DTI - SEA 6
Sub-contract Report

ASSESSMENT OF THE STATUS OF HORSE MUSSEL (*MODIOLUS MODIOLUS*) BEDS IN THE IRISH SEA OFF NW ANGLESEY

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By E. Ivor S. Rees, March 2005

SUMMARY

1. Beds of the Horse Mussel *Modiolus modiolus* are particularly sensitive to disturbance and come under both the Habitats Directive and priority listing by OSPAR. This short project under SEA6 was to re-locate and assess the status of beds in the Irish Sea off the north and northwest of Anglesey for which sketchy information previously existed. Because of the strength of the tidal currents and proximity to the electricity grid at Wylfa nuclear power station, future renewable energy development proposals might be made for the area.
2. Over the course of three short cruises with RV *Prince Madog* in the January – March 2005 period, side-scan sonar, sampling with grabs or dredges and sledge mounted camera deployments were used to investigate the seabed.
3. The area off NW Anglesey has exposures of bedrock, as a platform with coarse ground of boulders, cobbles and other lag deposits around it. There are very strong tidal currents. Side-scan sonar images confirmed the complex mosaic of seabed habitats in the area. This complexity makes it difficult to locate patches where the *Modiolus* aggregates or build up as 'reefs' or bioherms.
4. *Modiolus* was found, in sufficient abundance to be considered as 'beds', at four localities within the area covered. It probably occurred at other places, but because it was so patchy, even by targeting possible features seen on side-scan some patches could easily have been missed.
5. Seabed photographs from most tide swept areas, with embedded lag cobbles and gravel, showed the living *Modiolus* to be patchily clumped but not building up into extensive beds having a pronounced wave-form relief as seen elsewhere. Some mussels were seen as single individuals attached to stones and often with shell fragments held around them as a protective 'nest'.
6. The mussels on the embedded cobbles were smaller relative to those from more sheltered localities, most being in the 50 and 60mm length classes. Some of those in a depression which runs round the outside of the Anglesey rock platform exceeded 100mm.
7. The dominant epifauna on the *Modiolus* from the tide swept cobble habitat was the large barnacle *Balanus balanus*. The larger mussels from the offshore depression had more of the soft-coral *Alcyonium digitatum* on them.
8. The very tide-swept *Modiolus* beds with the predominance of *Balanus balanus* found off Anglesey do not precisely fit previously recognised biotopes under the MNCR and EUNIS classification schemes. Owing probably to scour from the bed load transport of sand, grit and shell fragments the range of associates is rather limited.
9. In spite of the hostile environment, even these *Modiolus* patches are believed to be more productive than the surrounding lag. Indirect supporting evidence for this comes from the relative concentration of whelk pot fishing in the parts of the area off NW Anglesey coinciding with the presence of horse mussel patches.

1. BACKGROUND

The Horse Mussel *Modiolus modiolus* in some places forms very dense beds that can carpet the sea floor or build up as reef like features or bioherms (Holt et al, 1998). These localised features are of considerable conservation interest, coming within the "reef" category of the EU Habitats Directive and they are listed as a Priority Feature by OSPAR. Moreover they often form localised areas of high biodiversity and productivity on parts of the seabed that are otherwise tide swept and sand scoured. They are thus of disproportionate ecosystem value. *Modiolus* beds are known to be highly vulnerable to physical disturbance both because individually the mussels are long lived and successful recruitment or spat survival seldom occurs except amongst an existing complex habitat created by the adults. Once destroyed beds do not seem to recover naturally in the medium term.

The primary aim of the present short project under SEA6 was to relocate areas of dense *Modiolus* in the part of the Irish Sea to the north and west of Anglesey. There were several pieces of past information suggesting the presence of beds. Some of the previous information came from widespread exploratory dredge surveys done in the late 1960s when Decca was the position fixing method routinely used. A few other locations with dense *Modiolus* were later found during National Museum of Wales benthos studies in the South Irish Sea (Mackie et al, 1995). These and a few other locations were included in a summary of the distributions of species of conservation interest in territorial seas around Wales by Moore (2002). Another past indication of the probable presence of beds were the notations for 'mussels' (*Ms*) on the pre-metric Admiralty Charts. The offshore parts of the relevant Irish Sea charts, used in the 1960s were still based on surveys that had been done in the 1840s. Furthermore it had not been recognised at the time in 1967 – 1980 when British Geological Survey did very extensive side-scan work, leading to the 1:250,000 Seabed Sediment Map series, that this sort of biological feature might show up on sonar and significantly modify the nature of the seabed or offshore sediments.

Two types of *Modiolus* bed are known to create features that are detectable on side-scan sonar records (Holt et al, 1995; Wildish et al, 1997). They can usually be recognised because of the way the mussels bind together to form quasi-regular waves on the seabed. These are similar in scale to mega-ripples produced in sand deposits by fairly strong tidal currents, but are somewhat more irregular. In the first type of *Modiolus* reef, which has been intensively studied off the north side of the Lleyn Peninsula, the mussels build up waves formed mainly by the accumulations of shell and faecal pellet mud (Sanderson et al, 2001). This type of bioherm can overly the lag gravel to a significant thickness. In the second type the mussels live more embedded in the gravel and cobbles, which they bind together with their byssal threads. This later type of bed has been found off the north end of Isle of Man and off the east coast of Ireland near the Codling Bank (Holt et al, 1998). The first type occurs in areas of moderately strong tidal currents while the second occurs in very strong current areas with unstable coarse sediment. Other bed types occur in slack tide areas where they may occur as clumps on rather muddy seabed but apparently without building obvious features showing strongly on side-scan sonar. As well as

occurring as different morphological types, the *Modiolus* beds also differ in the ranges of associated species growing on the mussels. In the present MNCR and EUNIS biotope classifications (Connor et al, 2003), distinctions between biotope types are based mainly on the differing assemblages of associates. These classification schemes were based heavily on beds surveyed by divers in Scottish sea lochs, so it is likely that more biotope types will be recognised as more of the beds in stronger tidal currents and deeper water are studied.

The approach adopted in the present study was to run two or more side-scan sonar lines across each of the sites where earlier sampling had recorded more than a few *Modiolus* and some other sites suggested as possible by the inclusion of mixed sediment with mud in strong tidal current locations on the BGS Seabed Sediment map. The sonar lines in the present study were spread to optimise the chance of finding features whose location had previously been based on imprecise position fixing, rather than aiming to overlap the sonar lines, as would be the practice if trying to fully chart the seabed by subsequent mosaicing of the data. Protocols were thus suitable for provisional habitat feature searches and were not to hydrographic survey standards. From inspection of the side-scan records, as the data appeared on screen at sea, locations were then chosen to be targeted later by grab or dredge sampling. This sampling was done to confirm the presence or otherwise of *Modiolus* on features that might have represented mussels binding the sediment together. Subsequently video and seabed photography tows were run where the mussels had been picked up in significant numbers. Weather, tide and turbidity conditions curtailed this aspect of the work. The project was carried out in the winter period, January – March 2005, partly to meet funding year end timing and partly to fit research vessel availability. As most of the sites to be assessed were in the very strong tidal current part of the Irish Sea to the north and northwest of Anglesey, the plan was to do the work mainly during a series of neap tides. The contract for hire of RV *Prince Madog* therefore took this into account and allowed flexibility for cancellation if weather forecasts were unsuitable during particular neap tide periods.

2. EQUIPMENT & METHODS

2.1 Side-Scan Sonar

The side-scan sonar used was a Cmax 800 digital system operated on the high frequency setting (325kHz). Based on previous experience in detecting *Modiolus modiolus* reef off the Lleyn Peninsula, the range setting was 150m to either side on the first cruise and 100m on the second. In the Cmax 800 side-scan system power comes from batteries in the fish itself, with the signals coming up a fibre optic cable handled on a small slip-ring fitted winch. Whenever possible the fish was towed at heights of 5-8m above the bottom. The Cmax system displays the records both on a VDU and on paper. Recording onto optical discs allowed re-analysis, post-processing and capture of selected images for later display. The side-scan system is linked to the ship's DGPS so ship positions are logged directly on the record. By positioning a cursor on the screen the location of a feature can be read off for later targeted sampling. The sonar programme also allows the heights of features to be read off from the width of the acoustic shadows. The main weakness in

geo-referencing particular features was in determining the lay-back of the sonar fish from the DGPS aerials on the ship. The stern of the ship, where the cable sheave is hung, is about 15m behind the aerial. With the sonar fish at a depth of about 50m about 3x the depth of wire needs to be put out to reach this depth, so the lay-back for most of the *Modiolus* reef searching was set in the computer at 165m. The ship's position at the start, turns and finish of the search pattern at each site was also logged in the bridge records. Subsequent to the cruises the records have been re-played from the optical disks and examples of the screen displays of the features screen grabbed as bitmap files.

2.2 Grab Sampling

The grab used was a modified long-arm stainless steel Van-Veen grab (on loan from National Museum of Wales). This 0.1m^2 grab has elbow bars on each bucket to prevent it landing on its side. This modification was developed by Dr A. Mackie at NMW. Long-arm Van-Veen grabs were used because they close much better than Day grabs when deployed on rather coarse sediment. Usually at least two grabs were taken at each station. Often the grab had stones in the jaws, but as dense *Modiolus* normally come up in clumps such qualitative samples would have been adequate to indicate the presence of mussels even if the grab jaws did not fully close.

2.3 Dredge Sampling

Much of the seabed sampling was done with a small Tjarno pattern dredge. This has a mouth width of 0.4m. The dredge bag is 5mm knotless netting supported and protected by two layers of trawl netting outside it. Given the strength of the tide in this area, the dredge was deployed with the ship drifting. It was left on the bottom until felt to bite a few times or for less than 2 minutes. Positions of deployment and recovery were logged, but deployment positions before the tow wire stretched out was taken as being closest to the actual spots the samples came from.

2.4 Biological Sample Processing

Notes were made of the apparent seabed habitat type from the material recovered by the grab or the dredge. The whole of each sample was then washed on a 5mm mesh screen. When *Modiolu*s was encountered they were as far as possible all picked off the screen, care being taken to look for small *Modiolus*. Single specimens can often be concealed within clumps of gravel and shell held together by the byssal threads put out by the mussels. Representative selections of the other fauna in the samples were also picked out for noting. The presence of these was recorded based on species recognition at sea by someone familiar with the Irish Sea benthic macrofauna. Thus, while large and obvious species could be identified to species, those where microscopy and working through specialist literature would have been need were only noted to Phylum, Class or Genus level.

All *Modiolus* were measured to 0.1mm using callipers with dial readout. Counts were also made of numbers of broken *Modiolus* too damaged to be measured. For each of the measured *Modiolus* the types of epifauna on the shells was also recorded. While barnacles could be identified by sight to species, other groups such as sponges and bryozoans were mainly only recorded to phylum level.

