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COMMISSIONED REPORT

Commissioned Report No.297

Repeat monitoring of the 'unfavourable-declining' *Modiolus* biogenic reef feature of the Lochs Duich, Long and Alsh SAC

(ROAME No.R07AC708)

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COMMISSIONED REPORT

Summary

Repeat monitoring of the 'unfavourable-declining' *Modiolus* biogenic reef feature of the Lochs Duich, Long and Alsh SAC

Commissioned Report No. 297 (ROAME No. R07AC708)
Contractor: Scottish Natural Heritage
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Background

Lochs Duich, Long and Alsh (DLA), North-West Scotland were designated as a marine Special Area of Conservation (SAC) in March 2005. The designation was made for the reef habitats present within the lochs. Reef habitats are an Annex 1 feature within the Habitats Directive. These include rocky reefs found throughout the site, and biogenic reefs formed by dense beds of horse mussel, *Modiolus modiolus*. Horse mussels are widely distributed around northern and western coasts of the U.K. However, beds that are dense enough to be considered a reef are rare and of high conservation importance. A key objective for the Lochs Duich, Long and Alsh Marine SAC is to maintain the extent, distribution, structure and function of the qualifying habitat (reefs) within the designated area (SNH, 2006).

The focus of this survey was the *Modiolus* beds found in Kyle Akin, at the mouth of Loch Alsh. This bed was previously surveyed in 1999 (Mair *et al.*, 2000). A follow-up survey as part of a Site Condition Monitoring (SCM) survey in 2004 indicated that density of live *Modiolus* had declined (EMU, 2006). In 2005, the condition of the Lochs Duich, Long and Alsh SAC was reported as unfavourable-declining, on the basis of a reduction in abundance of live *Modiolus*, identified during SCM in 2004. The primary aims of this survey were to:

1. confirm the extent of the declining *Modiolus* bed, through detailed mapping.

2. plan and conduct monitoring of the declining bed in sufficient detail to report on the status of the bed.

3. ascertain whether the decline observed previously applied across the whole *Modiolus* bed.

4. identify potential causes of the decline and possible management approaches.

Secondary aims of the survey were to:

1. confirm the extent of additional *Modiolus* beds identified within the SAC.

2. investigate whether any recent recruitment had taken place.

Selected elements of a survey carried out by Heriot-Watt University (HWU) in 1999 on the dense aggregations of *Modiolus modiolus* within Kyle Akin were repeated with the aim of directly comparing the results from the two surveys to enable an assessment to be made on the current condition of the *M. modiolus* bed.

Main findings

- The *Modiolus* bed in Kyle Akin is extensive, but did not appear dense in any location surveyed.
- Mapping *Modiolus* density by remote video is not possible due to the low densities of *Modiolus*, the difficulty in discriminating between live and dead *Modiolus*, and the dense brittlestar bed covering much of the seabed in Kyle Akin. Presence or absence only can be discerned with any reliability.
- There remains considerable doubt over the accuracy of relocation of the historical survey stations.
- *Modiolus* densities appeared broadly similar to those recorded in 2004, and significantly down from those recorded in 1999
- The large numbers of attached, empty *Modiolus* shells previously recorded in 2004, were still evident in this survey

The following conclusions were reached:

- There most likely was a significant decline in *Modiolus*, in Kyle Akin, between 1999 and 2004. However doubts over positional accuracy, the limited spread of quantitative data in relation to the size of the bed and the degree to which patchiness of the bed, low sample size and diver-error may have influenced the results, place some doubt on the degree of change and whether it applied to the whole bed.
- With no obvious source of a potential adverse impact it is not possible to determine the cause of any decline in *Modiolus*. Viral, bacterial, fungal or other pathogens are considered possibilities, as is smothering or other-competition for

resources. Higher than sustainable levels of predation on spat or juveniles is a possibility, though no evidence for this was found. Collection of adults by divers is also a possibility (EMU, 2006). Damage from mobile fishing gear is considered unlikely because there was no evidence of damaged or broken shells or habitat disturbance.

- Future monitoring needs to be conducted around permanently marked stations in order to ensure confidence in the accuracy of relocation, given the high degree of spatial variability within the bed. These stations need to be evenly spread across the entire known bed if findings are to be applied to the bed as a whole.
- A greater number of quadrat counts needs to be conducted at each station if anything other than very dramatic change is to be identified.
- Whole quadrat counts, as opposed to intersect counts, should be considered given the low densities encountered.
- *Modiolus* recruitment should be assessed using a significantly larger number of samples taken from across the known bed. These could be collected at each of the permanently marked stations.
- Historical stations within the bed should be phased out given their non-random location on the bed as recommended by Thomas and New (2006).

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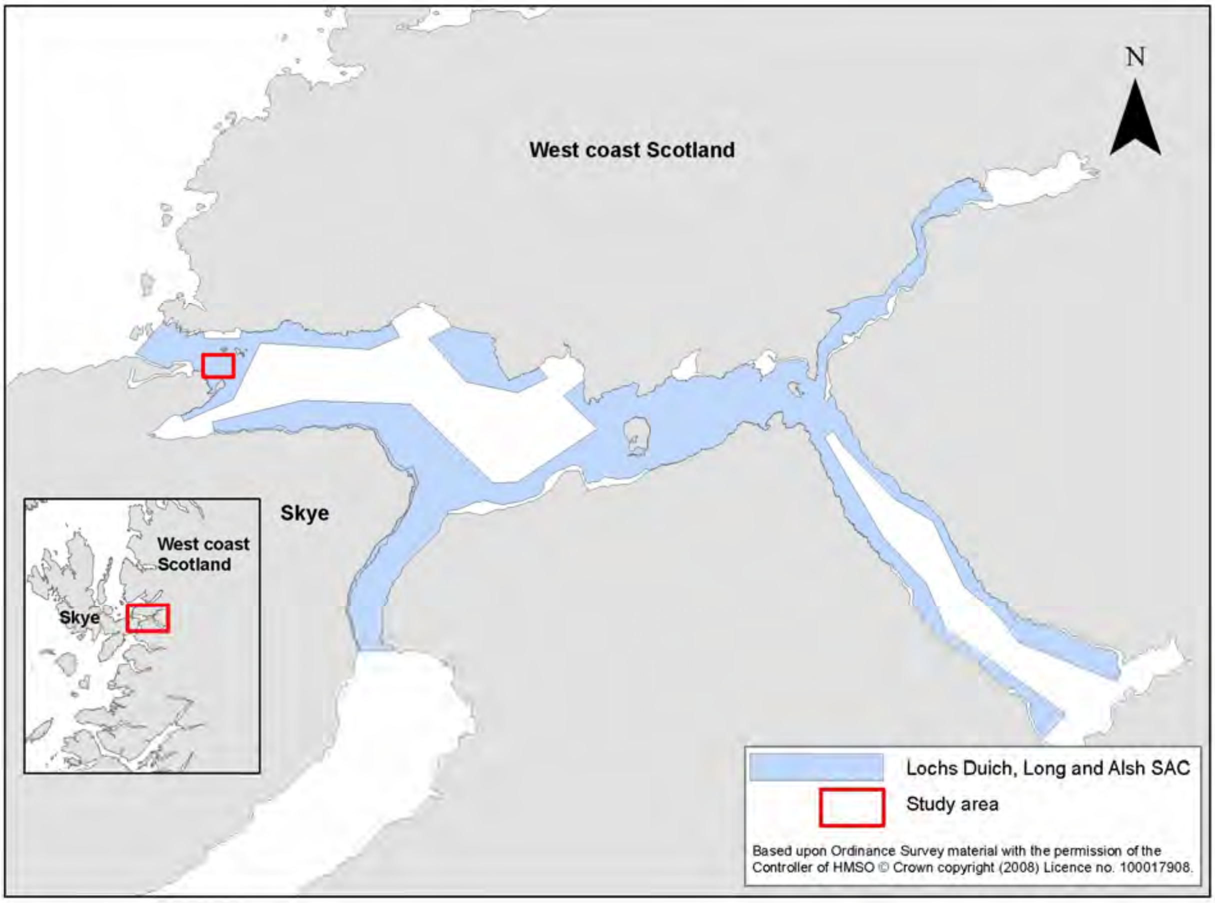
1. INTRODUCTION

Marine Bio-images was commissioned to conduct a survey of the horse mussel (*Modiolus modiolus*) bed within Kyle Akin, at the mouth of Loch Alsh, North-West Scotland (Figure 1.1). This survey was conducted between the 29th of May and the 6th of June 2007. The bed lies within Lochs Duich, Long and Alsh marine SAC. The bed has been classified as a biogenic reef, and as such is a contributory feature to the habitat 'Reefs' (Habitats Directive Annex 1) for which the marine SAC has been designated (SNH, 2006).

Figure 1.1 Lochs Duich, Long and Alsh SAC and study area.



The conservation objectives for the qualifying interest (Reefs) are that there should not be deterioration or significant disturbance of the qualifying interest. Specifically this includes ensuring the following are maintained in the long term:

Extent of the habitat within the site

Distribution of the habitat within the site

Structure and function of the habitat

Processes supporting the habitat

Distribution of typical species as components of the habitat

No significant disturbance of species of the habitat.

