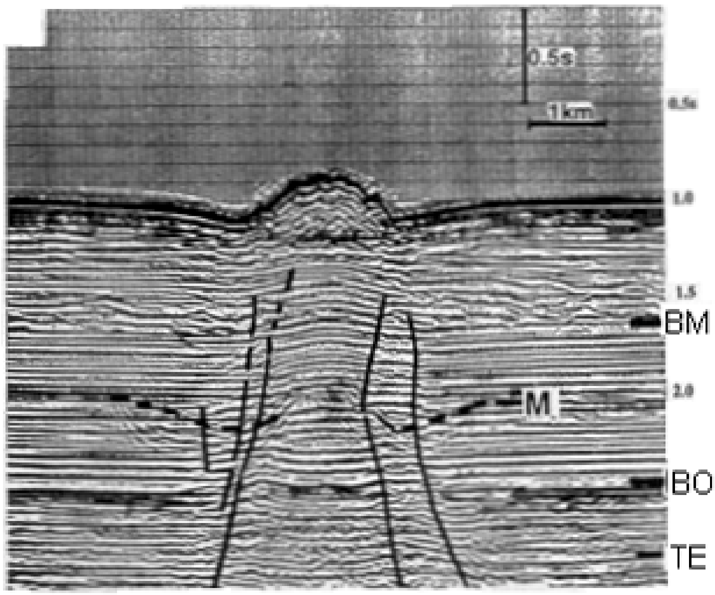
2.2 CARBONATE MOUNDS

In recent years large clusters of giant carbonate mud mounds, some more than 300m high, have been discovered off the continental margins of Europe. They are accumulations that generally occur in localised clusters and which vary in size and shape, being conical, ridged and ring shaped and, in some cases, having very steep sides. Large and small dome-shaped knolls which lie on the surface of the sea-bed have been described as well as complex knolls and pinnacle knolls (Hovland *et al.*, 1994) (figure 10). The examples in the Porcupine Basin are up to 2km long and 350m high (Kenyon *et al.*, 1998). Seismic profiles have also revealed buried mounds in the Porcupine Basin (the Magellan Reefs) some 50-100m high, but covered by tens of metres of sediment (Henriet *et al.*, 1998).

There is uncertainty and debate over the way in which carbonate mounds are formed and it may be that a variety of mechanisms are operating. In some areas the seepage of light hydrocarbons and nutrient-rich pore waters through the sea-bed might be the mechanism. The mounds studied by Hovland *et al* (1994) from the Porcupine Basin, for example, were close to sub-surface faults so their formation could therefore be linked to sub-surface tectonic structure and deep hydrocarbon generation (figure 11). In another area, detailed studies of several sea-bed mounds at the foot of the south-eastern Rockall Trough margin show that they are most likely to be volcanic rocks, outcropping at the seafloor, and that the growth of cold water corals taking advantage of increased currents off the bottom may have contributed to their formation (Kenyon *et al.*, 1998). The Magellan Reefs, on the other hand do not show any obvious correlation with deeper faults but may instead have been caused by funnelling of methane to the surface through hundreds of seeps to the sea-bed (Henriet *et al.*, 1998).

Recent surveys of the surface mounds in the northern Rockall Trough revealed tail-like features all with a common orientation (Masson *et al.*, 1998). These are thought to be the result of interactions with the prevailing bottom water current that may distribute material originating from the mounds and or influence sedimentation downstream of the mound.