2.5 UWTV and Still Camera Deployments

The UWTV used is based on a Rovtech Systems 'Seacam' recording on the ship onto a Sony Digital 8 recorder. Two 20 watt lights are powered through the 200m umbilical cable. The still camera system comprised a Photosea 1000 35mm camera and a 150 watt strobe controlled by a separate electronic timer unit. Both camera systems were mounted on the same sledge frame (Figure 1). As rigged, the video camera looks obliquely forward with the lights to either side. The still camera pointed directly downwards when the sledge was flat on the ground with the strobe mounted at 60^{o} behind it. The film used was 35mm Fujichrome Sensia 200 slide in 36 shot cassettes. The timer was set to fire at 42 second intervals. After processing the film images were scanned digitally for archiving and reporting.

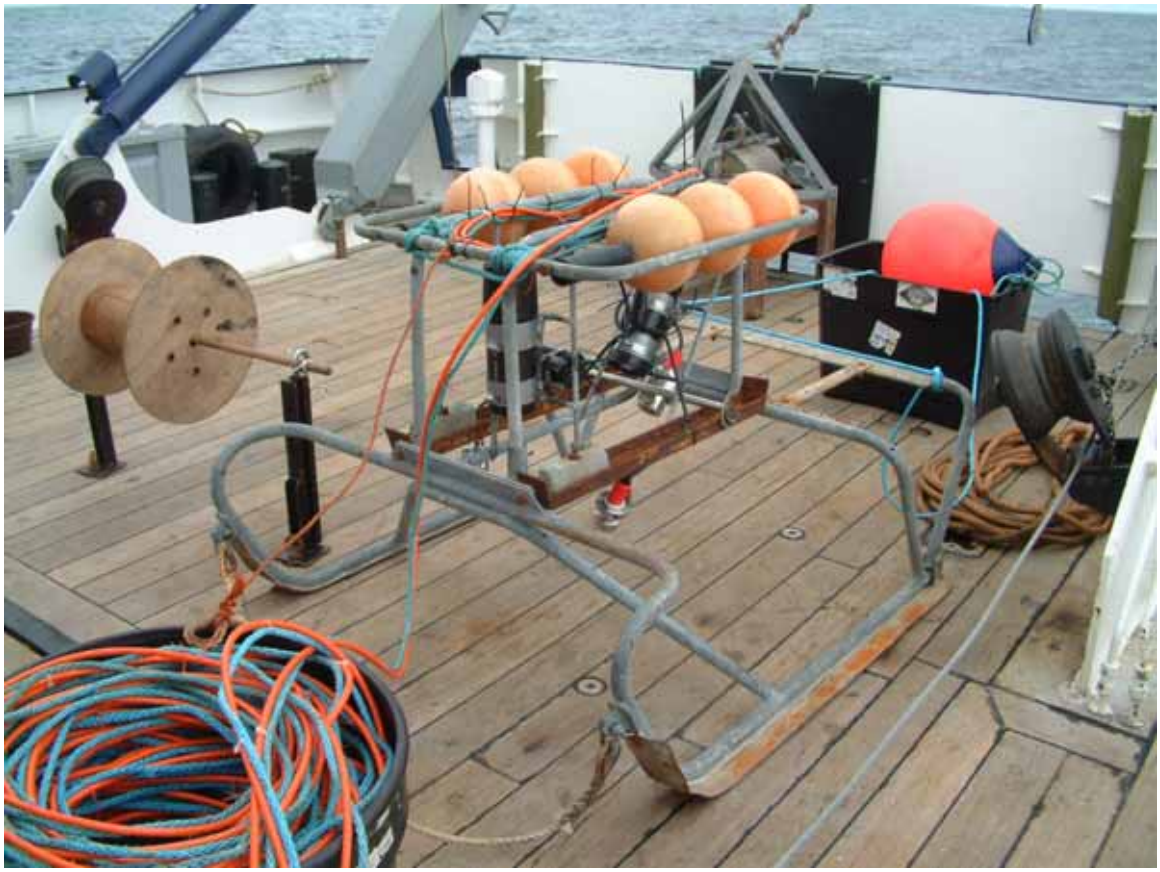

FIGURE 1.

Sledge with UWTV and film cameras. showing in the configuration used for *Modiolus* bed work. Black units are the still camera and strobe. UWTV (stainless steel with red cable connectors) below and behind the strobe.

The camera sledge is deployed on 10mm wire with a rope bridle and leader to limit chances of disturbance ahead of the field of view. A tail rope and surface buoy is also trailed behind the sledge to help recovery in case of snags and to stabilise the sledge track. The UWTV umbilical is handled separately from the towing wire. The aim was to tow the sledge over the seabed at less than 0.5kt. To assist in this, another coaxial cable was run from the control box with the video monitor, in the ship's laboratory, up to an extra monitor in the wheelhouse. This allows the watch officer to better control tow speed over the seabed. Tows were normally of 22 – 25 minutes on the seabed, to fit with expiry of the still camera film. In areas of such strong tides tows have to be timed for periods within about an hour of slack water and during neap tide periods.

3. TOPOGRAPHICAL SETTING

The topography of the Irish Sea to the NW of Anglesey is largely determined by the presence of an extensive sub-sea platform of hard Pre-Cambrian rock. This extends up to 15 miles off shore in a north-westerly direction from the Carmel Head corner of the island (British Geological Survey, 1990 Anglesey Sheet 53N 06W Sea Bed Sediments 1:250 000). Exposed rock or rock only patchily or thinly covered by boulders and lag gravel is also present at the seabed extending several miles offshore from Holyhead Bay and South Stack. At modern sea levels, the offshore rock platform lies mainly at depths of 40 – 60m. The bedrock exposures on the seabed show readily on side-scan sonar records with the complex mosaic of other coarse ground habitats.

The Quaternary sequence of glaciations and associated sea-level change has also had a major influence here. The Irish Sea ice sheet moved south-westwards across the rock platform and left deposits which were subsequently eroded and reworked during the marine transgression. The resulting lag deposits, which dominate much of the South Irish Sea, include patches of boulders and cobbles with gravel between. Intermittently there are also sand ribbons. These occur particularly to the northeast of the rock platform and there is some sand where the remnants of the moraines and other protruding features provide limited shelter from the currents. Overall however it is clearly an extensive area of coarse tide scoured rough ground, where the role of the sand is as much as an abrasive as a potential sedimentary habitat.

Another notable feature in the Irish Sea to the west and north-west of Anglesey the several depressions with depths over 100m. One of these depressions curves around the outside of the hard rock platform. It is more than 50m deeper than the rock platform and is likely to have been worn, at lower sea levels, into the glacial till along the route taken by the flow of the major rivers which now drain into Greater Liverpool Bay. This would have been at a time when there were seasonal melt-water spates and the rock platform was a peninsula jutting out These depressions are in places up to 130m deep but are often only 1 or 2 miles wide. They link up with the St George's Channel Depression running southwards towards the Celtic Sea.

Owing to the way Anglesey protrudes as a headland into the Irish Sea, tidal current strengths exceed 1m/s at mean springs. Considerable turbulence, generating over-falls, occurs across the irregular seabed features here. A depositional gradient to somewhat lower currents occurs around the NE corner of Anglesey allowing sand sheets and ribbons to develop which patchily overlay the lag gravels and cobbles..

4. PAST *MODIOLUS* RECORDS NW OF ANGLESEY

The distribution of records that may have indicated the presence of *Modiolus* in significant abundance in the past is shown if Figure 2. All these records represent isolated samples so it was not known how continuous the mussel beds might have been. Since there had not been searches with side-scan sonar or targeted video surveys, it was also not known whether the mussels built up as bioherms. One other sample (position not precisely known) from the area north of Anglesey and not shown on the figure was used as part of an age and growth study (Anwar et al, 1990). This study showed that the mussels here were not as large as at some other locations, but they fitted the general pattern of low growth rates and longevity measured in decades.

After looking over several of the Irish Sea Admiralty charts from the pre-metric period, it appeared that for offshore areas, the '**Ms'** notation of seabed type was used only in the area north and north west of Anglesey. The surveys, on which charts issued in the 1960's were based for the offshore Irish Sea, dated from the 1840s. The '**Ms**' notation appeared on the Holyhead – Great Orme sheet and at one spot on the larger scale charts lying beyond the northern border of the Holyhead – Great Orme chart. It is suspected that one particular survey officer may have taken more than the usual interest in seabed fauna. The period in the 1840s was when Edward Forbes was describing molluscs and undertaking dredgings in the Irish Sea, so some connection might be looked for. It is worth noting that the modern metric charts do not include the mussel notations in this area, but quite frequently there are 'Wd' notations for weed. Judging from what was visible on the videos during the present study, the modern notation probably refers most often in this part of the Irish Sea to the lemon weed *Flustra foliacea* . This bryozoan is a characterizing species of tide swept biotopes.