The bed was initially surveyed by Mair *et al.* (2000) as part of a review of *Modiolus* ecology and conservation in Scotland. A 200m long transect was surveyed, located on the southern side of Kyle of Lochalsh, south-east of String Rock, recording *Modiolus* abundance at 11 equidistant stations (Dt0 - Dt10) along this transect. Three additional stations in the same vicinity, StA and StB, to the west and east respectively, and St1, adjacent to the 200m transect were also surveyed as part of the 2000 survey. The method employed was diver counts within randomly thrown strung quadrats, with only *Modiolus* lying directly under string intersects being recorded. The stations surveyed by Mair *et al*. (2000) were re-surveyed in 2004 by EMU, as part of a SCM study (EMU, 2006). They identified a reduction in abundance of live *Modiolus* within these stations. As a result of this study, the condition of the Lochs Duich, Long and Alsh SAC was reported as unfavourable-declining in 2005.

The *Modiolus* quadrat data collected by Mair *et al*. and EMU was analysed by Thomas and New (2006) for Scottish Natural Heritage, to determine whether there had been a statistically significant change in the number of *Modiolus* between 1999 and 2004. It was concluded that there had been a statistically significant and biologically substantial decline in the probability of encountering live *Modiolus* on the survey plots. They also made recommendations regarding the future design of investigations into the health of the *Modiolus* bed. Specifically, they recommended that the size of the bed be mapped. They further recommended a grid of monitoring stations be set up across the mapped bed, allowing the previous transect to be phased out, given its non-random location. These recommendations, and the earlier studies, formed the basis for the design of this survey.

The primary aims of this survey were to:

1. confirm the extent of the declining *Modiolus* bed, through detailed mapping.

2. plan and conduct monitoring of the declining bed in sufficient detail to report on the status of the bed.

3. ascertain whether the decline observed previously applied across the whole *Modiolus* bed.

4. identify potential causes of the decline and possible management approaches.

Secondary aims of the survey were to:

1. confirm the extent of additional *Modiolus* beds identified within the SAC.

2. investigate whether any recent recruitment had taken place.

2. METHODS

2.1 Overview and timing

The bulk of the drop-video work was undertaken between the 29th of May and the 1st of June 2007. This was intended to map the bed in preparation for quantitative data collection by divers. A team of four (Laura Baxter, Claire Dalgleish, Suzanne Henderson and Colin Munro) mobilised on the 28th of May to undertake this work. The 1st of June was spent reviewing the video data and planning the diving, whilst the remaining team members (Lin Baldock and Lou Luddington) mobilised.

Diving commenced on the 2nd of June, with all diving ending on the afternoon of the 6th of June. In view of the widespread and patchy nature of the *Modiolus* bed in Kyle Akin, it was decided to concentrate efforts on data collection within the bed, and to omit the secondary objective of confirming the extent of additional *Modiolus* beds identified within the SAC. Additional video drops were conducted on the morning of the 6th of June, with a selection of these being dived during the afternoon. All data was transcribed at the end of each day. All team members demobilised on the morning of the 7th of June.

2.2 Drop-video survey

The drop-video survey was conducted from SNH's rigid-hulled inflatable boat (RIB) *Aphrodite*. The video system consists of a Sony miniDV camcorder in aluminium housing, mounted in a stainless-steel custom made frame. A wide-angle port is fitted as standard, and twin HID video lights were mounted on the frame. The video was connected to a surface field monitor by a 60m umbilical, with the monitor powered by a 12v car battery. The video was deployed by hand. At each station the vessel manoeuvred to a target waypoint. Once in position the camcorder was deployed. A start waypoint was logged immediately the camcorder was deployed (if deployment was directly on top of the target waypoint, this was used and no additional start waypoint logged). The video was lowered until the seabed could be clearly viewed on the surface monitor. The video was allowed to drift across the seabed for approximately 2-4 minutes, generally allowing 30m or more to be covered, depending on current and wind speed. An endpoint waypoint was also recorded for each video drop. All video footage was recorded within the underwater camcorder on miniDV tape. This was subsequently reviewed and presence/absence of *Modiolus* assessed for each video transect.

The intention was to use the drop video to initially identify the boundary of the bed through a series of short video drifts. Additional time available would be used to conduct video drops within the mapped boundary, identifying patchiness of ‘holes’ in the bed. However it quickly became apparent that the bed could not be mapped in this way. Live *Modiolus* were too cryptic to be spotted in real time on a small field monitor. Complicating factors were:

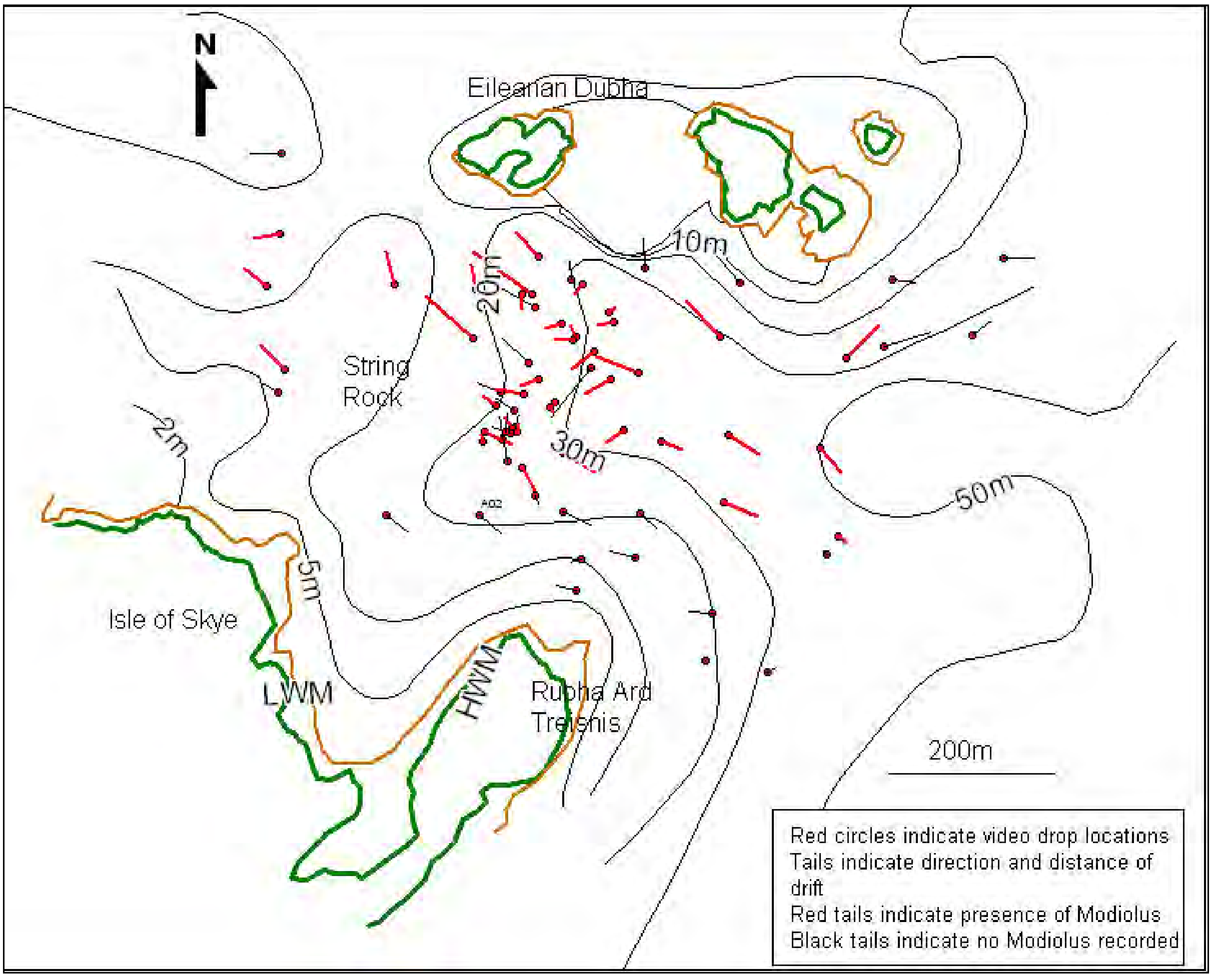
- Much of the seabed was carpeted with dense brittlestar beds, obscuring most of the substrate and any protruding *Modiolus*.

- There were numerous empty *Modiolus* shells on the seabed (in turn, very similar to the dark cobbles on much of the seabed). These shells generally remained attached, often in clusters, with the valves closed. Thus live *Modiolus* could only be identified from partially gaping shells where the yellow mantle or siphons could be seen. The camcorder had to be re-orientated to achieve this level of detail. Part-way through the survey it was positioned to look directly down, rather than angled across the seabed (which initially gave a wider view). This allowed a small area of seabed (around 250-300mm diagonally) to be viewed in greater detail. However, as the seabed was now only 80-100mm below the camcorder, the image travelled across monitor screen at a very high rate as the vessel drifted, making on the spot assessment very difficult.

- There did not appear to be dense aggregations of *Modiolus*, so rather than identifying ‘*Modiolus* substrate’ the aim became to spot individual live *Modiolus*.

