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# Defining biological assemblages (biotopes) of conservation interest in the submarine canyons of the South West Approaches (offshore United Kingdom) for use in marine habitat mapping

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ABSTRACT

In 2007, the upper part of a submarine canyon system located in water depths between 138 and 1165 m in the South West (SW) Approaches (North East Atlantic Ocean) was surveyed over a 2 week period. High-resolution multibeam echosounder data covering 1106 $km^2$, and 44 ground-truthing video and image transects were acquired to characterise the biological assemblages of the canyons. The SW Approaches is an area of complex terrain, and intensive ground-truthing revealed the canyons to be dominated by soft sediment assemblages. A combination of multivariate analysis of seabed photographs (184–1059 m) and visual assessment of video ground-truthing identified 12 megabenthic assemblages (biotopes) at an appropriate scale to act as mapping units. Of these biotopes, 5 adhered to current definitions of habitats of conservation concern, 4 of which were classed as Vulnerable Marine Ecosystems. Some of the biotopes correspond to descriptions of communities from other megahabitat features (for example the continental shelf and seamounts), although it appears that the canyons host modified versions, possibly due to the inferred high rates of sedimentation in the canyons. Other biotopes described appear to be unique to canyon features, particularly the sea pen biotope consisting of *Kophobelemnon stelliferum* and ceriantheids.



## 1. Introduction

Submarine canyons are topographically complex features (Harris and Whiteway, 2011) that are incised into many of the world's continental shelves and margins (e.g. Hickey, 1995; Brodeur, 2001). Canyons have been reported as containing diverse bottom types (Kottke et al., 2003), described as areas of high habitat heterogeneity (Schlacher et al., 2007), and are suggested to enhance biodiversity on landscape scales (Vetter et al., 2010). The presence of submarine canyons on the continental slope can significantly alter the hydrodynamic regime of the region, thus canyons may be highly unstable environments subject to periodically intense currents, debris transport, sediment slumps and turbidity flows (Shepard and Marshall, 1973; Inman et al., 1976; Gardner, 1989).

Canyons may act as conduits, transporting sediment and organic matter from the continental shelf to the deep sea (Shepard, 1951; Heezen et al., 1955; Monaco et al., 1990), and can be areas of enhanced production and species diversity as a result of the accumulation of organic matter and/or upwelling of nutrient rich waters (Hickey, 1995).

Submarine canyons have been suggested to play a role in generating areas of high megabenthic biodiversity due to their complex topographies (Schlacher et al., 2007). Canyon fauna flourish as a result of suspension feeding organisms benefiting from accelerated currents within canyons (Rowe, 1971) as well as increased secondary production (Vetter et al., 2010) due to the exploitation of local increases in zooplankton during vertical migration (Greene et al, 1988). In addition, detritivores benefit from enhanced sedimentation rates and accumulated macrophytic detritus (Vetter, 1994; Harrold et al., 1998). However, a high incidence of disturbance through sediment transport by intense tidal currents, turbidity currents and detrital flows may be unfavourable to sessile invertebrate megafauna while favouring highly motile species (Rowe, 1971; Vetter and Dayton, 1999; Vetter et al., 2010).

Topographic features such as canyons, which provide enhanced food supply, diverse habitats, and alter hydrodynamic activity have

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been described as 'Keystone structures' (Vetter et al., 2010). Keystone structures are defined as "distinct spatial structures providing resources, shelter or 'goods and services' crucial for other species" (Tews et al., 2004). Those canyons which act as keystone structures, and may be described as biodiversity hotspots, merit special attention in management (Smith et al., 2008). The inclusion of canyons as examples of topographical features that may potentially support Vulnerable Marine Ecosystems (VMEs) (FAO, 2009) reflects this.

Establishing a representative network of deep-sea Marine Protected Areas offers one tool with which to address the conservation needs of the deep sea. The need to establish such networks is driven by a number of international and national policies. The United Nations Convention of the Law of the Sea (UNCLOS) is an international agreement that provides the legal basis for high seas Marine Protected Areas (UNCLOS 1982). The Convention on Biological Diversity (CBD) is an international legally binding treaty which includes within it a requirement for nations to establish a 'comprehensive, effectively managed and ecologically representative network of Marine Protected Areas by 2020' [(COP 10 Decision X/2) CBD 2010]. The Oslo-Paris Convention (OSPAR) is the current legal mechanism guiding international cooperation on the protection of the marine environments of the North-East Atlantic; the agreement is between 15 European countries and the European Commission. Annex V of the OSPAR convention (The convention for the protection of the Marine Environment of the North East Atlantic) lists a number of deep-sea habitats as 'threatened or declining', including: seamounts, *Lophelia pertusa* reefs, coral gardens, carbonate mounds, and sea pen and burrowing megafauna communities. It calls for nations to establish, "an ecologically coherent network of well managed Marine Protected Areas by 2020" for the protection of these listed habitats.