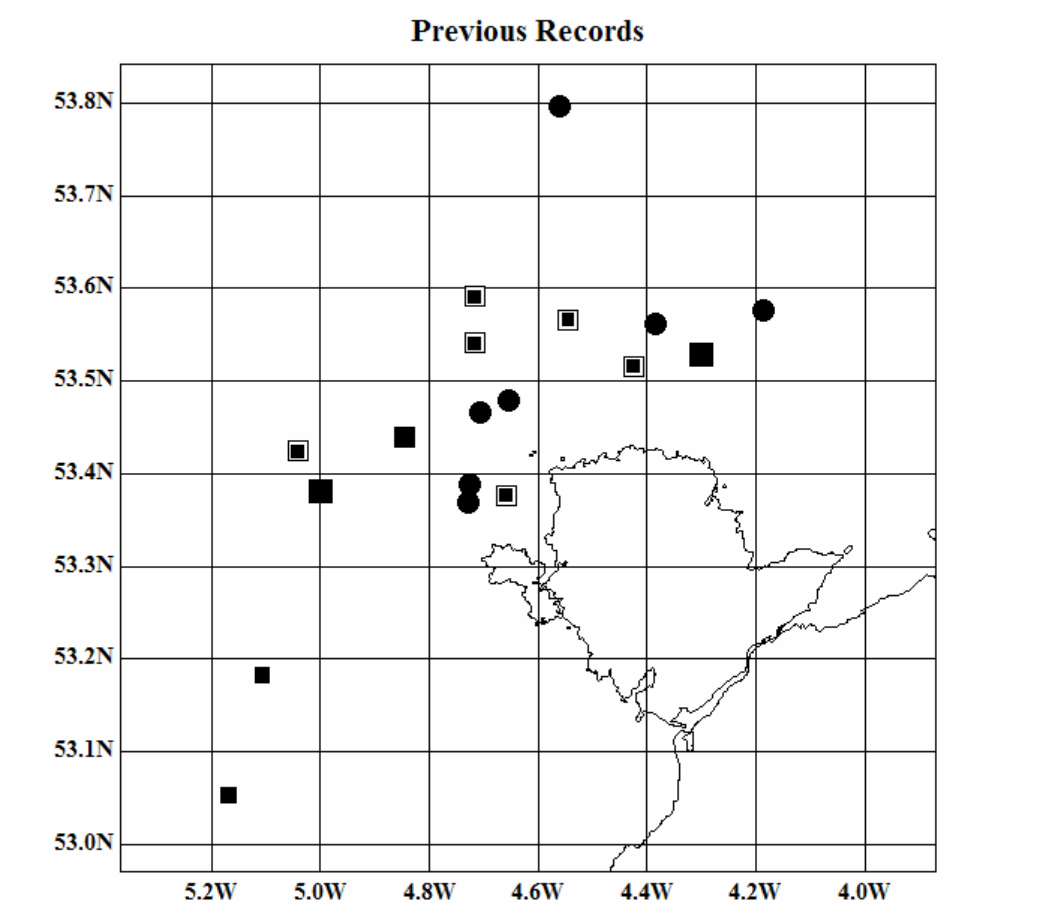

FIGURE 2.
Locations of previous records that have indicated the presence of *Modiolus* beds offshore from N & W Anglesey. Notations on pre-metric Admiralty charts of 'mussels' dating from surveys in the 1840s, filled circles; dredge samples with many *Modiolus* 1965 '*Insula*' survey, open squares with filled centres; samples with abundant *Modiolus* from National Museum of Wales *Biomor* & *Swiss* surveys, filled squares.

Small *Modiolus* also occur quite widely as singletons. These are often found surrounded by shell or gravel fragments held by the byssal threads so that a protective 'nest' is formed. Other individuals are sometimes found within the concavity of the larger heavy bivalve shells such as *Glycimeris glycimeris* or *Circomphalus casina*. There are numerous other records of individual mussels which have not been included here as they do not indicate the likely presence of 'beds',

5. RESULTS OF 2005 SURVEYS

5.1 Cruises

Three short cruises were undertaken with RV *Prince Madog* in the January to March 2005 period. A succession of severe gales in early January caused cancellations so the first cruise was not until 22nd to 25th January. This missed the neap tide period and due to stronger northerly winds than anticipated the quality of the side-scan records on this cryuse would only just have allowed large bioherms to be noticed. The second cruise from 15th to 19th March coincided with a period of neap tides and reasonable weather until the last day. As a consequence a good series of side-scan records were obtained and dredge sampling was successfully targeted at features yielding *Modiolus*. Although the water was quite clear, deteriorating weather prevented the deployment of cameras at the locations where significant numbers of live *Modiolus* had been collected. The final cruise period was also delayed by a gale on the first day, but on 6th and 7th March it was possible to undertake 6 camera deployments near enough to slack waters to give good results and 2 more when the current caused the umbilical to drag the sledge over so only brief views of the seabed were obtained. On this last cruise two short side-scan lines were also run over the western end of Constable Bank to confirm the orientation of the mega-ripples on the bank in support of another SEA6 project.

5.2 Side-scan sonar

The side-scan sonar records from the present study confirmed the complex hard ground nature of the area with bedrock exposures (Figures 3A & 3B). Only a small selection of frames grabbed as bitmaps from the records can be shown here as representative of the features detected. Although several features possibly representing patches of *Modiolus* or other shell bioherms and shell accumulations were seen, none were seen that were as obvious as in the *Modiolus* bed north of the Lleyn Peninsula where the bioherms clearly stand out from the underlying lag gravels (Sanderson et al., 2001).

Owing to the Quaternary history of the area it is quite likely that some of the features on the seabed here represent the remains of moraines and other sub-glacial ridge features not total obliterated during the marine transgression. There might also be relics of former coastal features not destroyed as they were overwhelmed. These all add to the complexity of the seabed morphology in the area. It has even been suggested that there may still be slight depressions in the seabed, kept open by tidal scour, that are evidence for pingos (Ceri James, personal communication). Certainly some apparent depressions, of about the right size and with less reflective sediment, were seen during the present study.

While sand ribbons can readily be identified, there were several other weakly waved seabed features and low mounds that could less easily be ascribed to features in the inorganic sediment. Given the propensity of dead shell to become aggregated into mounds and patches, it is quite likely that some of the unexplained features come from this source. While *Modiolus* shells are widely distributed in the NW Anglesey area, those of the Dog Cockle *Glycimeris glycimeris* were seen as a particular feature on parts of video from the deep depression beyond the rock platform. The acoustic properties of shell accumulations are not well understood, but will almost certainly give rise to different

patterns on side-scan records than sand, gravel or embedded cobbles. This is especially so where the *Modiolus* shells have become packed on edge (imbricated). This orientation of the shells was seen on some photographs from the present study. In the offshore depression the *Glycimeris* seemingly preyed on by large starfish (*Asterias rubens*) were seen as numerous paired valves mainly lying part open and with the umbo down so that the shells were protruding upwards.

Seabed 'comb' marks characteristic of scallop dredging were noted only in that part of the area where side-scan lines were run that lies north of Point Lynas.

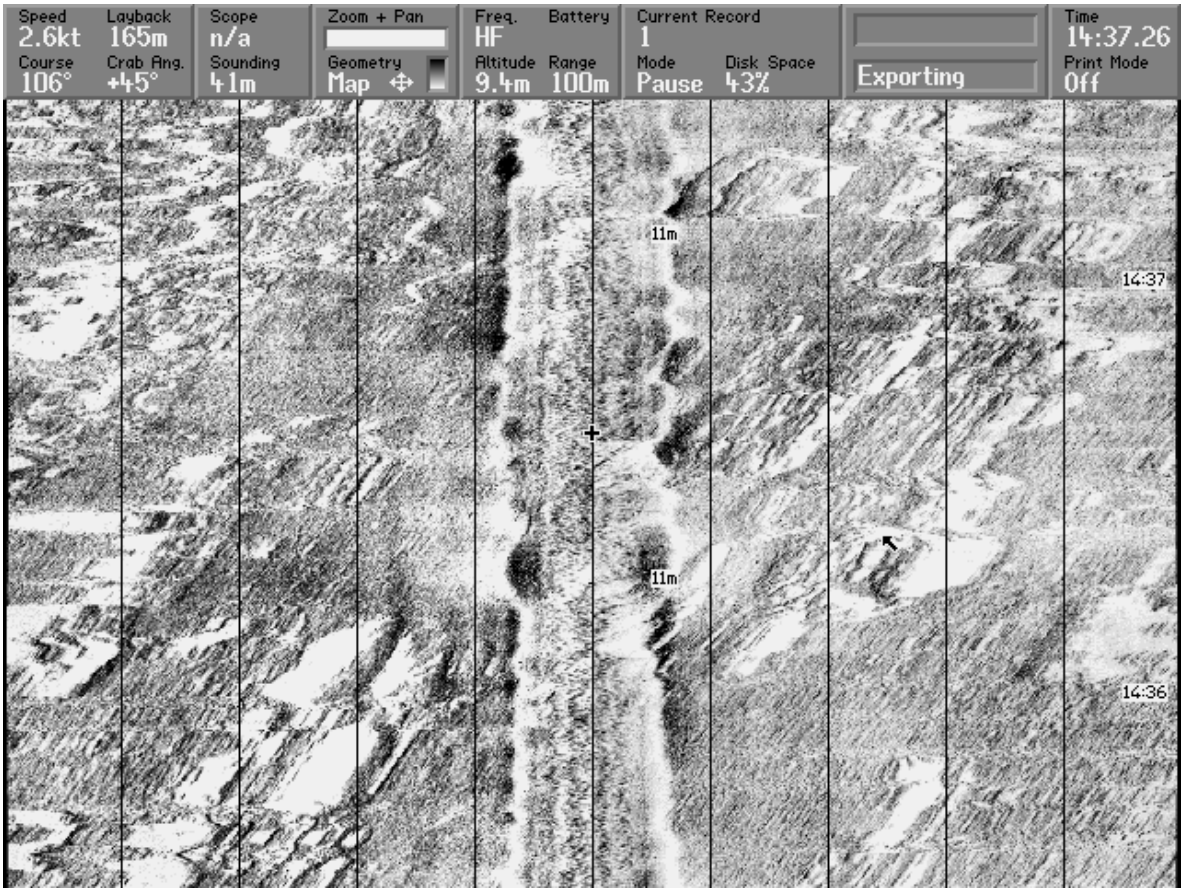

FIGURE 3A.
Lat. 53° 27.723'N; Long 04° 40.120'W. General Location: Station Q.
Interpretation - Rock outcrops with lag gravels lying between the outcrops. Part of the rock platform extending NW of Anglesey.

