Appendix 6. The Geo-marine resources of the South Dorset Coast Marine Natural Area by Professor Denys Brunsden.

This document is a first attempt to define the 'stories' and 'geo-values' which could justify planning designations in the new South Dorset Coast marine natural area in Weymouth Bay in Dorset, UK. It is based on a two hour discussion of the available information in the DCC offices. It could be greatly improved by a group discussion involving a wider group of specialists.

In 2001 UNESCO awarded natural World Heritage status to the Dorset and East Devon Coast (the Jurassic Coast) emphasizing the values of 'rocks, fossils and landforms'. This endorsement raised the site to international status and it is the only natural heritage site in England. It is one of the most famous geological sections in Britain and many consider it the most important Jurassic-Cretaceous section in the world (BGS 1996, Dorset County Council et al 2000, Donovan and Stride 1961, Underhill and Stoneley 1998, West 2009).

As part of the Finding Sanctuary Project the offshore areas have been carefully surveyed to establish the important marine habitats worthy of conservation. (Collins 2003, 2005, 2006, RPS 2005, and Seastar Survey Ltd 2010). Because of the onshore geological interest an exercise is now taking place to examine whether that interest extends offshore. A marine swath bathymetry survey (unfortunately without shallow seismic survey) for the habitat study is available (Axelsson 2011) and could be mapped by geo-scientists if the highest resolution data and suitable mapping software were available.

The DORIS imagery gives a remarkable picture of the geo-marine features of the seabed. It is immediately obvious that the geo-features are quite the equal of those on land. Since these are all the subject of comprehensive conservation designations, including World Heritage Status it is realistic to comment on whether the proposed 'habitats' selected for conservation should be supplemented to include the seafloor geology and geomorphology. To make boundary or designation decisions, however, it is necessary to provide criteria which be justified in any legal challenge. There is no agreed national or international rationale, working party, register of landforms, or Geological Conservation Review (Connor et al 2004). A desk study (MSc project) has been carried out by to establish the state of geological knowledge but there has not been an attempt to carry out detailed mapping, monitoring or geotechnical sampling (Gales, J. 2011). The process is at the very beginning. The first step, therefore, has been to outline the possible 'stories' that the marine zone can represent and to attempt to place a 'value' on them. The 'stories' fall into seven main groups which may also provide a starting point for a more general framework.

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Geological Framework

The conservation area includes remarkable geological features which could be used to give improved knowledge of the Jurassic and Cretaceous geological framework including the development and detail of the complex fold, fault and joint patterns of the Dorset coast and improvement of the original World Heritage story- the Mesozoic 'Walk through Time'.

Sedimentary History

The complex sedimentary history of the Middle- Upper Jurassic and Lower Cretaceous deposition of the Wessex Basin. The Kimmeridgian and Portland limestones are superbly portrayed to reveal the detail of the famous cycles and rhythms of deposition with clarity as good as the best sections on land.

Rocks and Relief

One of the most important stories of the World Heritage site is the textbook illustration of the relationship between rocks and relief which are taught to all British schoolchildren (May and Hansom 2003). It is a prime example of the development of longitudinal, concordant and transverse, discordant coasts compared internationally to that of Dalmatia. For the first time this story can be seen in spatial context together with the full offshore distributions of the controlling structures.

The rocks and relief story is continued by the wonderfully portrayed layout of rock ledges, exposing the spatial structure of the anticlines and revealing important details of faulting, jointing and rock ledge morphology and evolution. In addition the contrasts between the morphological expression of the Middle Jurassic, Kimmeridgian, Portland, Purbeck and Cretaceous outcrops contrasts strongly with the weathered and soil covered outcrops on land. The sabkha and subsidence structures of the Purbeck beds are superb.

Sedimentary structures and on-going geological processes

The area is rich in sedimentary structures at all scales. Entire sedimentary repositories are revealed including sand waves, mega-ripples, ripples, palaeo-spits and drapes. Of particular interest are low, scoured areas in the clays which appear to have formed a vale at times of low sea level and probably became a lagoon with two channels forming meandering exits as sea level rose. These features may also have been connected to the onshore valley systems at Lulworth and Arish Mell but the exact connection has been lost by erosion as sea level rose. It is possible that the low areas and the two deeps may contain Pleistocene/Holocene deposits which will reveal the environmental history. (Bastos et al 2003, Pingree 1978).

The sea level history.

On land there is a well studied inter-glacial raised beach sequence. The new imagery shows that this may be only a small part of an extended sequence underwater. The sea floor has a succession of terraces, shore platforms and cliff lines to a depth of -100m. There are palaeo-drainage extensions and shorelines. It is known that there is at least one strongly developed Holocene submerged shoreline along this entire coast so it will be possible to greatly extend our knowledge of these features in the new area. It may be possible to map the shorelines

with the new imagery and perhaps, with sampling, to establish a new Holocene chronology. The proposed conservation area contains landforms, including submerged caves, which may provide new data on sea level change, drainage development on exposed sea floors, drainage truncation, and the nature of sea floor development during sea level rise and the nature of sediment draping during the Holocene.
Perhaps the most important are the tidal flow features, bay circulations and subsequent isolation of sediment accumulation zones. Associated with these are the tidal ebb and flood 'deeps' which have developed as a time sequence over the last glacial/Holocene cycle. There is a unique opportunity to add to our knowledge of these landforms and to connect them to the evolution of such iconic features as Chesil beach. The deeps are of great interest in view of the extensive modern research into the origin of the deep fluvial landforms of the English Channel (e.g. Paphitis et al 2010).