It was therefore decided to adopt a grid mapping protocol, first identifying the area we assumed the bed would lie within, extending this slightly, then plotting across this area. Drop video stations were plotted at all grid line intersects. It practice, the station locations frequently had to be relocated from grid intersects due to shallow rocks, islands or greater depth than the umbilical could reach. In addition to this, slight delays in deployment and vessel drift in strong winds or tide as the system was being deployed, meant that some stations were located down-wind or down-tide of the proposed location. Nevertheless, a good, even spread of video stations was achieved across all areas where deployment was practical (Figure 2.1). On completion all videotape was reviewed on a large television monitor in the hotel accommodation. Each station was scored as to presence or absence of *Modiolus*, with brief additional notes on habitat also being made. This assessment was then used as the basis for planning dives.

Figure 2.1 Map showing the location of drop video stations and direction of video drift in Kyle Akin, Loch Alsh, 2007.

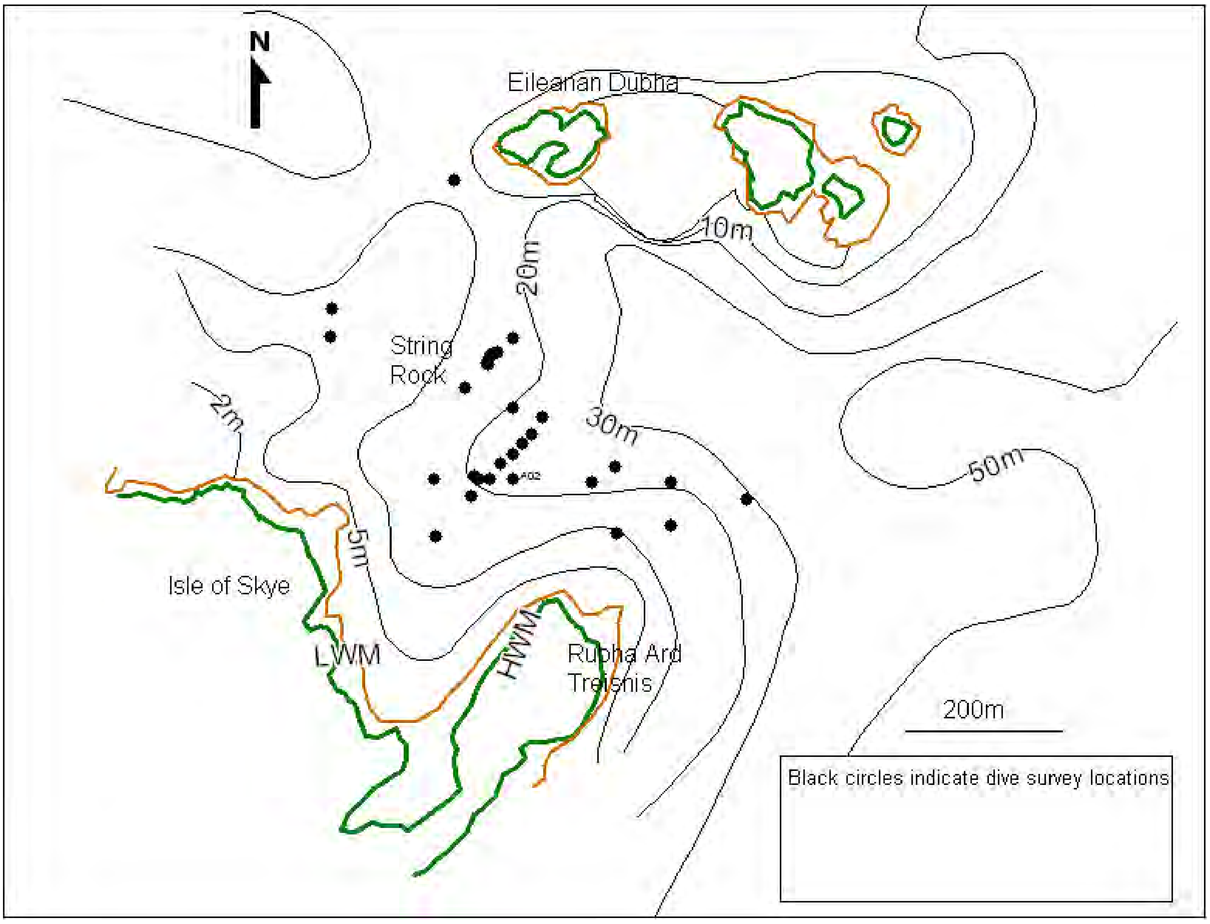


Sixty eight video stations were surveyed, giving a good spread of data across the planned survey area.

2.3 Diving survey

All diving was conducted from the RIB *Aphrodite*. A six-person dive team was used (Lin Baldock, Laura Baxter, Claire Dalgleish, Suzanne Henderson, Lou Luddington and Colin Munro), allowing three waves of diver pairs to operate. The main diving task was diver quadrat counts of *Modiolus*. These were conducted at a number of historical stations, to provide year on year data, plus a number of additional stations. Historical stations concentrated on stations along the diver transect surveyed in 1999 and 2004. In earlier years this transect had been surveyed by laying a 200 m transect line, marked at set intervals, along which the divers would swim. Upon reaching the station marker quadrats would be randomly thrown and counts conducted. No transect line was laid during this survey, station relocation it was thought could be achieved by finding the location using the GPS with a similar level of accuracy. Travelling between such stations by underwater transect line is impractical, especially given the distances likely to be involved. Consequently the methodology standardised on calculating the latitude and longitude of each selected station, then deploying a shotline on station, down which the dive pair would descend. These positions can be found in appendix 2.

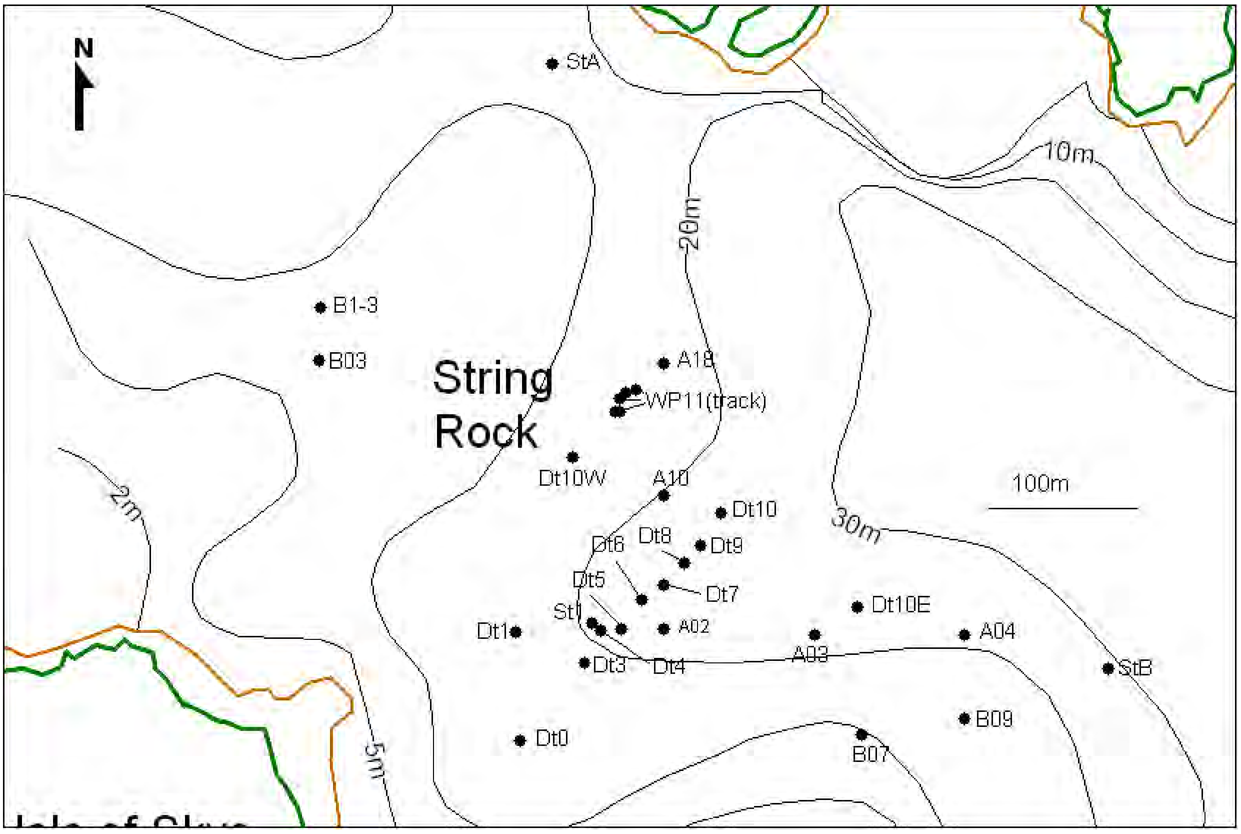
Figure 2.2 Map showing the general location of *Modiolus* dive stations surveyed during this study of a site at Kyle Akin in 2007.



2.3.1 Quadrat surveys

In order to make the data as comparable as possible with previous years, the same quadrat size (0.5 x 0.5m) and counting method was employed. Strung quadrats (strung at 10cm intervals, creating 16 string intersects) were used to conduct quadrat intersect counts to assess *Modiolus* density. Thus only *Modiolus* directly beneath a point intersect were included in the counts, giving a maximum possible value of 16. At each station a minimum of five quadrats counts (the number used in earlier surveys) were completed. If time constraints allowed additional counts were completed. The reasons for this were that *Modiolus* appeared both sparse and very patchy in their distribution, thus conducting additional counts may help inform on appropriate number of quadrats for future surveys, and also allow a better assessment of abundance.