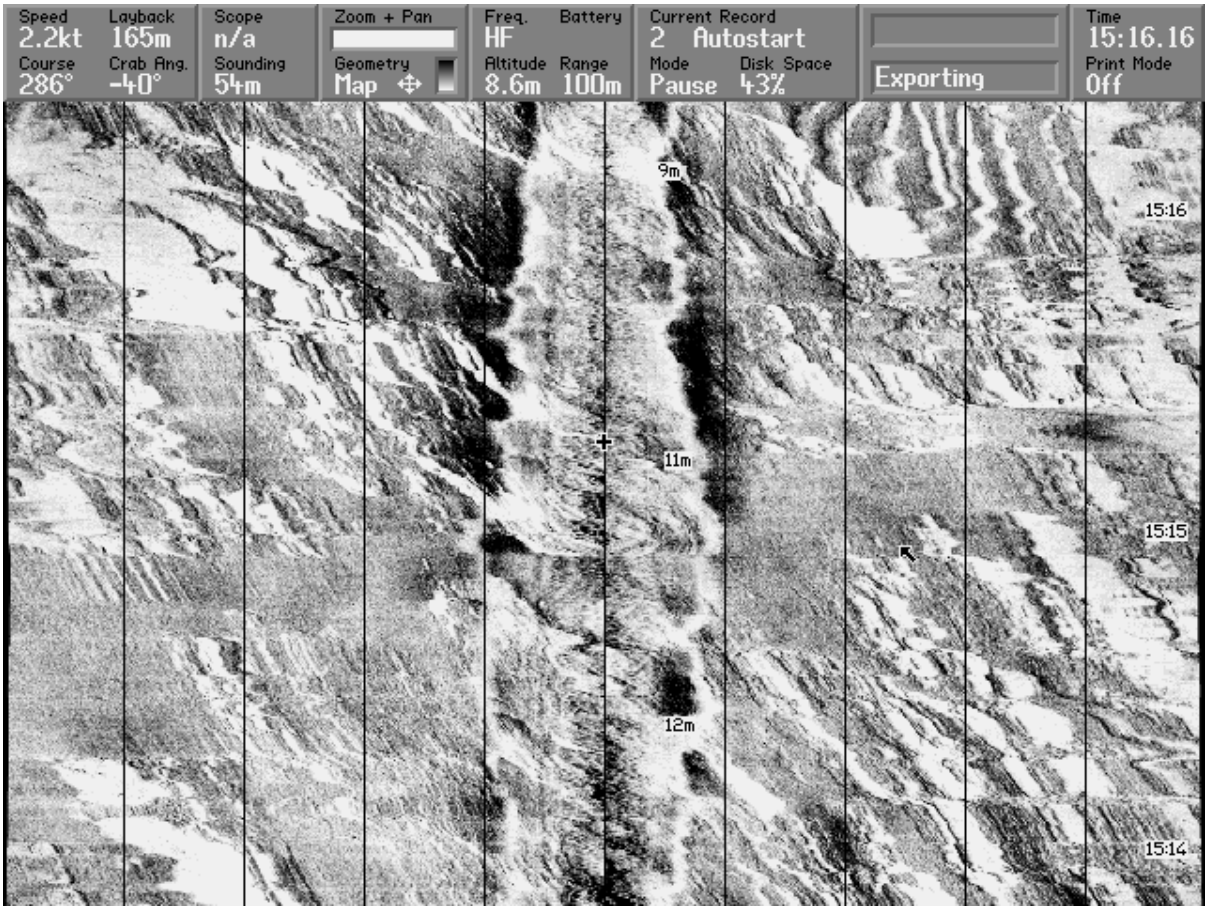

Figure 3B
Lat. 53° 27.683'N; Long. 04° 40.759'W.
General Location – Station Q
Interpretation – Rock outcrops with gravel between outcrops. Note reverse direction of ship travel from Fig 3A, hence the different orientation of the outcrops.

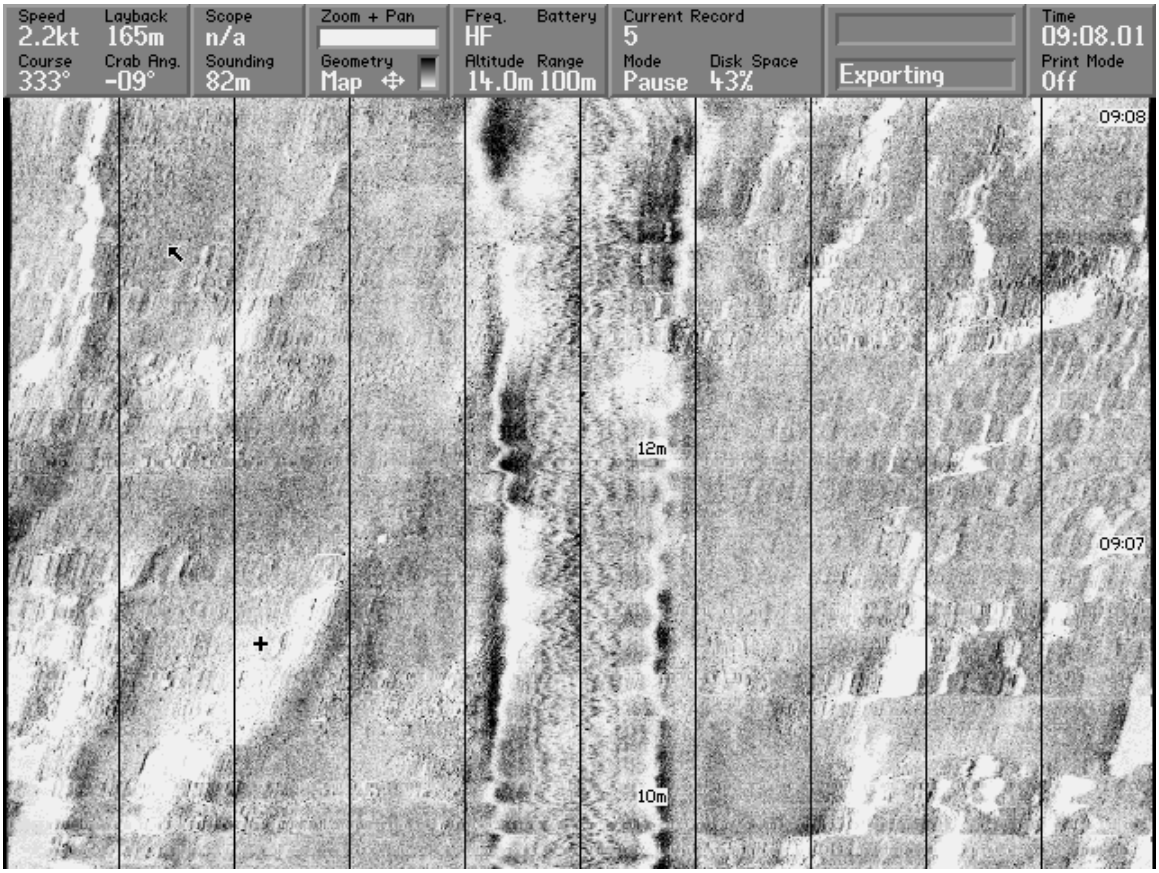

FIGURE 4

Lat. 53^{o} 38.224'N; Long. 04^{o} 33.103'W.
General Location – Station S
Interpretation – Linear ridge or mound features in the bottom of the depression / deep channel NW of the Anglesey rock platform. The features are aligned roughly with both axis of the depression and probably the near bed currents, The features lack any obvious mega-ripples superimposed on them yet they appear 'soft'. It is not known whether these are relict bedforms or perhaps accumulations of shell. Similar features were seen on side-scan records from station R where videos showed patchy abundance of *Glycimeris* shells as paired valves protruding upwards.

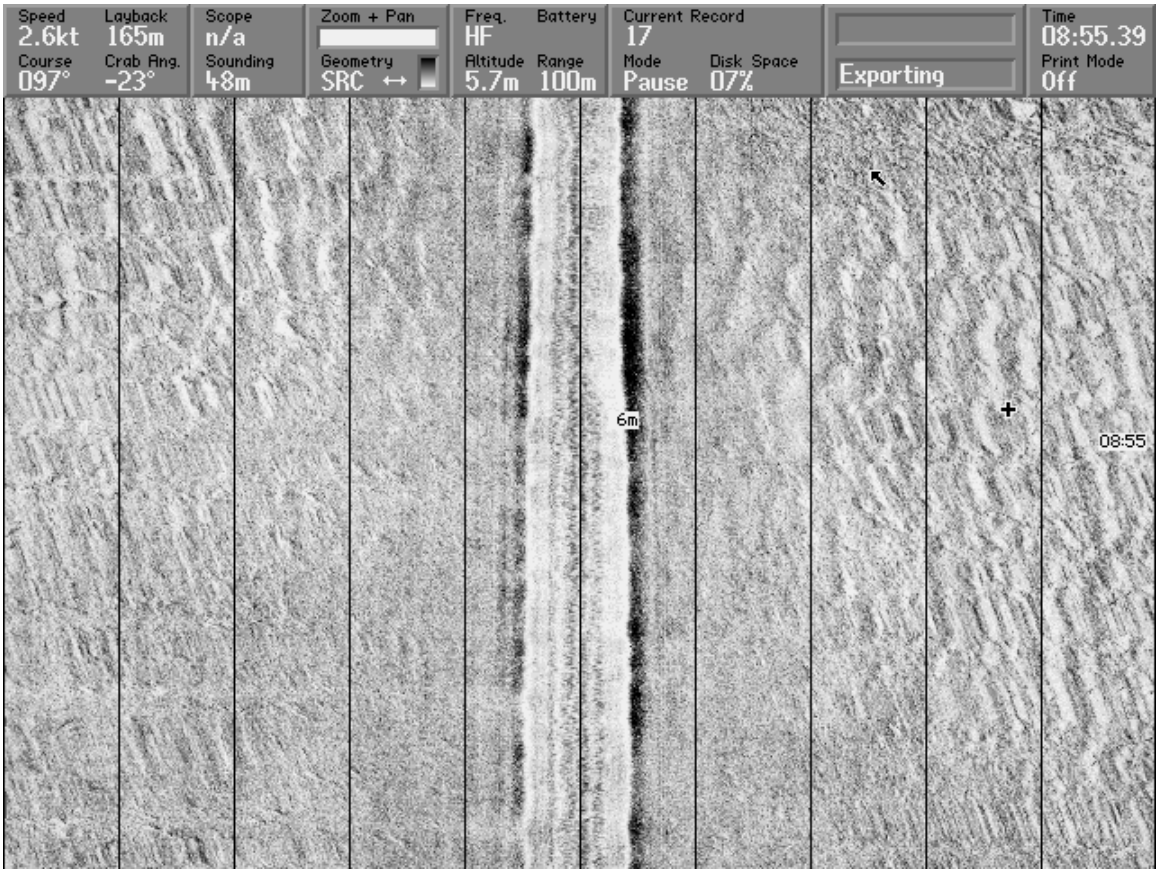

FIGURE 5

Lat. 53^{o} 19.097'N; Long. 04^{o} 54.023'W.
General Location – Station J
Interpretation – Large patch with irregular and weakly developed mega-ripple features possibly created by *Modiolus* overlying embedded cobbles and gravel but by only one shell in thickness or it could be partly caused by differential amounts of dead shell lying on the bed. Crest to crest wave lengths are about 8m and the patch is at least 60m across.

