Estuaries are complex ecosystems linking the terrestrial and aquatic environments and are composed of an interdependent mosaic of subtidal, intertidal and surrounding terrestrial habitats. There is a gradient of salinity from freshwater at the head to increasingly marine conditions towards the open sea. Input of sediment from the river, shelter from wave action and often, low current flows lead to the presence of extensive sediment flats. Similar large geomorphological systems where seawater is not significantly diluted by freshwater are classified within the Annex I habitat *Large shallow inlets and bays***.** The intertidal and subtidal sediments of estuaries support biological communities that vary according to geographic location, the type of sediment, tidal currents and salinity gradients within the estuary. The parts of estuaries furthest away from the open sea are usually characterised by soft sediments and are generally more strongly influenced by fresh water.
Many habitats found within estuaries, such as intertidal mudflats and sandflats, sandbanks, saltmarshes and rocky reefs, are identified as notified features in their own right and are covered in separate guidance. Estuaries may also support populations of important species. The physiographical character of estuaries is similar to that of a large shallow inlet and bay but is influenced to a greater extent by freshwater.

Large shallow inlets and bays are large indentations of the coast, which are generally more sheltered from wave action than the open coast. They are relatively shallow and usually average less than 20m in water depth. They are complex systems linking the aquatic and terrestrial environments and are composed of a mosaic of marine and surrounding transitions to terrestrial habitats. The selection of European marine sites favoured larger areas, which tended to encompass the greatest variety of habitat and community types (Brown *et al.*, 1997).

Intertidal mudflats and sandflats are submerged at high tide and exposed at low tide. Their physical structure can range from the mobile, coarse sand beaches of wave exposed coasts to the stable, fine sediment mudflats of estuaries and embayments. This is a widespread habitat type which occurs throughout the UK. European marine sites were selected to encompass the ecological variation across the geographical range of this habitat type in the UK (Brown *et al.,* 1997).

Subtidal sandbanks consist of sandy sediments that are permanently covered by shallow seawater, typically at depths of less than 20m below chart datum (but sometimes including channels or other aereas greater than 20m deep). The habitat comprises distinct banks (i.e. elongated, rounded or irregular 'mound' shapes), which may arise from horizontal, or sloping plains of sandy sediment. Where these areas of sandy sediment are closely associated with the banks, they are included within the habitat type.

Reefs are rocky marine habitats or biological concretions that rise from the seabed. They occur widely round the UK coast. They are generally subtidal but may occur as continuous transition into the intertidal zone and are consequently exposed to air at low tide. There are two main types of reef, biogenic and rocky. Biogenic reefs are formed by invertebrates such as honeycomb worm, *Sabellaria aveolata* or mussels, *Mytelis edulis.* Rocky reefs are raised rock that may be colonized by plant and animal communities.

Sub features

Glasswort *Salicornia* spp and other annuals, referred to in this document as **pioneer saltmarsh**, vegetation comprises a small number of species which are dominated by glasswort *Salicornia* spp. This vegetation occurs in a large number of saltmarshes in the UK and European marine sites were chosen to represent the geographical range of the habitat type. Generally the largest areas of pioneer saltmarsh have been selected, and since it occurs as an integral part of a sequence of habitats, from sand/mudflats to more stable saltmarsh vegetation, preference has been given to sites where it forms part of well developed successional sequences (Brown *et al.,* 1997).

Pioneer saltmarsh develops at the lower reaches of saltmarshes where the vegetation is frequently flooded by the tide. Wave exposure is particularly important in determining whether pioneer saltmarsh will colonise an area as it is only able to do so in sheltered sites where it is protected from strong wave action. Pioneer saltmarsh is an important precursor to the development of more stable saltmarsh vegetation.

Atlantic salt meadows *Glauco-Puccinellietalia* community, referred to in this document as saltmarsh, occur on North Sea, English Channel and Atlantic shores. There are more than 30,000 ha of saltmarsh in the UK and European marine sites were selected to represent the geographical range and ecological variation of the habitat. The European marine sites chosen are for the most part the largest examples of this habitat type, which support a well developed zonation of plant communities (Brown *et al.,* 1997).

Saltmarshes play a fundamental role in the life of an estuary, bringing stability to its margins and also operating as a source of primary productivity. They are a rare and specialised habitat in their own right and many of the plants which occur there survive nowhere else. Saltmarsh develops when vegetation colonises soft intertidal sediments of mud and sand in areas protected from strong wave action. Saltmarshes exhibit a zonation of vegetation which is influenced by the degree of tidal innundation, in turn related to the level, or height of the deposited sediment on which the saltmarsh has developed. This zonation is generally displayed as bands of characteristic vegetation communities. The lower levels of the saltmarsh, landward of the pioneer zone of glasswort, experience the greatest number of tidal innundations and are generally species poor. In the mid marsh zone, as the number of tidal

innundations decreases the vegetation becomes more diverse with a more complex structure and a greater proportion of herbs. At the upper levels of the marsh, which the tide only reaches on the highest spring tides, the vegetation is diverse and includes some species which are restricted to this zone.