On-going geomorphological processes.
In keeping with the requirements of Criterion viii of the World Heritage procedure the MCA includes the development of rocky and soft rock cliffs under a variety of coastal wave and tide conditions (May and Hansom 2003). A fundamental geomorphological question underlies all of these 'stories' based on the idea of whether there is a *'connectivity or continuity between land and sea processes and landforms'*

Areas of Seabed Geological Interest
The following areas were selected for consideration during the preliminary discussion. It must be emphasised, however, that this was a very brief discussion and the selection requires detailed review by a specialist team of experts.

The Context Box
Aspects of the geological history of the Wessex Basin including the development and detail of the Purbeck anticline and Shambles syncline; the complex fault and joint patterns which further elucidate the story of mid-Cretaceous tension and later Tertiary compressional activity. The box includes a display of the sedimentary structures of the Weymouth bay wave and tide circulation cell. The depth range ensures that the age range of the seabed covers most of the Holocene. This consideration may not have been included in the habitat selection.

The Context Box and the Kimmeridge-Purbeck Anticline Ledges
The complex sedimentary history of the Middle- Upper Jurassic and Lower Cretaceous deposition. The Kimmeridgian and Portland limestones are superbly portrayed to reveal the detail of the famous cycles and rhythms of deposition. The evolution of the ledges and the successive development of shore platforms under conditions of rising sea level is an important geomorphological story.

The Near Shore Geological Structures (White Nothe to Worbarrow Tout)
One of the most important stories of the world heritage site is the textbook illustration of the relationship between rocks and relief. The landforms of Stair Hole, Lulworth Cove,

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Worbarrow Bay and Durdle Door are taught to all British schoolchildren. It is a prime example of the development of longitudinal, concordant and transverse, discordant coasts compared internationally to that of Dalmatia. For the first time this story can be seen in spatial context together with the full offshore distributions of the controlling structures. This section also shows the degree of connection between onshore and offshore landforms and geomorphological systems. For example, the fine unstudied landslides of White Nothe, Gad Cliff and St Albans Head have underwater extensions indicating the relationship between sea level rise, cliff retreat and slope instability. The fluvial history is almost entirely erased which raises implications about the level at which the inland valleys were developed.
The rocks and relief story is continued by the wonderfully portrayed layout of rock ledges, exposing the spatial structure of the Purbeck and Lulworth Banks anticlines. The fault patterns first revealed by Donovan and Stride (1961) are much more detailed than the original side-scan sonar imagery and the geological story of structural evolution of the Wessex basin is enhanced. In addition the contrasts between the morphological expression of the Middle Jurassic, Kimmeridgian, Portland, Purbeck and Cretaceous outcrops contrasts strongly with the weathered and soil covered outcrops on land. The sabkha and subsidence structures of the Purbeck beds are superb.

The Shambles-Sedimentary structures and on-going geological processes

The area is rich in sedimentary structures at all scales. Entire sedimentary sinks and repositories are revealed in the Adamant Banks, the Shambles Banks and the Portland banks. Sand Waves, Mega-ripples, ripples, palaeo-spits and drapes are common. Two areas are selected as particularly important, the Shambles and the sediments and palaeo-spits of the Portland Deep.

St Albans Ledge and Deep

Of particular interest are the low, scoured areas in the Kimmeridge clays below the Portland Sand and Stone ridge. This appears to have formed a vale as the less resistant rocks were eroded by tidal currents and, at low sea level probably became a lagoon with two channels forming meandering exits. It is possible that the low areas and the two deeps may contain Pleistocene/Holocene deposits which will reveal the environmental history. Only a small area has been selected but it should be noted that the Portland Stone/Sand ridge crosses the whole area and may be a significant sea level/shoreline marker (c. 30m deep).

Portland Bill/Deep and the Sea Level History

On land we have a well studied inter-glacial raised beach sequence at Portland Bill. The new imagery shows that this may be only a small part of an extended sequence. The sea floor below Portland has a succession of terraces, shore platforms and cliff lines to -100m. There are palaeo-drainage extensions and shorelines. It is known that there is a strongly developed Holocene submerged shoreline along this entire coast as far as Start Point so it is likely that it may be possible to confirm these features in the new area. It is also known that there is a shoreline at -18m at the proposed Portland Gas Site. It is possible to map these features with the new imagery and perhaps to establish a new Holocene chronology. The proposed conservation area contains landforms which may provide new data on sea level change,

drainage development on exposed sea floors, drainage truncation, and the nature of sea floor development during sea level rise and the nature of sediment draping during the Holocene.

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