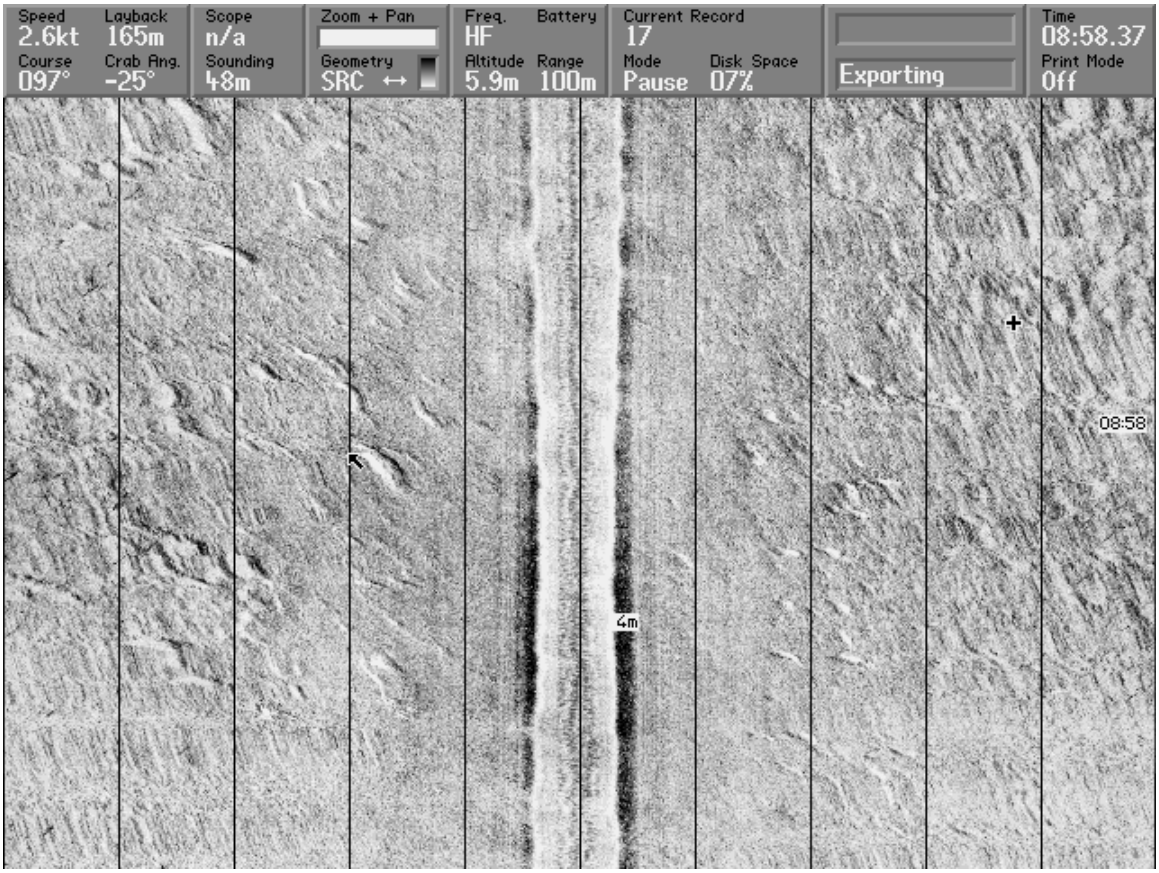

FIGURE 6

Lat. 53° 19.121'N; Long. 04° 53.824'W.
General Location – Station J
Interpretation – Isolated small mounds or strings of slight mound type features overlying tide swept embedded cobbles. The mounds appear to be orientated with the tidal streams and to overly the 'grain' of the lag at a slight angle. These could be isolated very small parches of *Modiolus* that have bound shells together. Features of about the same size were seen on some photographs from this area.

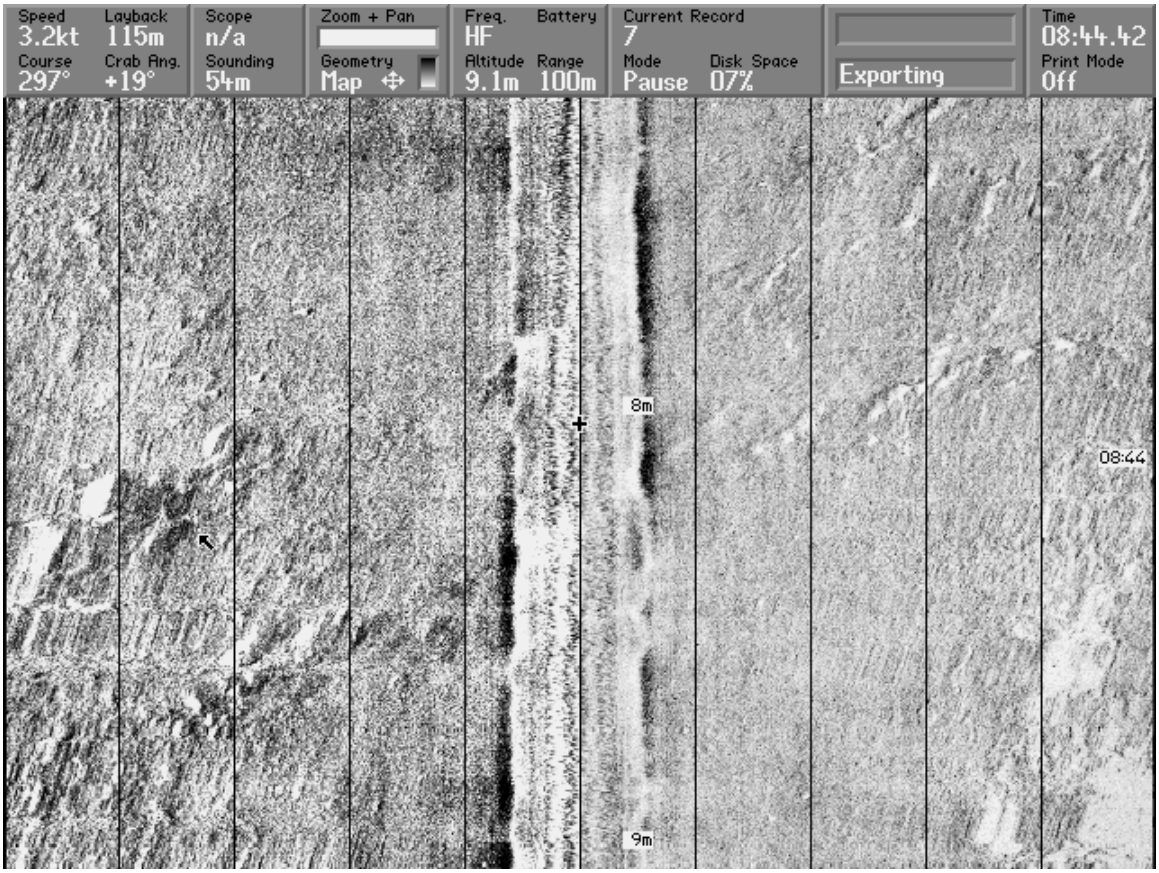

FIGURE 7A

Lat. 53^{o} 23.114'N; Long. 05^{o} 00.703'W.
General Location – Station C
Interpretation – On the left side of the image there is a rough feature probably formed of boulders representing a re-worked glacial feature. On the right there are narrow two lines of low wave form features that could represent *Modiolus* or their shells overlying embedded cobbles and lag gravel.

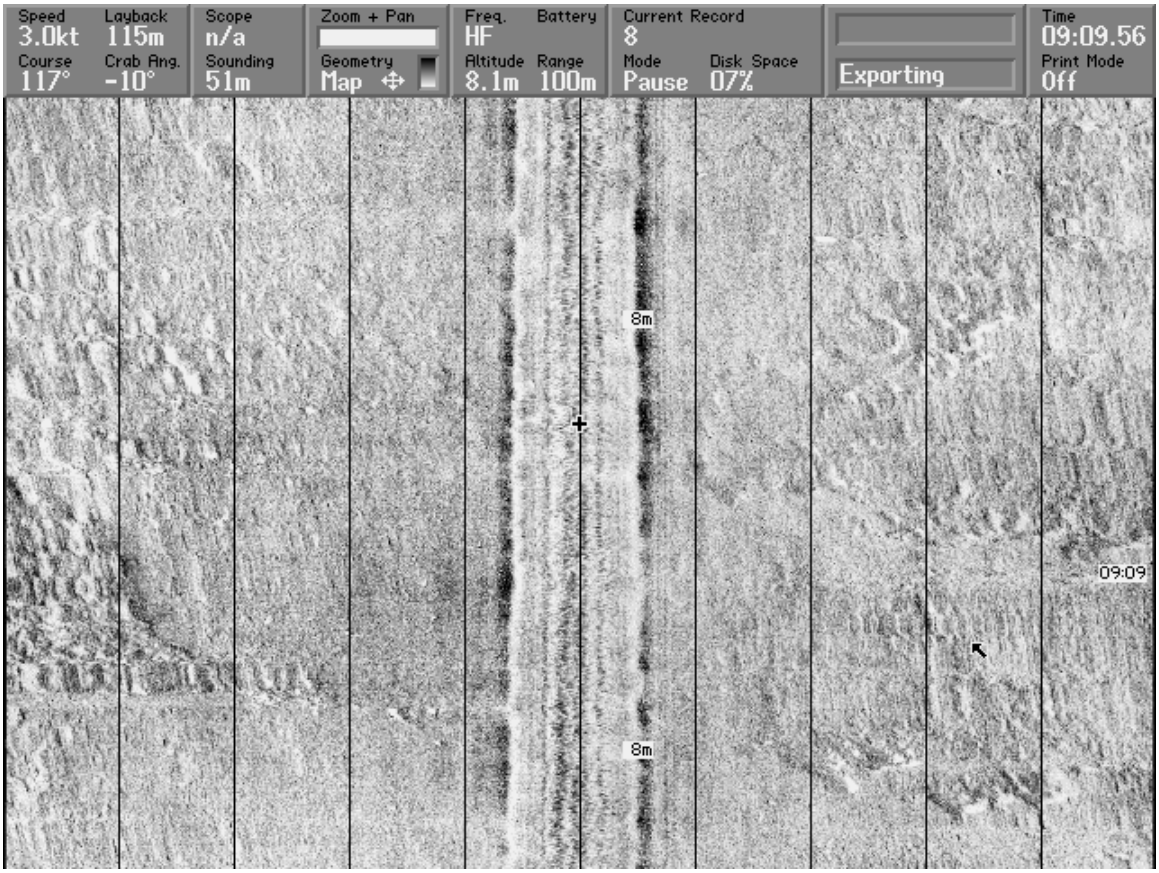

FIGURE 7B
C6
Lat. 53° 22.950'N; Long. 04° 59.993'W.
General Location – Station C
Interpretation – Small patches and lines of mounds with irregular low wave forms that could be of biogenic origin, with a more solid, probable boulder feature mid left.