Intertidal boulder and cobble skear communities

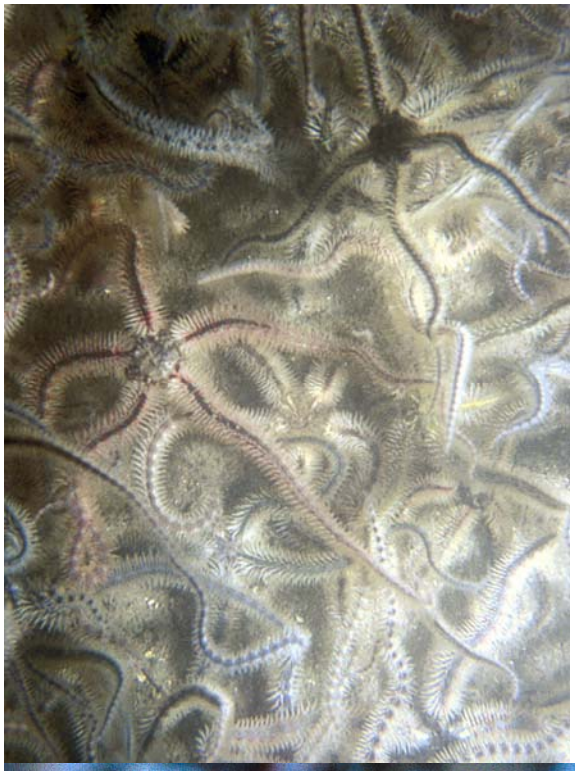
Although the Bay is principally a region of soft sediments there are important areas of exposed boulder and cobble skears which provide an important habitat for a range of marine organisms and thus contribute to the structure of the Bay. The boulder and cobble areas are mainly colonised by mussel beds *Mytilus edulis* and associated species (Woombs, 1997) and there are also extensive reefs of the nationally scarce honeycomb worm *Sabellaria alveolata* colonising the boulder and cobble skears off Morecambe (Woombs, 1997).

Subtidal boulder and cobble skear communities

The wave sheltered subtidal boulder and cobble skear sites in the Walney Channel are particularly important as they provide a habitat for a nationally scarce assemblage of cushion sponges, hydroids and sea squirts which thrive in these tide-swept waters (George, 1992; Cook, 1998). The subtidal boulder and cobble areas are also densely colonised by mussel beds *Mytilus edulis* and associated species (Woombs, 1997).

Brittlestar bed communities

The tideswept waters of the Walney Channel are inhabited by a dense bed of brittlestars *Ophiothrix fragilis* (George, 1992) which are a key structural component of the area and may play an important role in local carbon and nutrient cycles. Brittlestar beds are a major concentration of biomass and provide food for a range of fish species.



Intertidal boulder clay communities

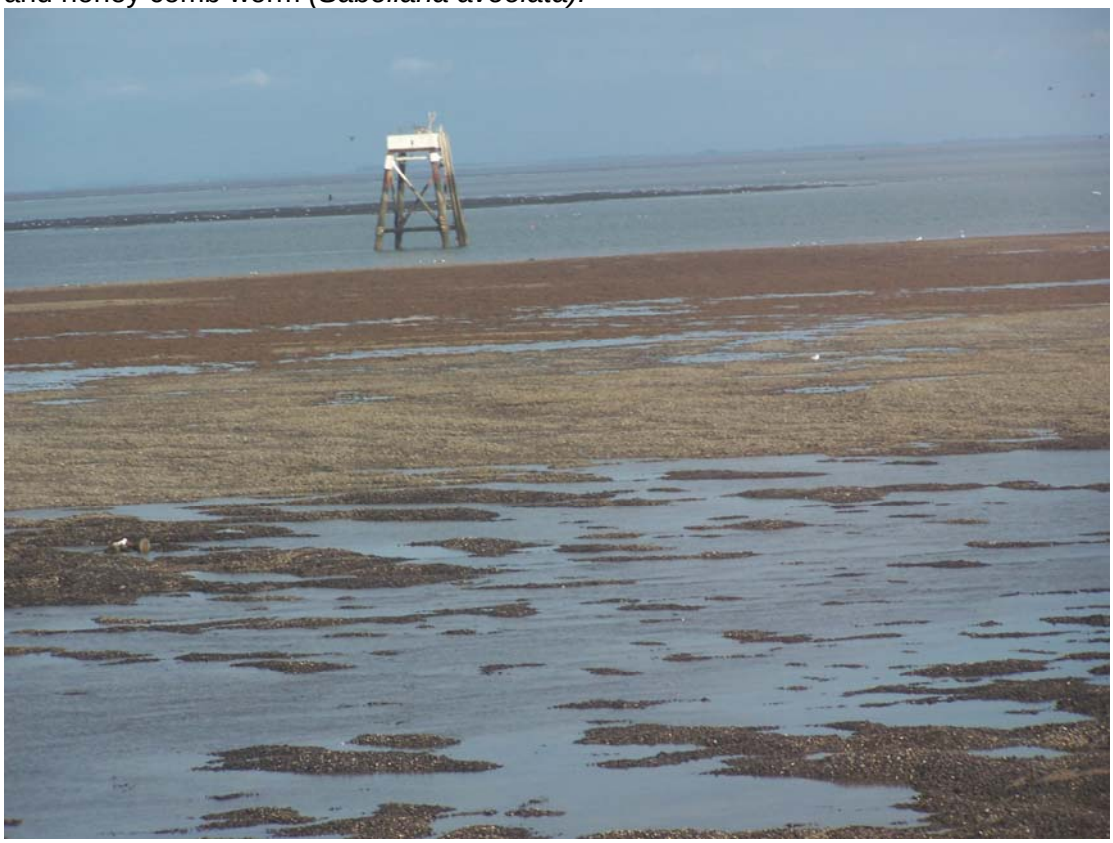
Exposed lower shore outcrops of boulder clay around the Bay provide a habitat for colonies of piddocks *Barnea candida* which are a nationally rare species of bivalve (Woombs, 1997). These communities are fragile and contribute to the diversity of the Bay and the European marine site.