Figure 11: Sesmic profile of carbonate mounds and sub-surface fault traces (from Hovland *et al*., 1994)



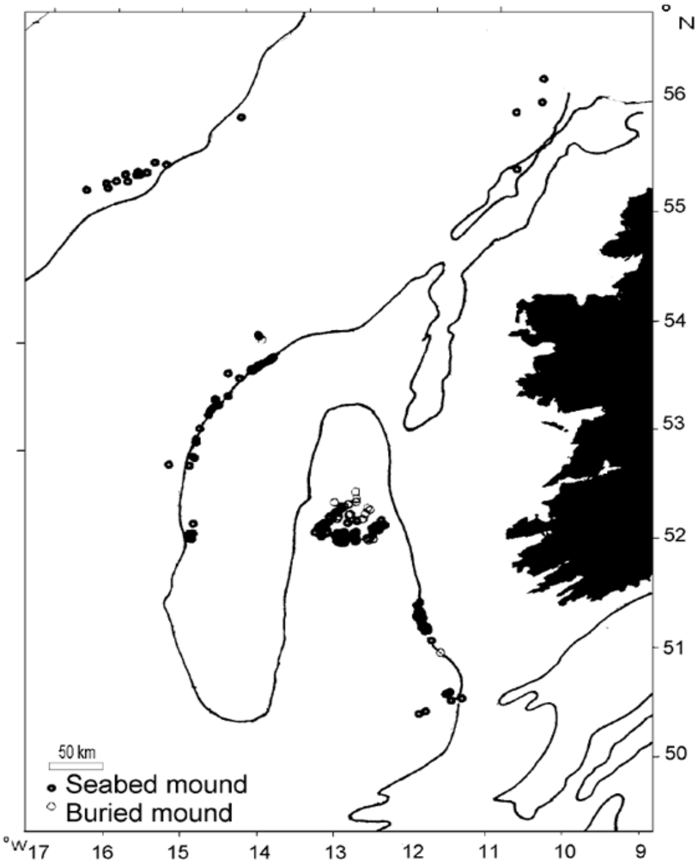
Lines indicated inferred fault plans and suspected hydrocarbon migration routes to the surface.

BM=Base Miocene; BO= Base Oligocene;
TE=Top Eocene; M=first multiple reflector

2.2.1 Occurrence in the OSPAR maritime area

Carbonate mounds are widely distributed on the eastern margin of the north Atlantic from the Iberian Peninsula to offshore Norway in water depths of 50m to perhaps 2,000m (Masson *et al.*, 1998). The findings of deep sea surveys undertaken in the last few years suggest that the European slopes of the Rockall and Porcupine basins may be the most prolific area for the formation of carbonate mounds in the world (Anon, 1999). Recent discoveries include a giant cluster of reefs including hundreds of buried mounds off south-west Ireland (Kenyon *et al.*, 1998) (figure 12) and a new field of seafloor mounds in 1000m of water in the northern Rockall Trough (Masson *et al.,* 1998)

Figure 12: Carbonate mounds off the coast of Ireland (from Anon, 1999)



2.2.2 Carbonate mound communities

Sampling of the biological communities associated with carbonate mounds have revealed that they are often dominated by suspension feeders and can support rich deep-water coral communities. Living corals have colonised some of these mounds and debris from the deep-water colonial coral (*Lophelia* sp.) has been recovered from cores as well as the surface of mounds (Kenyon *et al.*, 1998).

Surveys of the Porcupine and Rockall banks have indicated that the summits and upper slopes of most of the carbonate mounds and knolls identified on sidescan sonar were covered by a carpet of coral debris. Living coral was also present with the most abundant species being the colonial corals *Lophelia pertusa* and *Madrepora oculata* which formed colonies up to 30cm high. The solitary coral *Desmophyllum cristagalli* and the octocoral *Stylaster* sp. were also occasionally present and nearby areas of cobbles and small boulders provided a surface for settlement of individual coral colonies (Wilson & Vina Herbon, 1998).