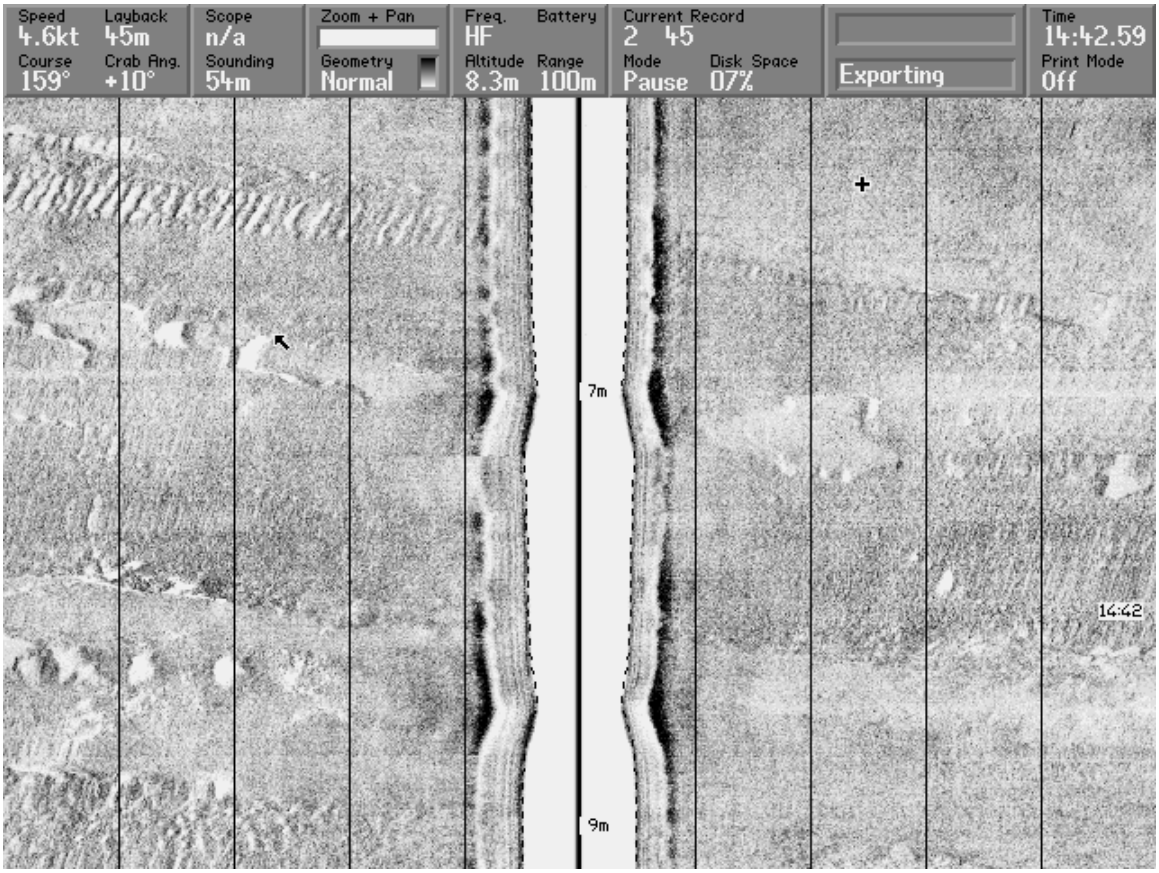

FIGURE 8
A12-4
Lat. 53° 33.025'N; Long. 04° 19.830'W.
General Location – Station A2
Interpretation – Lag gravel with overlying linear features. At the top left of the image there is a sand ribbon with regular mega-ripples on it. Below it there are two linear features that have areas that are noticeably smooth and poorly sound reflecting and also clear well spaced mounds. It is suggested that in the smooth areas the lag is almost completely overlain by shell, but the shell has not mounded up. Large quantities of *Modiolus* shells were brought up in some dredges in this general area. The mounds might be shell or there could be some living *Modiolus* holding the shell accumulations together.

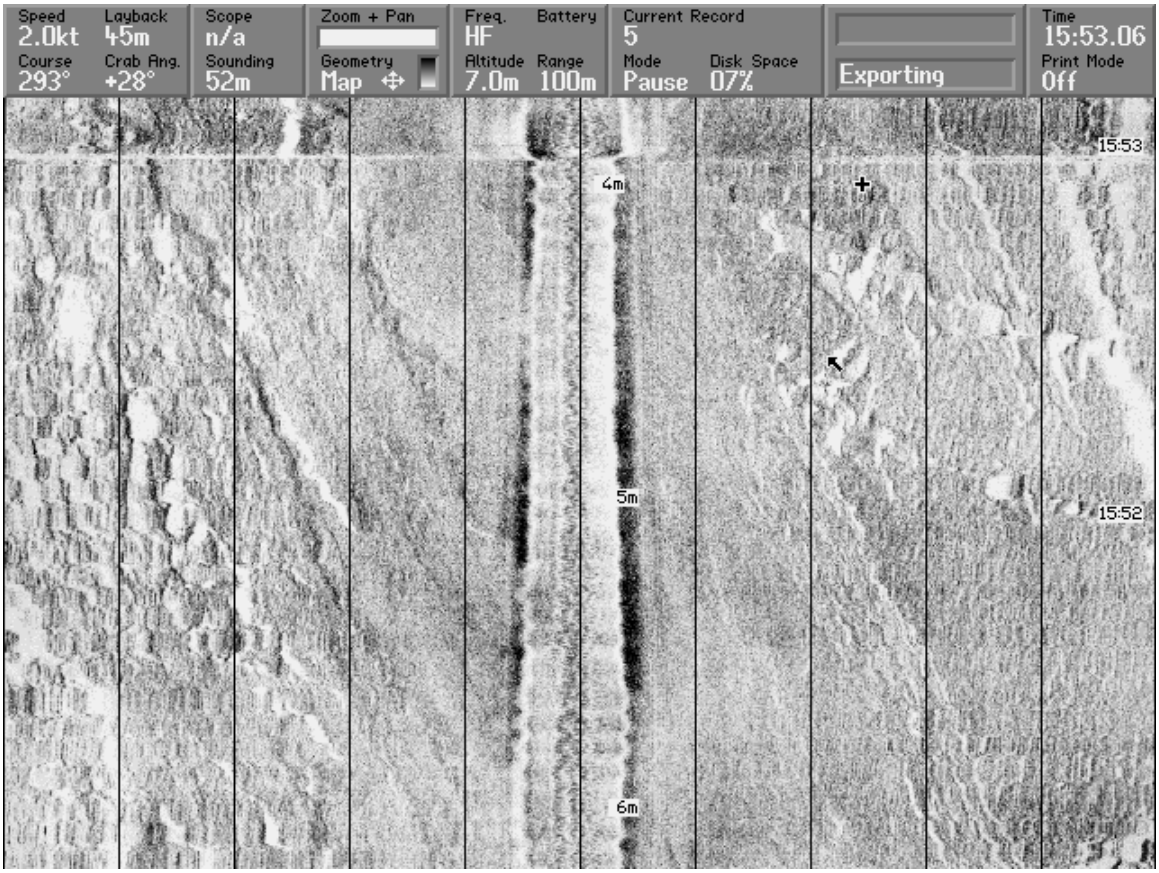

FIGURE 9
A1_1
Lat. 53^{o} 33.113'N; Long. 04^{o} 14.460'W.
General Location – Station A1
Interpretation – On the right side of this image there are paired tracks made by a scallop dredger, with other less clear marks on the left of the image. The 'combed' appearance of the tracks indicates they were made by multiple dredges towed on gang bars rather than by beam trawls. The tracks cross some of the narrow mound features that may represent the *Modiolus* ribbon beds in this area.

5. 3. *MODIOLUS* IN GRAB & DREDGE SAMPLES

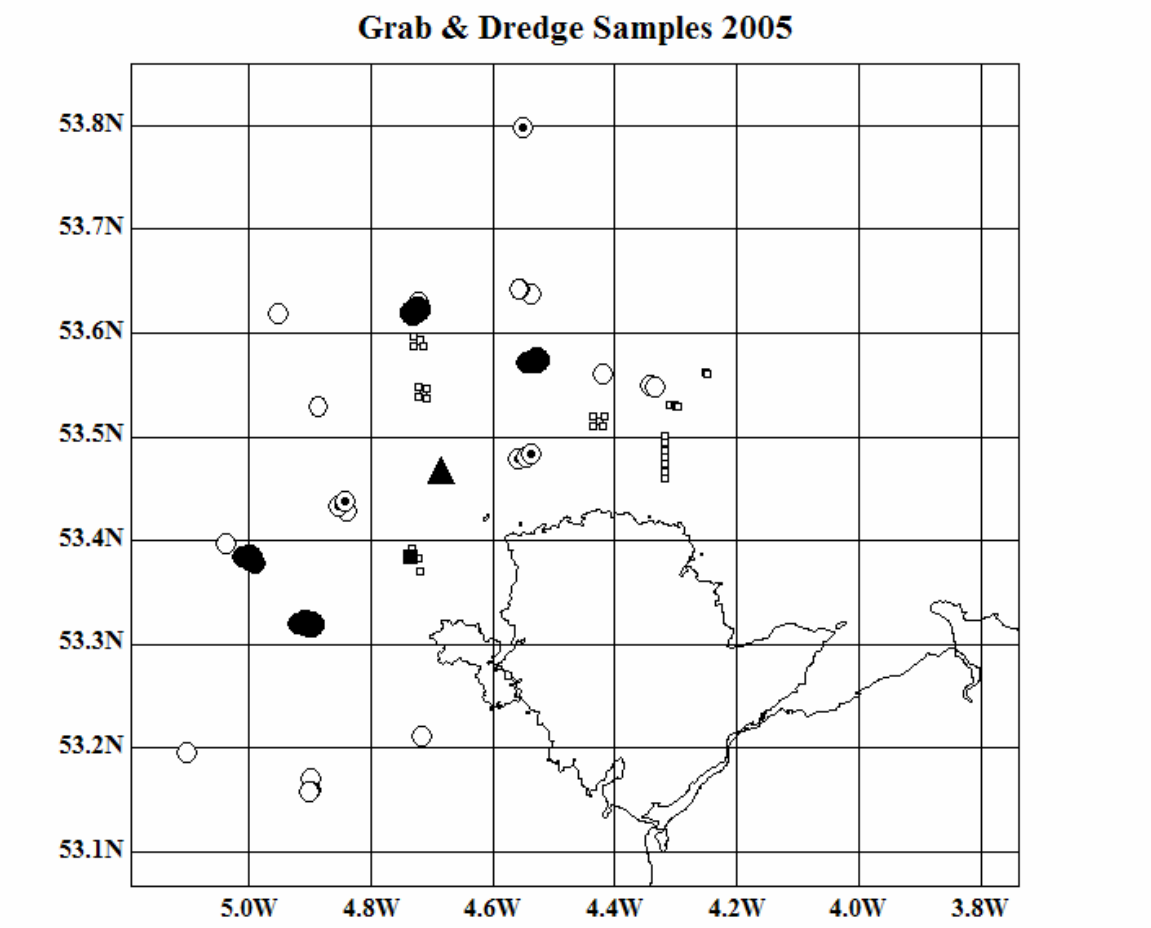

FIGURE 10
Spread of sample locations during January – March 2005 surveys. Filled circles are locations where significant numbers of live *Modiolus* were found in drift dredge samples. Open circles no *Modiolus* found in dredges. Circles with central spot, a few *Modiolus* present. Small squares are grab sampling positions. Triangle shows position where clumps of small blue mussel *Mytilus edulis* were found.