Figure 2.3 Map showing the individual dive stations surveyed for *Modiolus* using a quadrat intersect methodology in Kyle Akin in 2007. WP11 indicates the track of a dive where the divers swum along a bearing to detect the boundary of *Modiolus* distribution.



In addition to intersect counts, counts in quadrat squares were also conducted at a few stations, where time permitted. This was a decision made in the field, given the high number of '0' counts and low counts the previous method was producing, due to the low densities encountered, and the potential problems we felt this may produce for statistical analysis. Additionally it provided a direct comparison of counting methods for assessment in regard to future surveys.

Figure 2.4 Quadrat from station Dt5, showing typical ophiuroid cover.

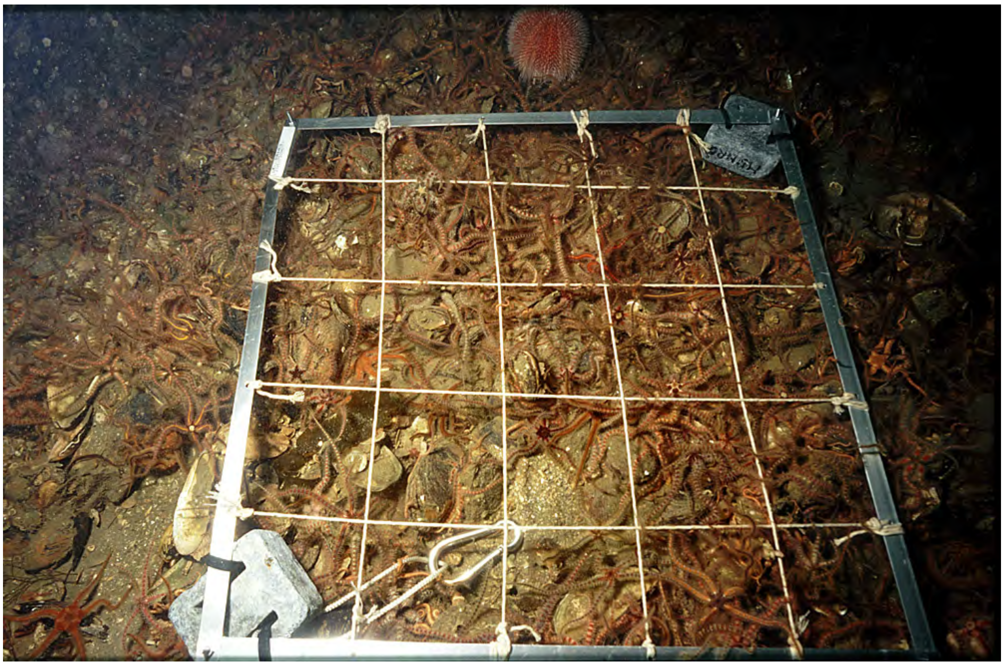
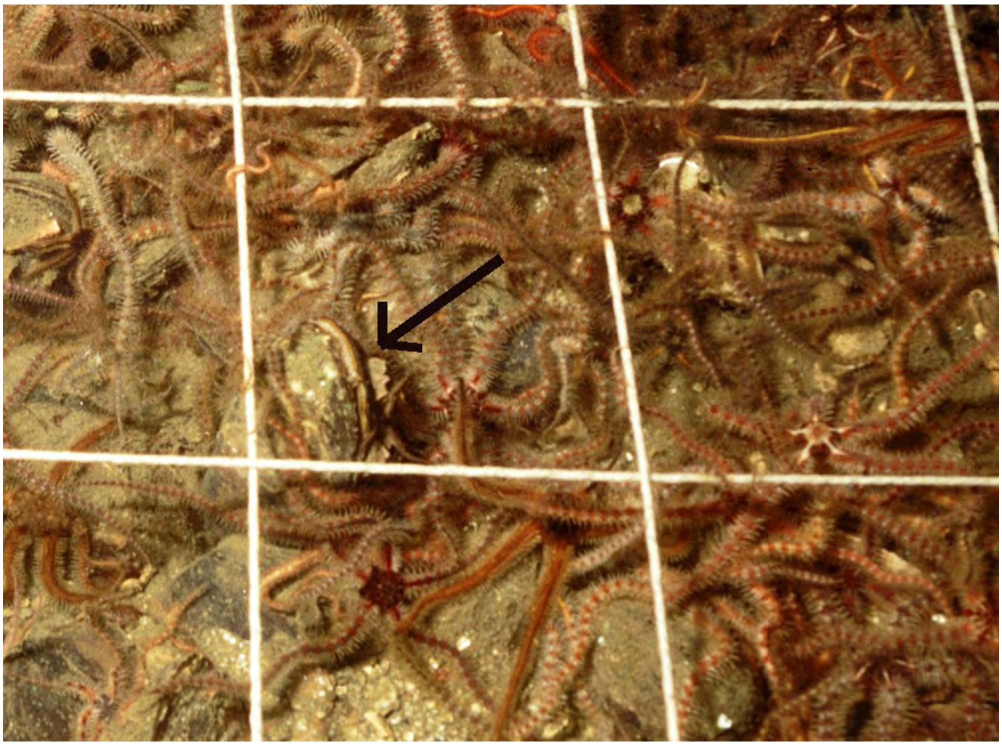


Figure 2.5 Enlargement of a section of the quadrat shown in figure 2.4 showing conspicuous live *Modiolus*.



2.3.2 *Modiolus size data*

At two stations (Dt5 and St1) *Modiolus* clumps were collected for measurement in order to attempt to assess whether there had been recent recruitment to the population. Only two samples were taken in order to minimise disturbance to the feature. The methodology employed was the same as that used in Mair *et al*., 2000. A 5l bucket was placed upside down over a clump of *Modiolus* and the *Modiolus* scooped into it by hand. The bucket was then sealed before bringing to the surface. The contents of the bucket were then carefully sifted through on the pier at Kyle of Lochalsh, and all *Modiolus* extracted and measured for length, tumidity (width) and height. Once measured, all *Modiolus* were returned to the sea. Bivalves found within the clump samples that were too small to be positively identified in the field were preserved in alcohol for subsequent identification. Also present in the clump samples (approximately three to four in each sample) and recorded by divers, from both within the *Modiolus* bed and in an extensive bed adjacent to the *Modiolus* bed, was the file shell *Limaria hians*.

2.3.2 *Permanent markers*

Permanent markers were deployed along the dive transect at stations Dt4, Dt7 and Dt10, to be used for accurate relocation in future surveys. These consisted of 40kg cylindrical concrete weights to which small (approximately 180mm diameter) plastic fishing floats were attached. The buoys were spliced on with floating polypropylene line such that they floated approximately one metre above the seabed. At each station two of these weights were deployed, connected by approximately 5m of line. When deployed the line between the markers was stretched tight. The aim being to provide a snag-line as a further aid to relocation for divers in future years.

Figure 2.6 Illustration depicting sub-surface markers on the seabed.