Coastal lagoon communities

Coastal lagoons are bodies of water, natural or artificial, partially separated from the adjacent sea. The coastal lagoons at south Walney contain soft sediments which support the macrophyte *Potamogetin pectinatus* and a range of other plant and animal species. These communities are fragile and contribute to the diversity of Morecambe Bay European marine site.

Biologenic reefs

There are two types of biological reef in Morecambe Bay; mussels (*Mytilus edulis)* and honey comb worm *(Sabellaria aveolata).*



Steve Benn

Low marsh communities

The lower levels of the saltmarsh, landward of the pioneer zone of glasswort *Salicornia,* experience a great number of tidal innundations, usually more than 360 a year. Because of this, the vegetation communities of the low marsh and low-mid marsh are often species poor, composed of plant species which can withstand such conditions. Characterising species of this zone include extensive areas of saltmarsh grass *Puccinellia maritima* with smaller areas of sea purslane *Halimione portulacoides* in ungrazed areas.

Bart Donato

Mid marsh communities

The mid marsh zone comprises a transition between low and upper marsh. As the

number of tidal innundations becomes less frequent, the vegetation becomes more diverse with a more complex structure and a greater proportion of herbs. This zone is characteristically dominated by the saltmarsh grass/fescue *Puccinellia/Festuca* communities, of which over 1,000 ha occur in the Bay, and by smaller areas of saltmarsh rush *Juncus gerardii* community.

High marsh communities
At the upper levels of the marsh, tidal innundation only occurs on the highest spring tides and the vegetation reflects this with some species being restricted to this zone. The sea rush *Juncus maritimus* community is found in this zone and is more strongly represented in Morecambe Bay than elsewhere in England. Other important features of the higher saltmarsh communities include the saltmarsh flat-sedge *Blysmus rufus* and a few-flowered spike-rush *Eleocharis uniglumis* communities which are rare in Morecambe Bay (Burd,1989).

Transitional high marsh communities
The higher marsh communities will grade into transitional communities at around extreme high water spring tide. Transitional communities are an important structural aspect of the upper saltmarsh. They may be freshwater transitional communities, such as the common reedbed *Phragmites australis*, common-club rush *Schoenoplectus tabernaemontanii* and sea club rush *Scirpus maritimus* communities, or grassland transitions include creeping bent *Agrostis stolonifera,* red fescue *Festuca rubra* and tall fescue *Festuca arundinacea* communities. Historically, where the upper saltmarshes have been truncated by sea walls, these habitats have been lost.

Sand communities
Animal communities living within the sandy sediments over the central part of the Bay include high numbers of polychaete worms such as lugworm *Arenicola marina* and molluscs such as the Baltic tellin *Macoma balthica* and the edible cockle *Cerastoderma edule*. In more exposed areas with more mobile sand the communities are less diverse and include amphipods *Bathyporeia* spp. and the isopod *Eurydice*

pulchra (Anderson, 1972; Adams, 1987; Rostron, 1992). The sand communities provide a rich feeding ground for internationally important populations of waterfowl which overwinter in the Bay.

Mud communities

Towards the mouths of the estuaries feeding into the Bay, the salinity decreases and the sediment is finer. Muddy sediments support a high biomass of ragworm *Hediste diversicolor* and peppery furrow shell *Scrobicularia plana* and higher up the estuaries in lower salinity, ragworms and the burrowing amphipod *Corophium volutator* (Anderson, 1972; Adams, 1987; Rostron, 1992). The mud communities provide a rich feeding ground for internationally important populations of waterfowl which feed in the Bay.

Eelgrass bed communities

An important feature of the intertidal mudflats and sandflats are the eelgrass beds *Zostera angustifolia* and *Zostera noltii* in the Walney Channel (see Figure 1). Eelgrass beds are nationally rare (Stewart *et al.,* 1994) and this is the only example of this habitat in north west England. Eelgrass beds are an important habitat as they provide important spawning, nursery and refuge areas for fish. They also help to stabilise the sediment, contribute to primary productivity and are also an important food source for overwintering wildfowl (Davison & Hughes, 1998).

Paul Kay