Live *Modiolus* were found in three types of situation. The two locations lying to the west and northwest of Holyhead Island were at depths of about 50 metres on very tide swept seabed which photographs show to be predominantly characterised by embedded cobbles and.gravel. The mussels were in clumps and patches so there was great variability between samples. The furthest north of the four groups of circles is in the depression northwest of the rock platform. The other group of filled circles is on boulder ground just to the east of the rock platform. It happens to lie at the eastern edge of the west bound traffic separation lanes.

5. 4 *MODIOLUS* SIZE FREQUENCIES

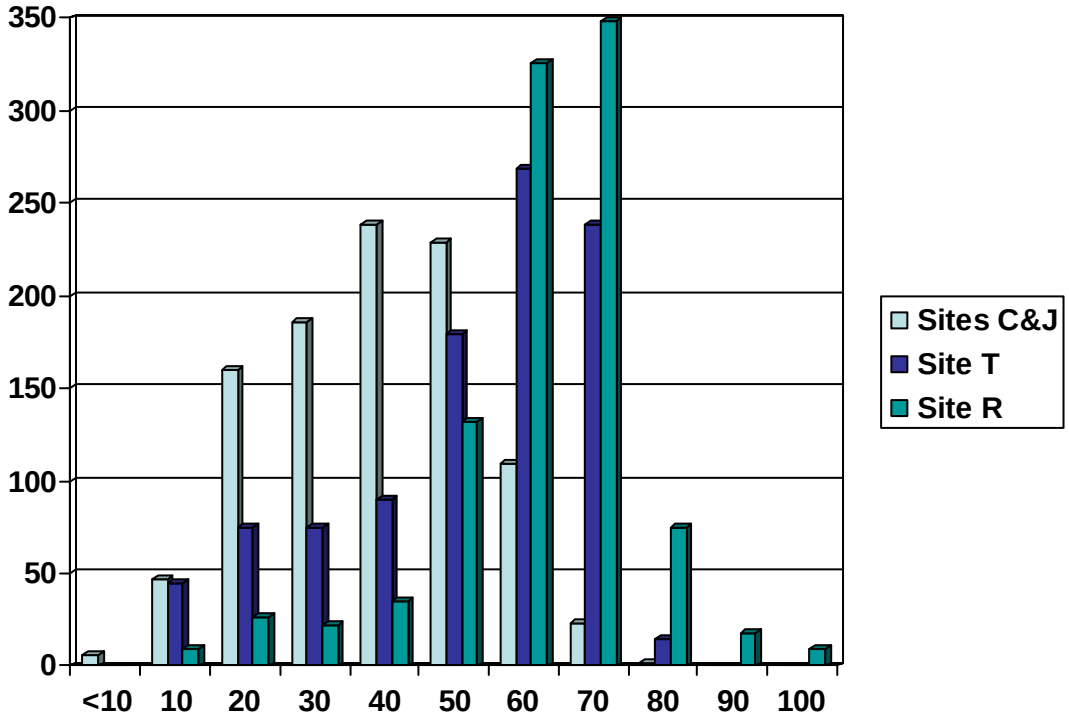

FIGURE 11
Length frequency distributions by 10mm size classes expressed as N/1000. Sites C & J are from positions west of Holyhead Island, T is at the eastern margin of the separation lanes and R is in the offshore depression.

The *Modiolus* from the very tide swept hard ground west of South Stack (Sites C & J) were of similar size ranges and were noticeably smaller than at the other two locations. At C and J the modal sizes were in the 40 and 50 mm classes. At site T the peak was in the 60mm class and at R it was in the 70mm class. Site T is boulder ground to the east of the rock platform, while R is at depths over 100m in the depression northwest of the rock platform. To judge from video evidence , the epibiota on the mussels and their appearance, site R is probably subject to slightly less current stress and 'grit blasting'. Only at R were any individuals found in the 90 and over 100mm size classes. It appears that on the very tide swept embedded cobble ground the horse mussels grow less well, possibly due to sand / grit scour or the larger ones have not survived. Although care was taken in looking for them, no very small sized *Modiolus* likely to have been from a 2004 spatfall were seen anywhere NW of Anglesey in January – March 2005. Indeed there were very few small mussels that may have come from spatfalls in either 2002 or 2003. This contrasts with the North Lleyn bed where spat and small mussels have been seen living in great abundance amongst the byssal mats of the adults.

5.5 EPIFAUNA ATTACHED TO MODIOLUS

Large *Modiolus modiolus* (70mm class) with epifauna of *Balanus balanus* and hydroids.

Small *Modiolus modiolus* (30mm class) embedded or nested in gravel and shell, binding the particles around itself by byssus threads..

Saddle oyster *(Pododesmus patelliformis*) on *Modiolus* (70mm class)

FIGURE 12

Examples of *Modiolus modiolus* specimens from the NW Anglesey area with a range of epifauna on the larger ones.

The epibiota found on each of the live *Modiolus* was noted as they were measured at sea. While some taxa can be recognized to species, others can only be ascribed at phylum level under field recording conditions. The data has subsequently been put in spreadsheet format to allow sorting by shell length classes. The data set shows differences between the epibiota at the two most tide scoured locations, where *Balanus balanus* predominates and the other sites where there were proportionately more soft epifaunal species on the mussels. The data set also picks up differences in the sizes at which colonization by the various epibiota begins. For example, relatively small sized *Modiolus*, which were probably part concealed in the shell hash, had tubes of the polychaete worm *Sabellaria spinulosa* attached to them.

	Size Classes (length mm)					
	<20	20-29	30-39	40-49	50-59	>60
No. *Modiolus* examined	26	82	94	122	117	69
Porifera	0	0	1	4	6	0
Hydrozoa	4	4	28	54	64	54
Actinaria	0	0	0	1	0	1
Sabellaria spinulosa	0	5	22	37	62	42
Leptochiton asellus	0	0	0	0	3	3
Emarginula fissura	0	0	0	1	0	3
Pododesmus patelliformis	0	1	2	0	0	1
Pomatoceros sp.	0	4	16	27	42	39
Balanus balanus	0	7	33	68	91	100
Verruca stroemia	0	0	0	1	0	0
Bryozoa ‘crust’	4	18	40	67	74	72
Flustra foliacea	0	2	2	1	3	6
Ascideacea	0	0	6	7	24	53
Holothuroidea	0	0	0	0	0	1

TABLE 1.

Percentage of living *Modiolus* by size classes with various taxa of epibionts noted on them. The mussels in this table were only from the most tide and sand scoured stations W of Holyhead Island (st C & J).

5.6 OTHER BENTHOS

Notes were made on the range of benthos picked up in each grab or dredge. The data has been put into spreadsheet format which should allow allocation of most to a biotope. Generally however, the range of species found was much as would be expected from such coarse ground with cobbles. Some dredges did nevertheless encounter localised coarse sand and gravel deposits with such infaunal bivalves as *Circomphalus casina. Spisula elliptica* and *Glycimeris glycimeris* and the purple heart urchin *Spatangus purpureus*.

Psammechinus miliaris	24
Hydralmania falcata	20
Sabellaria spinulosa	20
Balanus balanus	20
Astarte sulcata	19
Xanthidae *indet*	19
Pagurus bernhardus	18
Hyas coarctatos	18
Flustra foliacea	16
Alcyonium digitatum	14
Inachus leptocheirus	14
Ebalia tuberosa	12
Circomphalus casina	12
Pandalus montagui	11
Nemertesia antenina	10
Balanus crenatus	10

TABLE 2
Most frequently noted species in dredge samples from coarse grounds NW of Anglesey Jan – Mar 2005. Taxa listed in rank order of frequency of occurrences. Total number of dredges taken 36. Total taxa recognised while sorting at sea 91.

5.7 VIDEO AND PHOTOGRAPHS

FIGURE 13
Embedded cobbles and boulders. Very tide swept ground typical of the area around sites C and J to the west and north west of South Stack. Note particularly how very scarce the signs are of epifauna on these apparently stable embedded stones. This suggests there has been considerable scour by sand, grit particles or loose shells, preventing the survival even of many calcareous encrusting forms such as *Pomatoceros* spp. or barnacles.

FIGURE 14
Overlay patch of abundant old *Modiolus modiolus* shells lying on top of embedded lag cobbles and gravel. Note that most of the shells are positioned with the concave side down. Some sand is trapped amongst the shell hash. There are a few probably live *Modiolus* partly nesting amongst the shells and gathering shells with the bysaal threads.

FIGURE 15
Massed *Modiolus* shells some of which are packed on edge (imbricated). The enlarged part in the lower photograph shows a living *Modiolus* and an urchin *Psammechinus miliaris* amongst the mass of shells. This type of shell accumulation will give a different response to sonar pulses than the embedded cobble ground. The shells at many different angles will probably scatter sound giving a 'softer' appearance.

FIGURE 16
Patch of sand veneer over the embedded cobbles with some loose shell hash. Note the clump of shells at the lower edge of the photo formed by living *Modiolus* holding each other and shells together by byssal threads. The living *Modiolus* have large barnacles *Balanus balanus* growing on them.

FIGURE 17
Clump of living *Modiolus* protruding enough from the underlying embedded cobbles to give a slight shadow and to slightly obstruct the bed load transport of sand. Note the clusters of *Balanus balanus* attached to living *Modiolus* , shells and stones in the clump.

FIGURE 18
Shell accumulation with some live *Modiolus* in the lee of a small boulder.

FIGURE 19
Large *Asterias rubens* which are probably the main predator of the *Modiolus*. These two are lying between two embedded boulders.

FIGURE 20
Bed of the depression north west of the Anglesey rock platform (depth 103m), with frequent colonies of *Alcyonium digitatum* some of which are attached to living *Modiolus*.

FIGURE 21
Alcyonium digitatum colonies in the depression northwest of the Anglesey rock platform. Note there is more sand here over the lag gravel. A small sponge colony is visible on the lower margin of the photo.

FIGURE 22
Enlarged sections of photos of gravel with an abundance of Dog Cockles *Glycimeris glycimeris*. Numerous paired valves of *Glycimeris* were seen that seemed to have been preyed upon fairly recently by large *Asterias rubens*. The videos from the depression showed patches with *Glycimeris* shells packed together. The appearance suggested that these patches would have a different acoustic response than where there was bare gravel. A few small pits were seen from which the starfish had dug out the bivalves. Note the stone crab *Ebalia tuberosa* and a small *Chlamys* sp. on the left hand photo.