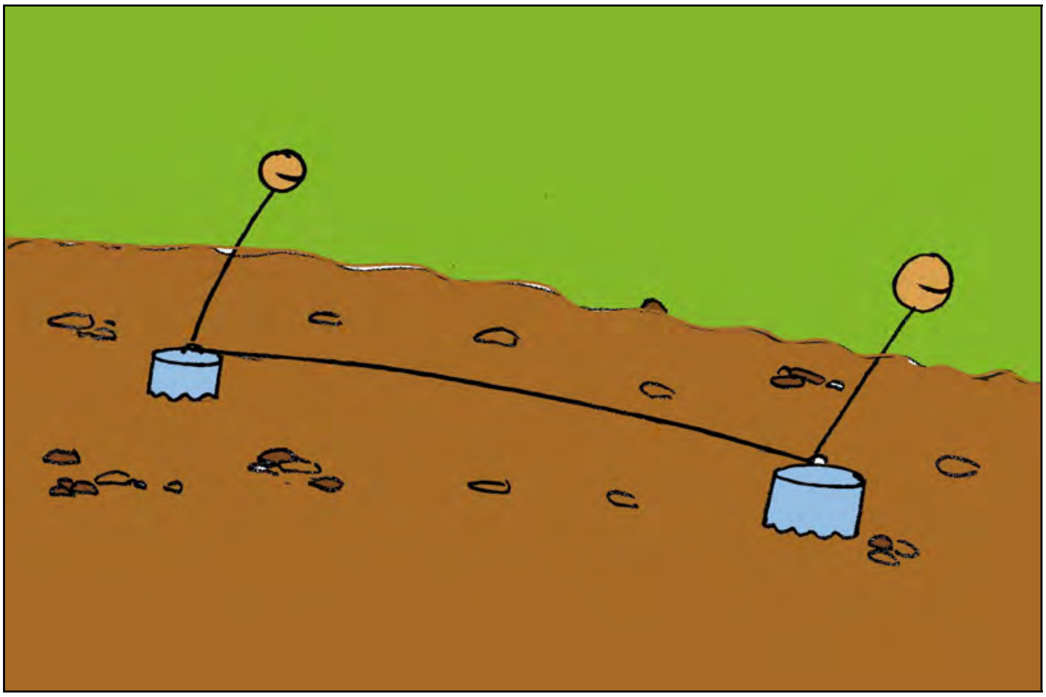
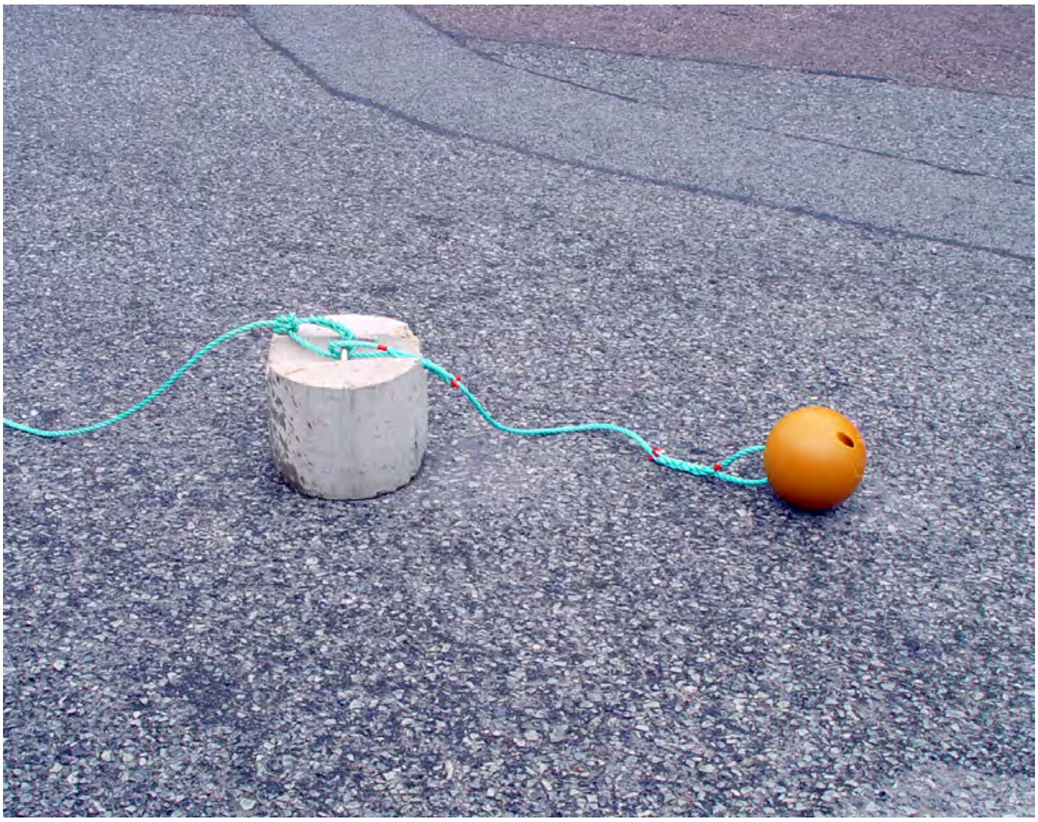


Figure 2.7 Photograph of sub-surface marker before deployment.

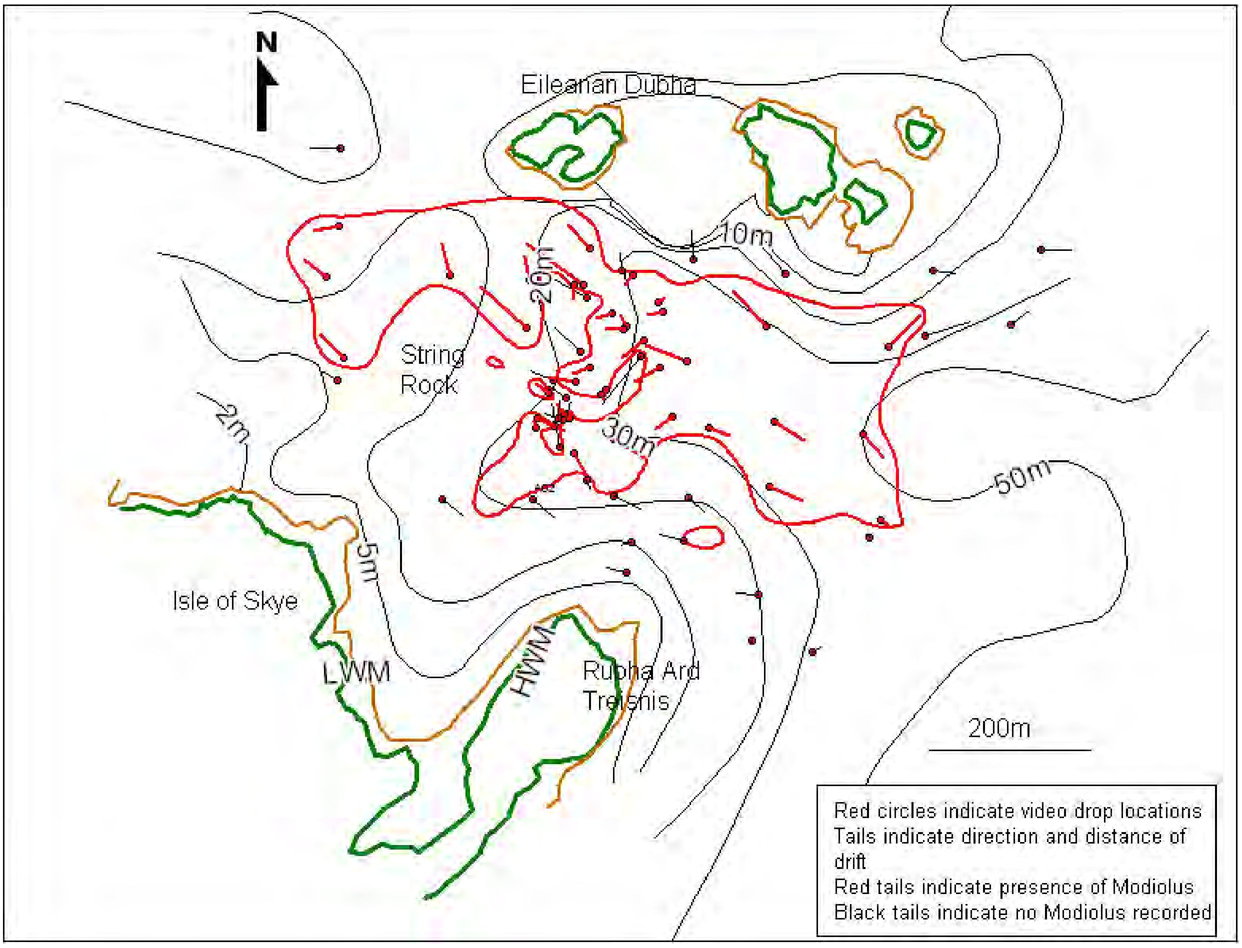


3. RESULTS

3.1 Drop video survey

The full data from the drop video survey are given in appendix 1. *Modiolus* were found to occur across most of the area surveyed. They were found to be present at virtually all stations in the southern channel of Kyle Akin, between Rubha Ard Treisnis on Skye and Eileanan Dubha. *Modiolus* presence extended at least 750m in a north-west to south-east direction along the channel east of Rubha Ard Treisnis. *Modiolus* were found as shallow as 7m chart datum (CD) to beyond 50m CD. Additional detail on the boundaries of the *Modiolus* bed came from quadrat dives. Divers at station DT3 (57.272956°N 5.713767°W) found a sharp delineation between *Modiolus* bed (channel side) and sediment plain (Skye side) at this point. Similarly, at waypoint 16 (57.274588°N 5.713379°W) the south-western limit of the bed was located by divers being deployed partway between two stations (A18, where *Modiolus* had been recorded and DT10W, where it had not) and swimming south-west until the boundary was reached. This data has been incorporated into the overall map of *Modiolus* distribution, figure 3.1. Although it was not possible to assign quantitative values to the *Modiolus* seen on the drop video footage, nowhere within the survey area did they appear to occur in high densities.

Figure 3.1 Map showing the distribution of *Modiolus,* (red line is the boundary) identified in Kyle Akin, Loch Alsh during the 2007 survey.



3.2 Diving survey

3.2.1 Quadrat surveys

Quadrat counts at sites where previous data had been collected are available for Dive Transect stations Dt1, Dt3, Dt4, Dt6, Dt7, Dt8, Dt9 and Dt10, and St1, StA and StB. Year on year comparisons are presented in Table 3.1 below.

Additionally new sites were surveyed which were not surveyed during the previous surveys. The quadrat counts for these are found in appendix 3.

Table 3.1 Comparison of *Modiolus* quadrat counts at the bed in Kyle Akin, Loch Alsh from 1999, 2004 and 2007.