Sampling of the fauna from Porcupine Basin carbonate mounds revealed that although most of the animals were suspension feeders there were also deposit feeding, carnivorous or omnivorous species. (Sumida & Kennedy, 1998). The branching structure of dead coral underlying the living colonies provided a surface for settlement which was also elevated from the sea-bed and was extensively colonised by sponges, bryozoans, hydroids, soft corals, ascidians, calcerous tube worms, zoanthids, crinoids and bivalves. Many large eunicid worms and sipunculids were also found burrowing inside the coral material, perhaps using the coral for shelter. The suspension feeding ophiuroid *Ophiactis balli* was also abundant, sheltering in the dead coral material and the suspension feeding bivalve *Astarte* sp. abundant in the sediment underlying the thickets at some sites.

The area around carbonate mounds can also support an abundance of species. In the case of the Porcupine Basin there was extensive evidence of the working of the sediment apparently by echiuran worms, cerianthid anemones and caridean shrimps (Wilson & Vina Herbon, 1998). Whereas the tail-like features downstream of carbonate mounds in the northern Rockall Trough showed high densities of the xenophyophore *Syringammina fragilissima* compared to numbers in the background sediments. There was also a slight increased in the density of metazoan invertebrates on the tails and mounds relative to the background (Masson *et al.,* 1998) (box 2). The reason for this clustering is unclear at the present time.

A number of factors may have influenced the development of these rich communities. Elevation from the surrounding sea-bed, a suitable surface for attachment, and shelter among the branching structure of the corals can all play a part. It has also been suggested that, in areas where hydrocarbon seepage might be a mechanism for mound formation, there is localised eutrophication, providing nutrients for bacteria which, in turn, act as a food source for colonial, cold water ahermatypic corals (Hovland *et al.,* 1994).

Box 2: Biological characteristics of three types of seafloor mound surveyed in the northern Rockall Trough (from Masson *et al.,* 1998)

Feature	**Background**	**Tail**	**Mound**
Acoustic parameters			
Sidescan backscatter	Low	Moderate	High
Bathyrnetric profile	Level	Level	Elevated
10 kHz return strength	Normal	Normal	Reduced
Faunal density (/100m^2)			
Xenophyophores	2.1	32.8	29.5
Invertebrates	1.6	2.3	4.3
Fish	4.5	5,2	5.4
Other observations			
invertebrate detritivore /sestonivore ratio	14	5.5	1.0
Xenophvophore predator densitv (/100m^2)	0.3	0.9	0.8
Observations of coral	None	Single, apparently, isolated colony attached to glacial erratic boulder fields.	7 occurrences of coral with associated debris Number of coral colonies ranges 1 to 70

2.2.3 Conservation issues

Carbonate mounds and their associated marine communities have been the subject of study during a number of deep sea expeditions in recent years and they continue to be a focus for research. Much clearly remains to be learnt about these features and the biological communities they support however, the presence of coral colonies and coral debris on these structures has already raised conservation issues.

Some surveys have reported extensive carpets of dead corals and only small colonies of living coral on carbonate mounds, suggesting that conditions were suitable for the growth and development of the coral banks at some stage but that this is no longer the case (Kenyon *et al.*, 1998). Possible reasons put forward to explain this are natural changes in the current regime, sea temperature and food supply to the area. Another possibility is that the paucity of living coral is linked to fishing activity which is very intensive in some of the areas where mounds occur and that repeated trawling does not allow time for the continual growth of coral colonies.

Coral colonies will clearly be vulnerable to sea-bed disturbance and therefore management of such activities in the vicinity of carbonate mounds may need to be considered. There is also a need to distinguish between impacts caused by human activity and natural fluctuations over long periods of time.

2.2.4 Conservation actions

The mapping of carbonate mounds is an ongoing task and, as a consequence, the full extent and distribution of these features in the OSPAR maritime area is still to be determined. Major clusters are already known to occur in the Porcupine Basin and the Rockall Trough however, and it is these sites which are the focus of current study and for which most is known. These locations are, therefore, the logical places to start determining the conservation importance of carbonate mounds and their associated marine communities to see if there are any regional differences in the marine life they support, to assess their contribution to the biodiversity of the deep sea in the OSPAR maritime area and identify potential MPAs.