The above represents just a small selection of the photos obtained on the last two days at sea of this project. A particularly good video record was obtained from station R in the deeper water. Here there was more life visible, such as *Alcyonium* colonies, sponges and a number of fan worms *Sabella pavonina*. The video also showed very large *Asterias rubens* in feeding positions apparently digging *Glycimeris glycimeris* out of the bottom. This starfish is known sometimes feed by digging buried bivalves out of the sediment (Allen, 1983). The presence of visible pits in the seabed and numerous paired valves would support evidence for predation on *Glycimeris*. Some of the shells had accumulated into mounds,

5.8 OCCURRENCE OF *SABELLARIA*

Sabellaria spinulosa 'reef', broken piece from dredge sample,

Sabellaria spinulosa crust / 'proto – reef' on cobble. Note also the small blue mussels *Mytilus edulis* in crevices of the crust.

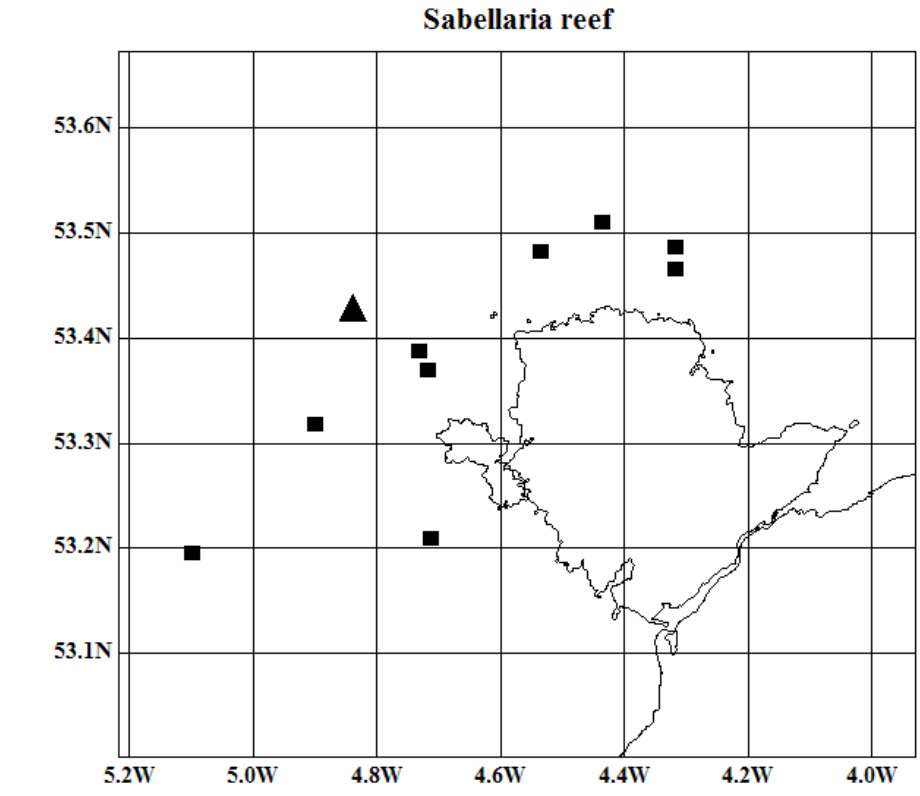

FIGURE 23.
Occurrences of *Sabellaria spinulosa* apparent 'reef' (filled triangle) and crust / 'proto-reef' N & W of Anglesey during SEA6 project January to March 2005.

The tube worm *Sabellaria spinulosa* is very widespread in the parts of the Irish Sea with lag gravels as individual worms attached to stones and shells. Off NW Anglesey many of the living *Modiolus* had *Sabellaria* tubes on them. Where they occur abundantly on stones they can form a crust with interlaced tubes several layers thick. These crusts can be considered as 'proto-reef'. The positions where these were found are shown on the above map. It was noticeable in material brought up from the seabed that in these 'proto-reefs' the ends of the worm tubes were turned upwards. At one position pieces of reef were collected that were up to 10cm thick (see photo above).

On videos *Sabellaria* is difficult to see because the sand grains they are made of blend in with the background. However a few patches were seen that appeared to represent aggregations growing up through patches of sand. The impression was gained that the *Sabellaria* crust was building upwards partly because of the localized accumulation of sand. This would explain the up turned ends to tube crusts seen in dredged samples.

6. TYPES OF *MODIOLUS* BED BIOTOPES

The very tide swept *Modiolus* patches, on the surface of sand scoured and embedded cobbles, do not readily fit into any of the categories of Horse Mussel biotopes in the present MNCR and EUNIS classification schemes. The *Modiolus* biotopes in these schemes were classified to a large extent on the differing mixes of associated epibiota occurring with them. From the associated fauna on the *Modiolus* off Anglesey and their in situ appearance on photos, the *Modiolus* biotope here may be of a particularly stressed type. Stress in this case probably comes mainly from the bedload transport of sand, grit and shells impacting on the mussels and anything growing on them rather than tidal current velocities alone. This would also help explain the relatively small size of the *Modiolus* here. Locally increased sediment transport such as from port dredging or spoil disposal has been reported to impact on condition in *Mytilus edulis*. The 'grit blasted' *Modiolus* biotope, with *Balanus balanus* as the overwhelming dominant epifaunal species, probably represents a distinctive type at level 5 in the EUNIS classification. These large barnacles dominate by their mass coupled with the high frequency of occurrence.

7. INDUSTRIAL DEVELOPMENT CONTEXTS

At present there are no oil or gas development plans known to the author that are likely to directly impact the area NW of Anglesey where *Modiolus* occurs. The closest past hydrocarbon related developments were the drilling of a single exploratory well off the Lleyn Peninsula by Hamilton and a now decommissioned SBM oil terminal off Amlwch operated for a few years by Shell. Although the SEA6 process was primarily with a view to oil and gas it was considered appropriate to bear in mind other possible developments.

The area NW of Anglesey has particularly strong tidal currents. It is relatively close to the high voltage National Grid line at Wylfa nuclear power station. These two considerations make this part of the Irish Sea an obvious possible location that might be considered for offshore tidal current power generation schemes. At the time of writing,

such works await the development of the appropriate and cost effective technology. Locating offshore structures and interconnecting cables off this part of Anglesey will nevertheless need to take account of the presence of *Modiolus* beds.

There have in the past also been proposals for inter-connector electricity cables between the UK and Ireland going via Anglesey. The very rough hard ground NW of Anglesey will probably militate against routes through the *Modiolus* bed areas being first choices. Similar comments probably apply to inter-connector gas pipes or the choice of landfall for these or pipes from offshore wells. The underlying hard rock geology would imply that gas or oil resources are unlikely to be found in the immediate area of this study.

Parts of the areas off Holyhead where *Modiolus* beds have been recorded seem to coincide with or are close to locations used for the disposal of capital and maintenance dredged material from the port of Holyhead. There have been major dredging operations at this port in recent decades around new berths for larger ferries and around the jetty used by Anglesey Aluminium to bring in alumina.

Fisheries with mobile bottom gear and particularly scallop dredges however present the greatest threats to the sustained existence in good condition of *Modiolus* beds within the Irish Sea. There is evidence that a small bed lying about 10 miles north of Point Lynas has suffered deterioration in the last five years probably due to scallop dredging activity. The beds further west off Anglesey are amongst ground with enough boulders to impede dredging. Nevertheless pressure to explore more difficult ground and the use of more precise navigation has elsewhere resulted in creep onto previously unexploited rough grounds. There is at present quite intensive fishing with pots for whelks (*Buccinum undatum*). Off NW Anglesey this activity appears to be concentrated where the *Modiolus* are found. Seabed disturbance by the potting gear may be minimal but long-term the ecological effects of removing tonnage quantities of whelks are not known. A marine traffic separation zone angles round the north west of Anglesey. This incidentally provides a degree of protection from mobile fishing gear to parts of the seabed in the area.

8. CONCLUSIONS

1. In the part of the Irish Sea north and north west of Anglesey *Modiolus* was not found in 2005 in the abundance that earlier records might have implied. No places were found where they had built up large bioherms comparable to those found north of the Lleyn Peninsula.
2. *Modiolus* was found from the direct sampling and from the video and photographs to occur here now mainly in small patches and clumps rather as than semi-continuous beds.
3. On photographs the very tide swept area west of South Stack was mainly floored by embedded cobbles and gravel. The absence of much epifauna on the stones seemed to be due to frequent abrasion by sand, grit and shells carried by the currents as bed load.

4. A much richer fauna was found in the channel / depression running around the outside of the NW Anglesey rock platform. The *Modiolus* in the depression were also much larger. Videos showed there were large numbers of *Glycimeris* which here seemed to be preyed upon by large *Asterias rubens*.
5. The very tide swept *Modiolus* biotope NW of Anglesey does not precisely fit any of the categories of horse mussel bed in the current classification schemes of marine biotopes. With the predominance of *Balanus balanus* on the mussels they probably represent a new category at level 5 in the EUNIS classification.
6. No spat *Modiolus* were found and the length frequency distributions suggest that there has been little successful recruitment of *Modiolus* in recent years. There is however an abundance of dead shell. At several places where beds had been detected in the past, they could not be found in 2005. Although partly this may be due to habitat patchiness, it suggests that *Modiolus* may be declining off NW Anglesey.

9. RECOMMENDATIONS

1. The side-scan showed up several small features on the seabed that could have been be due to either shell accumulations or biogenic 'reef' formations. Others could have been relics of the glacial and sea level change history of the area. Confident identification of such features will require a higher level of geo-referencing than used on this survey. It will need the use of USBL equipment to locate the camera sledge and the sonar fish relative to the DGPS aerial on the ship This will probably require several camera tows to get the equipment on to any particular features.
2. A multibeam sonar survey of particular sections of the NW Anglesey area needs to be undertaken. This is especially so for the deeper channel / depression beyond the rock platform.
3. More work is needed to check what if any of the *Modiolus* bed north of Point Lynas, at the inferface between the NW Anglesey area and Greater Liverpool Bay, has survived scallop dredging disturbance.
4. Bearing in mind the apparent lack of successful recent recruitment, the NW Anglesey *Modiolus* beds should be re-visited in a few years time to check on their condition.
5. The approaches adoted here need to be used in the several other parts of the wider SEA6 area, where *Modiolus* beds are known to occur or have occurred in the past. This would be with a view to updating data and reviewing the current condition of *Modiolus* beds in the Irish Sea as a whole. Also bearing in mind the listing of *Modiolus* in various international conservation initiatives and the disproportionate ecological value of such sensitive biogenic features.

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