	Heriot Watt 1999		EMU 2004		Marine Bio-images 2007	
Station	Quadrats	Mean	Quadrats	Mean	Quadrats	Mean
Dt0	0;0;0;0;0	0	0;0;0;0;0	0	0;0;0;0;0	0
Dt1	0;0;0;0;0	0	0;0;0;0;0	0	0;0;0;0;1;0;0,0;1,0	0.2
Dt3	0;0;0;0;0	0	0;0;0;0;0	0	3; 3; 0; 0; 1	1.4
Dt4	4;7;6;9;8	6.8	4;1;4;2;2	2.6	1;1;6;0;1;1;1,1;1;3;0;0;0;2;4;0;2;2	1.4
Dt6	5;8;4;7;7	6.2	4;6;2;2;4	3.6	4;4;2;2;1;2;6;2;2;1;4,3;2;3;2;3;1;1;4;6	2.75
Dt7	7;5;3;4;4	4.6	3;0;5;2;4	2.8	1,4;1;1;2;1;2;3;2;2;3,1;2,3;1;4;5	2.2
Dt8	10;8;9;9;7	8.6	4;6;4;4;4	5	4;4;5;3;2	3.6
Dt9	10;7;8;5;9	7.8	7;3;7;5;4	5.2	2;2;1;0;0;2;1	1.1
Dt10	7;9;10;8;5	7.8	4;5;3;8;6	5.2	2;2;3;6;3	3.2
StA	7,8,6,8,6	7	0,3,2,2,2*[1]	1.8	0,0,0,0,0	0
			0,0,0,1,2*[2]	0.6		
StB	5,4,2,3,2	3.2	1,2,1,3,0 [3]	1.4	2,1,2,1,1 [1]	1.4
			0,0,2,0,1 [4]	0.6	2,0,1,0,1 [2]	0.8
St1	7;2;6;4;4	4.6	0;1;2;1;0*	0.8, 3.35**	5;1;2;4;4	3.2

* Data for first five quadrats only ** Mean for all 34 quadrats sampled in 2004
[1] Diver 1 data [2] Diver 2 data, [3] StB, diver 1 quadrat counts, [4] StB, diver 2 quadrat counts

The mean number of *Modiolus* counted per quadrat, in 2007, varied from 0 to 3.7 (from all sites, historical and new); the maximum individual count in any quadrat, at any site, being seven (16 is the maximum possible count when a mussel is present at every intersecting point). Large confidence intervals exist on the mean values at most sites, indicating the high variability in the data for individual quadrats. All quadrat data is presented in appendix 3.

3.2.2 Modiolus size data

The size data for *Modiolus* collected at Dive Transect Station Dt5, and at St1, is given below. Five small mussels extracted from the samples (three from Dive Transect Station Dt5 and two from St1) were too small to accurately identify or measure in the field. These were preserved in alcohol and subsequently examined and measured in laboratory conditions. They are believed likely to be juvenile *Modiolus modiolus*, but it was not possible to exclude the possibility they were *Modiolula phaseolina*, given the small size. The size measurements for these are given in italics within table 3.2.

Table 3.2 *Modiolus* sample size data from clump samples taken by divers at stations in Kyle Akin, Loch Alsh, 2007. Figures in italic refer to small individuals that may possibly be *Modiolula phaseolina*.

	Dt5			St1		
Specimen	Length	Width	Height	Length	Width	Height
1	85	32	32	101	37	55
2	98	41	41	105	42	46
3	89	32	32	91	40	48
4	78	29	29	*5.95*	*4.30*	*2.80*
5	37	14	14	*5.00*	*3.60*	*2.35*
6	*7.45*	*4.90*	*4.00*			
7	*4.35*	*3.35*	*2.40*			
8	*4.00*	*2.90*	*1.60*			

3.3 Data analysis

3.3.1 Data assumptions

In analysing the quadrat data from the dive transect stations surveyed in 2007 along a transect that had previously been surveyed in 1999 and 2004, it has been assumed that accurate relocation of the sites occurred, even though there is significant doubt as to whether the transect was accurately located in all three years.

In 2007, eight of the 11 transect stations previously surveyed were resurveyed. Three further historical sites in the area were also surveyed. Relative to the transect these additional sites were positioned to the north-west (StA) and to the east (StB), and close to transect station Dt4 (St1).

Most sites were surveyed by two divers. Counts were made by the two divers acting independently and assessing numbers in the same $0.25m^2$ quadrant after its placement.

At all quadrats counts were conducted by recording numbers of live *Modiolus* touching string intersects within each strung quadrat. At five stations additional counts were conducted where the total number of *Modiolus* within the quadrat was recorded.

The key questions considered in analysing the data were:

> How do overall densities compare with those previously recorded? Is there a significant decline in the *Modiolus* populations since 2004 or since 1999?
>
> Do the data allow us to detect significant difference in the population of *Modiolus* at different sites?

Additional questions addressed were:

> Do the data indicate significant differences in repeat diver counts of *Modiolus* from the same quadrat and what might cause this if there is?
>
> Do the data reveal whether some sites are significantly more variable (patchy) in *Modiolus* populations than other sites?
>
> Could monitoring the total number in the quadrat be preferable method?
>
> How many repeat quadrats are advisable; are five, as in previous surveys, sufficient?

3.3.2 Statistical Analyses & Results

3.3.2.1 General data inspection and statistical description - variability

Initially, raw data of counts of numbers of mussels present at intersects within each quadrat, obtained by each diver in the 2007 survey, was used to obtain mean counts for each site and their confidence intervals (CI), standard deviations (SD) and standard errors (SE). These data were analysed by the Kolmogorov-Smirnov (K-S) test to determine whether they were normally distributed. A large number of the sites (18 of the 24 sites) showed non-normally distributed data with KS-test P values <0.05. This was mainly due to the large number of zero values in some sites (e.g. Dt0, B09, B07, StA) although in some cases (e.g. site A02) reflected diver variations in counts.

The analysis showed large differences in the mean (and median) count recorded at most of the sites surveyed, varying from zero to 3.6 (Table 3.1 and Appendix 4) with the maximum individual intersect count in any quadrat, at any site, being seven (16 is the maximum possible count when a mussel is present at every intersect). The large confidence intervals on the mean values at most sites are indicative of the high variability in the data for individual quadrats.

3.3.2.2 Abundance data (% presence) and comparison to historical data

Previous surveys have calculated the percentage presence at each site based on presence/absence data, where 100% presence of a *Modiolus* at each of the 16 intersects equals 100% abundance. Percentage presence at each site and their SD, SE and CI were obtained for 2007 survey data. The mean percentage presence at individual sites varied between 0% and 22.5% (see Appendix 5). As with raw count data many sites showed a high variability and non-normal distribution of the data.

To gain an idea of overall percentage presence recorded from all sites and all divers, all data were used to calculate an overall mean percentage presence. A mean value of 8.3% (CI mean 1.0) was obtained for the 313 quadrats monitored, but showed large variation, with values of 0% to 43.8 % (see Appendix 3). These results are based on unequal number of data points per site and the data are not normally distributed (K-S P <0.001) because of the large number of 0% values, so a mean percentage presence of horse mussels was calculated for each of the 24 sites in the 2007 survey. This gave a value of 9.10 + 1.45 % (SE) (Confidence interval of mean 3.0). This includes many new sites, so a further calculation concentrated on just the sites used in previous surveys (section 3.3.2.3).

3.3.2.3 Data on *Modiolus* abundance at historical sites only – changes in abundance over time

Data for new sites in 2007 where we do not have detailed historical data were excluded, and an overall mean percentage presence of 11.35 $\pm$ 2.39 ($\pm$ SE) (CI 5.33, see Appendix 4) was obtained for the 11 sites that had also been monitored in 1999 and 2004. This value indicated a trend of declining overall mean percentages recorded over time: 29% in 1999; 15% in 2004; 11% in 2007. StA has horse mussels present in both 1999 and 2004 but none in 2007. Site Dt3 (Dive transect 3) previously had no *Modiolus* recorded in either 2004 or 1999, while in 2007 there was a mean count of 1.4 (mean 8.75% abundance). This might indicate a change in the edge of the bed or errors in transect station relocation.

Further statistical analysis using a repeat measures (RM) ANOVA explored the changing numbers of *Modiolus* since 1999 at all sites except Dt0, where no horse mussels had been recorded in any survey. This comparison makes the assumption that site relocations are accurate. The mussel count per five quadrats was calculated for each site and in each year, for use in the RM analysis. Where more than five quadrat counts had been made all data available were used in making the calculation of the count per five quadrats. Where two divers had made counts a mean count per five quadrats was employed in the analysis.

The RM-ANOVA shows a significant difference between years ($P<0.001$; Appendix 8), exceeding the variation between sites. The Holm-Sidak method for multiple comparisons between years showed that there was a significant decline in *Modiolus* present in 2004 compared to 1999 (as concluded in previous data analyses: Thomas and New, 2006) and that 2007 counts were also significantly less than in 1999, but that the difference in mean counts of *Modiolus* (at intersects) at these sites between 2004 and 2007 was not statistically significant.

3.3.2.4 Is there significant difference in *Modiolus* abundance at different sites?

To assess whether there was significant variation in numbers of horse mussels at different sites ANOVA on individual counts of numbers present was performed using all data available (both divers and all quadrats). This analysis confirmed a non-normal distribution of the data and a Kruskall-Wallis ANOVA on ranks was therefore performed. This test indicated a significant difference between sites ($P<0.001$; see Appendix 6 for further details). Dunn's multiple comparison method (that can be used when group sizes differ) was used to identify significantly different sites (Appendix 9). The sites in table 3.3 were identified as significantly different from one another (Dunn's multiple comparison tests: $P<0.05$).

Interpretation of any spatial arrangement of density patterns has not been carried out, but the identification of significantly different sites justifies further examination of spatial differences.

The following sites were identified as significantly different from one another (Dunn's multiple comparison tests: $P<0.05$):

Table 3.3 Diver survey sites in Kyle Akin 2007, where *Modiolus* quadrat counts were identified as significantly different from each other using Dunn's multiple comparison tests ($P<0.05$).