Within Europe, the main legislative power for managing fisheries and marine nature conservation is based on the Common Fisheries Policy and Habitats Directive (92/43/EEC). The Habitats Directive (conservation of the natural habitats of wild fauna and flora) is the first international tool to address the protection of selected habitats and species, listed under the Directive's Annexes I (habitats) and II (species). The Habitats Directive requires member states to designate and protect sites as Special Areas of Conservation (SACs). These protected areas together create the *Natura 2000* sites, a network of protected areas throughout the EC. Cold-water coral reefs, coral gardens and sponge dominated communities all come under the definition of Annex I listed 'reef' habitat.

The challenge now is how to practically implement such networks given our limited understanding of the deep sea ecosystem. While a number of deep-sea habitats have been identified as vulnerable to anthropogenic activities (e.g. cold-water coral reefs and sponge aggregations) (FAO, 2008), poor knowledge of the distribution of these habitats hinders conservation efforts and network planning. Additionally, it is difficult to use criteria (such as those set out by the FAO) that have been developed for assessing habitat vulnerability (FAO, 2008) as many deep-sea habitats have yet to be described, particularly in terms of their rarity, resistance, resilience and vulnerability. For example, although some habitats, such as cold-water coral reefs, are easily damaged from activities such as bottom trawling, it is not cold-water coral reefs that are subject to repeated trawling action in the way that some soft bottom deep-sea habitats are (Thrush et al., 2001). Additionally, to create the synergy needed for an MPA network design, a better understanding is urgently needed of which species are present, their distribution, and some detail about their connectivity; this may be achieved through the use of physical oceanography proxies and/or knowledge about species reproduction/larval dispersal.

For nations to fulfil their legal requirements in terms of conservation they require maps that inform them of the spatial distribution of species and habitats. In light of the vast area covered by the deep sea, numerous approaches have been adopted to mapping, with a view to preserving deep-sea habitats (Harris and Whiteway, 2009; Howell, 2010). Mapping at a landscape scale (megahabitat scale of kilometres to tens of kilometres; *sensu* Greene et al., 1999), using large topographic features such as submarine canyons, allows large areas to be covered using lower resolution data, and is thus both cost and time effective. Whilst mapping at this scale may be appropriate for generalised, global conservation efforts, these mapping units have less ecological or biological meaning due to their lack of detail. Most ecological and biological processes occur at a finer scale. Therefore, the production of meaningful fine-scale habitat maps ($<1$ km) which adequately take into account lateral and vertical variation within these megahabitat features is necessary. In recent years significant research effort has been focused on seamount features, adding much to our understanding of these systems (Clark et al., 2010; Howell et al., 2010a; Rowden et al., 2010; Shank, 2010). However, contrastingly, submarine canyons are more poorly sampled, and thus less well understood (De Leo et al., 2010).

To implement ecologically representative networks, biologically meaningful maps are required to inform managers on the distribution and diversity of habitats. To adequately protect species and habitats, particularly those that are listed as being of conservation interest, the approach taken needs to be at a scale that is relevant to the biology. Taking a bottom-up approach, through first defining benthic assemblages that can then act as fine-scale mapping units, cannot only be used to inform the distribution of assemblages, but may also allow the inference of associations between biology and larger scale features (geomorphology), which may then enable these large scale features to be used for mapping across broad areas. To achieve an ecologically coherent network across regions, and globally, we need to be able to combine habitat maps originating from national and international programmes. To date deep-sea maps produced by different projects/countries are not able to be combined because of a lack of an agreed deep-sea classification system and recognised and agreed definitions of mapping units. To overcome this, standardisation of mapping practices is necessary, with consistent terms used.

To adequately protect vulnerable habitats, there is a need for clarity in the working definitions used. Habitats such as *Lophelia pertusa* reefs have been widely documented (Wilson, 1979; Mortensen et al., 1995; De Mol et al., 2002) and the definition of these habitats are more widely recognised. There are few descriptions of benthic assemblages from canyon systems (Schlacher et al., 2010), and none in the context of statistically defining units for use in habitat mapping, or assessing the potential conservation value of canyons. Consequently, the objective of this study is to: support international habitat mapping efforts through developing standardised descriptions of deep-sea biological assemblages, with a focus on assemblages that fit descriptions of 'listed' habitats, for use as functional and consistent mapping units (biotopes).

## 2. Material and methods

### 2.1. Study area

The SW Approaches study area is located on the Celtic Margin and is an area characterised by a number of submarine canyons (Fig. 1; Huthnance et al., 2001; Mulder et al., 2012). The upper reaches of three canyons were the target of this investigation. Two