Act 1990, was reconstituted by the Natural Environment and Rural Communities Act 2006. Support is provided to the JNCC by a company limited by guarantee (JNCC Support Co) that the Committee established in 2005.

Details of publications produced by JNCC are available from:
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