Dt8 vs. Dt10W	Dt6 vs. StA	A02 vs. Dt10W
Dt8 vs. StA	Dt10 vs. StA	A02 vs. StA
Dt8 vs. B07	Dt10 vs. B07	A02 vs. B07
Dt8 vs. Dt0	Dt10 vs. Dt0	A02 vs. Dt0
Dt8 vs. Dt1	St1 vs. Dt10W	Dt6 vs. B07
Dt8 vs. B09	St1 vs. StA	Dt6 vs. Dt0
Dt7 vs. Dt10W	St1 vs. B07	A04 vs. StB
Dt7 vs. StA	St1 vs. Dt0	A04 vs. StA
Dt7 vs. B07	B1-3 vs. Dt10W	A04 vs. B07
Dt7 vs. Dt0	B1-3 vs. StA	A04 vs. Dt0
Dt0 vs. Dt10W	B1-3 vs. B07	A04 vs. Dt10W
Dt6 vs. Dt10W	B1-3 vs. Dt0	

3.3.3 Are there significant diver differences in Modiolus counts from same quadrats?

Analysis of differences in results based on the two divers making counts in an identical series of between five and 12 quadrats, employed paired t-tests and Wilcoxon Signed Rank tests (for non-parametric data). As different pairs of divers were involved in these comparisons, results at each site were compared separately.

There was no significant difference between the results for the two divers at Dt1, Dt4, Dt6, Dt7, StB, A18, A03, WP11, A02, A04, B09 and B03 (P values between 0.125 and 0.853: see Appendix 7). However, a significant difference between diver recordings of counts ($P = 0.005$, Paired t test) was observed at one site: B1-3 (Dive 28) where diver records gave mean values of 3.7 ± 1.62 and 1.9 ± 0.43 (means $\pm$ SE) respectively, with a difference of 1.8 (95 % CI of difference 0.69-2.9).

At many of the sites both divers in the pair generated data. Attempts therefore were made to perform two-way ANOVAs with diver as one factor and quadrats as a second factor for the series of sites sampled. However, the data included many zeros (probably more than in previous surveys) and was non-normally distributed. Attempts to transform to achieve normality, including use of $\log_{10}$ (X+1) that had previously been recommended (EMU, 2006) were unsuccessful. Two way-ANOVA on Ranks was not an available option with the software employed.

The Wilcoxon tests at individual sites (see above) appeared to be the simplest and most appropriate way of assessing diver differences. These tests also made full use of all available data assessing *Modiolus* presence in up to 20 quadrats. These tests indicated that variation between divers was not detectable (above variation between quadrats) except in one case (site B1-3). At this site relatively large numbers of *Modiolus* were present (mean abundance 17.5%) and diver differences are perhaps more likely to be significant in such cases. It would have been useful to assess this idea at the three sites with slightly higher mussel presence (St1, Dt8 and Dt10) but there was no duplicated recording from quadrats by two divers at any of these sites. The issue of possible diver differences therefore appears to need further examination with a systematic study design (avoiding areas with low densities or mussel absence) and focusing on possible counting of dead mussels and missing cryptic ones that would inflate or deflate, respectively, recorded numbers, as well as increasing quadrat numbers (see results of Power calculations).

3.3.4 Total counts compared to intersect counts

The data obtained for total counts in quadrats rather than simply at intersects is limited to six sites (appendix 3) and cannot be compared to any historical data. A detailed analysis of these data has not been performed but inspection of the data indicates that total numbers are, as expected, higher than for intersect counts, but equally variable. However, with reduced abundance of *Modiolus*, total counts may be a preferable method in the long term. Any benefit would need a fuller appraisal and needs to be balanced against the loss of an ability to compare data with historical data. Inclusion of additional quadrats, rather than moving to full counts, would seem to be a preferable use of time on site in view of the results of Power calculations (see 3.3.5 below).

3.3.5 Power calculations to determine desirable number of quadrats in future studies

The data generated in the 2007 survey indicates a high variability in the count data at individual stations. Ignoring stations where no *Modiolus* were present, the descriptive analysis (Appendix 4) gave standard deviations (SD) of 0.42 to 1.88 on mean counts per quadrat of between 0.20 to 3.2 horse mussels. With this level of variation between sites calculating how many quadrats are needed for detection of differences is problematic as to perform Power calculations for sample size information requires some estimation of SD. We have employed a SD of 1.88, the higher end of the range in the 2007 survey and based the selection of levels of change predicted around the higher density (3.2) to calculate sample size needed for statistical detection.

All calculations were based on a widely accepted Power value of 0.8, i.e. to achieve an 80% chance of detecting a specified effect with 95% confidence (with the alpha value set at 0.05).

Calculations were made assuming comparison of four, six and eight stations. Results are summarised in Table 3.4.

Table 3.4 Power calculations to determine desirable number of quadrats to detect specified difference in horse mussel counts at four, six or eight sites.

Number of Sites	4	6	8
Quadrats/site to detect significance with a 40 % difference in count	48	56	63
Quadrats/site to detect significance with a 50 % difference in count	28	33	36
Quadrats/site to detect significance with a 60 % difference in count	22	26	29
Quadrats/site to detect significance with a 80 % difference in count	13	15	17
Quadrats/site to detect significance with a 100% difference in count	9	10	11

These results indicate that the high level of variability in horse mussel counts at many sites in the 2007 survey results in the need for as large a number of quadrats as practicable in future studies. Previous studies have mostly employed five quadrats per station, but in 2007 up to 20 quadrats were used at some sites, with two divers collecting data. With the reduced and variable abundances of *Modiolus*, a larger number of quadrats is valuable and five is less than is needed to detect anything other than dramatic changes.

Once the population of *Modiolus* has been mapped then future monitoring of abundances would be best centred on monitoring a limited number of sites using 10 or more quadrats per station. Table 3.4 shows that the number of quadrats needed to detect a specific level of change always increases as the number of sites monitored is increased.

4. DISCUSSION

4.1 *Modiolus* distribution and mapping

If changes in the numbers, density or distribution of *Modiolus* within the area are to be identified, then mapping the current boundaries and changes in density/abundance within those boundaries is a fundamental requirement. However, this is a far from simple task. The key problems are:

1. Much of the area where *Modiolus* are believed or suspected to live is carpeted in dense brittlestar beds. These obscure the underlying seabed and any *Modiolus* there. In order to assess presence of *Modiolus* they need to be physically brushed aside.

2. Much of the area was covered in empty *Modiolus* shells. These tend to remain attached to the seabed, sometimes in clumps, with valves still joined and closed. Thus live *Modiolus* can only be positively identified when the valves are gaping and either the yellow mantle or siphons are visible. For remote video assessment, the abundance of dark cobbles of similar size to *Modiolus* was an additional confounding factor.

3. Live *Modiolus* are often either partially embedded within sediment, or sparsely distributed within higher densities of dead *Modiolus*.

4. The low densities and apparent patchiness of distribution, make identification of boundaries difficult.

As described, these difficulties resulted in a systematic grid survey, and post-survey analysis, approach being adopted. However, even with this approach, it was not possible to assign any abundances to *Modiolus* at video drop locations, and presence or absence remained uncertain for many stations.

It would appear, from this survey, that remote video cannot accurately assign densities to *Modiolus* in the conditions in which they occur in Kyle Akin. The only effective method appears to be using divers to clear the overlying brittlestars and count numbers per unit area. Obviously this would be an extremely labour-intensive, expensive and potentially hazardous operation, given the depth, currents, shipping channel and sheer size of the area. An alternative approach would be to use the map of *Modiolus* ‘presence’ generated during this survey (possibly expanding it with more wide-ranging remote video surveys) and simply select a number of stations across this area for detailed periodic assessment by divers.

4.1.1 Positional errors

In the statistical comparison of year on year data it has been assumed, necessarily, that positions were accurate, e.g. Dt8 was assumed to be located in exactly the same position when surveyed in 2007 as it was in 2004 and also in 1999. This is almost certainly not the case. In 1999 and 2004, a 200m long transect line, marked in distances, was laid along a compass bearing, stretched taut and the start and end point noted on GPS (differential GPS in 1999, as Selective Availability had not then been removed). No matter how much care is taken, this inevitably introduces several sources of error. Any line 200m long, even when stretched taut, will have a certain amount of bowing in the mid-sections, through currents and possibly catching around boulders. There will also be a degree of stretch in the line, and when released a certain amount of elastic recoil. This method was repeated in 2004 by driving a RIB along a compass bearing, towards a waypoint, at slow speed this will inevitably result in the vessel veering off course through tide or windage, resulting in course corrections being made as the line is laid. The problems of line bowing, drag, stretch and elastic recoil that occurred in 2000 will also have occurred in 2004.

In 2007 no line was laid. Instead the position of stations along the transect were calculated and shot lines deployed at the station waypoints. This method assumes that the earlier stations had been precisely in line between the two end-points (which is probably not true, for reasons above). The nominal accuracy for GPS is now around ±10m (averaging for satellite clock errors, ionospheric errors, ephemeris errors etc.) thus assuming no other errors, the difference between in between-year positioning could be up to 20m. In 2007 there was often considerable difficulty getting precisely on-station; strong winds tending to blow the RIB's bow off-course and only a hand-held GPS being available with a sometimes slow-updating screen may have on occasion reduced the accuracy with which the shot line was deployed.

Taking all these factors into account, it is possible that the discrepancy between station locations in different years may be as little as 5m or less, equally, it would not be surprising if the discrepancy were 30m or greater. If the bed were fairly uniform over short distances this discrepancy would be less significant, however it does not appear to be so (as illustrated by table 3.3, showing significantly different stations). From both the quadrat counts results and our own observations *Modiolus* density appears highly variable over short distances. For this reason it is recommended that any future *Modiolus* counts are conducted around marked stations, such as those deployed during this survey. Given the patchy nature of *Modiolus* distribution, random stations are not recommended as our observations suggest a much larger number of stations than could realistically be surveyed would be required, in order to remove the effect of spatial heterogeneity from year on year comparisons.

4.2 *Modiolus* abundance

4.2.1 Quadrat counts

A repeat measures ANOVA indicated a significant difference between years in abundance of *Modiolus* (P<0.001). As had been concluded previously by Thomas and New (2006) , the Holm-Sidak method for multiple comparisons between years showed that there was a significant decline in *Modiolus* present in 2004 compared to 1999 and that 2007 counts were also significantly less than in 1999. However, this analysis did not indicate a further significant decline since 2004.

The results also indicate that the high level of variability in *Modiolus* counts at many sites in this survey indicates the need for as large a number of quadrats as practicable in future studies. Previous studies have employed five quadrats per site, but in this study up to 20 quadrats were used at some sites, with two divers collecting data. With the reduced and variable abundances, a larger number of quadrats are valuable and five is less than needed to detect anything other than dramatic changes.

The findings suggest that future monitoring may generate data that can be interpreted with greater confidence if monitoring is concentrated on a limited number of stations, physically marked to ensure accurate relocation, and using 10 or more quadrats per station. These can be randomly located within a grid across the bed (e.g. the diveable parts of the bed could be subdivided into 10 squares, with a station randomly located in each square). Randomly locating stations every survey period is not recommended. The patchiness of *Modiolus* distribution suggest a very large number of random stations would be required to differentiate change over time from spatial variation. Continuing focus on the existing 200m transect south-east of String Rock is also not recommended as this does not provide data that can be confidently extrapolated across the bed as a whole (also stated by Thomas and New, 2006).

Thomas and New (2006) recommend a minimum of 20 stations across the bed. Given the labour-intensive nature (and consequential costs) of station marking and quadrat counts, we suggest a lower number of stations with higher numbers of quadrat counts at each station as, logistically and economically, a more realistic option. The permanent markers deployed along the existing transect, at stations Dt4, Dt7 and Dt10, are low cost and simple to deploy. Marker buoys such as these have been successfully used for station relocation in other areas (e.g. in Milford Haven, Munro, 1999).

4.2.2 Comparison between years

Given the doubt over the location of individual stations between years, it is not possible to draw conclusions about changes at individual stations. For example, the mean counts for St1 from 1999 (five quadrats), 2004 (first five quadrats only) and 2007 (five quadrats) are: 4.6, 0.8 and 3.2 respectively. The data suggests a dramatic decline in 2004, and an equally dramatic recovery in 2007. This is clearly an unlikely scenario, with positional errors between years seeming the more likely explanation. However, EMU conducted 34 replicate quadrat counts at St1 in 2004. If all 34 quadrats from 2004 are included, the mean now becomes 3.4 (instead of 0.8) suggesting not an increase in 2007 but a further decline. The obvious question is 'would the trend be different if 34 quadrats had been recorded in 1999 and 2007?'. This difference in means for 2004, depending on the number of quadrats considered, is greater than apparent year on year change, and places considerable caveats on any interpretation of the data.

However, taking all 11 stations that were surveyed in all three years, a downward trend is suggested, at least between 1999 and 2004. Other data corroborates this. Mair *et al*, (2000) noted that at the sites surveyed in Loch Alsh, overall *Modiolus* densities are 106m^2. (although this was derived from one station, and only four 0.5x0.5m quadrats, so the above caveats apply). They further state that *Modiolus* appeared to form 'continuous cover over the seabed'. This latter description is clearly at odds with observations from this study, suggesting a dramatic change has taken place. Also in 1999, the ratio of dead shells to live *Modiolus* was recorded as low compared to other locations considered, at 0.6, suggesting around 1.65 live *Modiolus* for every dead one. This also appeared markedly different from surveyors' impressions in 2007. Although no quantitative data was collected, it appeared at most stations that dead shells were in significantly greater abundance than living ones. Again, the 1999 data was from one station only, so caution must be exercised in interpretation.

A further consideration is that the stations compared are all quite close together in relation to the now known distribution of *Modiolus* within Kyle Akin. Thus changes that may have occurred in that section of the bed may not apply across the bed as a whole.

Taking all factors into consideration, it seems probable that there has been a decline in *Modiolus* between 1999 and 2004 within Kyle Akin, at least within the embayment west of

Rubha Ard Treisnis where the dive transect was located. Whether there have been any significant changes in the population between 2004 and 2007, or whether the earlier decline was widespread or confined to the shallower survey area, cannot be determined from the data available. However, in the area surveyed, no evidence of significant further decline was found.

4.3 *Modiolus* recruitment

Due to the small sample size and that there were only two samples taken across the bed, any interpretation must be made with extreme caution.

In 1999, no *Modiolus* smaller than 40mm were found in the samples collected from Kyle Akin (significantly larger samples than collected in 2007), the sizes varying between 45 and 120mm in length. In 2004, all *Modiolus* collected were between 60mm and 110mm in length, possibly indicating that there has been an extended period during which little or no recruitment occurred. This may be linked to any die-off of larger *Modiolus* that may also occurred post 1999. However, five small mussels, between 7.45 mm and 4.35mm in length, were recorded within the 2007 sample. These were identified as most likely juvenile *Modiolus modiolus*. However, it was not possible to exclude the possibility these were *Modiolula phaseolina*. This suggests there has been some recent recruitment. From growth curves plotted for 1999 collected samples (Mair *et. al*., 2000), using the von Bertalanffy (1938) growth model, this would suggest all five small mussels collected were under one year old. Before any meaningful assessment or interpretation of recruitment could be made however, it is recommended that a larger number of samples should be taken from across the known bed.

4.4 Is this a Biogenic reef?

The bed lies within Lochs Duich, Long and Alsh marine SAC, and has been classified as a biogenic reef, and as such is a contributory feature to the habitat 'Reefs' (Habitats Directive Annex 1). The definition of biogenic reefs given in the UK marine SACs Project is:

'Solid, massive structures which are created by accumulations of organisms, usually rising from the seabed, or at least clearly forming a substantial, discrete community or habitat which is very different from the surrounding seabed. The structure of the reef may be composed almost entirely of the reef building organism and its tubes or shells, or it may to some degree be composed of sediments, stones and shells bound together by the organisms.' (Holt *et al*., 1998).

It further states that the criteria used in the report are:

'the unit should be substantial in size (generally of the order of a metre or two across as a minimum, and somewhat raised, mainly in order to disqualify nodule like aggregations such as may be formed by S. spinulosa and scattered small aggregations such as occurs with many of the species under consideration) and should create a substratum which is reasonably discrete and substantially different to the underlying or surrounding substratum, usually with much more available hard surfaces and crevices on and in which other flora and fauna can grow.' (Holt *et al*., 1998).

The densities of *Modiolus* encountered during this survey do not seem to fulfil these criteria. At no dive site did the *Modiolus* shells (live or dead) form a continuous substrate. They could not be considered 'solid, massive structures'. At all locations surveyed by quadrat counts, live *Modiolus* formed less than around 20% of the substrate, and frequently considerably less. There was no strong evidence that the areas where *Modiolus* was encountered were significantly different, in either substrate or associated species composition, from those where *Modiolus* appeared absent. At some locations, clumps of dead *Modiolus* shells were reasonably dense, and could be considered the main stable hard substrate to which epifauna attached. However this was still patchy in distribution and consisted of discontinuous clumps rather than coalescing into larger structures.

4.5 Has there been a recent die-off of *Modiolus* and if so what may have been the cause?

The evidence suggests that a fairly dramatic die-off of *Modiolus modiolus* probably occurred between 1999 and 2004. However there is no strong evidence to implicate any one particular factor as being responsible. Impacts from bottom trawling or other mobile fishing gear seem unlikely, a) given the proximity of shallow rocks, and b) because many of the dead *Modiolus* shells remain attached in clumps, suggesting physical disturbance has not occurred.

Given the high tidal flows in the area, the proximity of open ocean and the lack of any obvious significant industrial or agricultural inputs nearby it is difficult to envisage any local point-source pollution being responsible for the observed decline.

High levels of mortality in adult *Modiolus* due to predation are considered unlikely. It is believed that juvenile *Modiolus* do suffer high levels of predation, but that mature *Modiolus* are largely predator-free (Seed and Brown, 1978; Witman, 1985).

Lack of recruitment was noted by Mair *et al.* (2000) not just at Loch Alsh, but also in Loch Creran and Busta Voe, suggesting that a widespread rather than a local mechanism may be responsible. However, other studies, e.g. Wiborg,1946; Rowell, 1967 (cited in Schweinitz and Lutz, 1976), have described infrequent recruitment in *Modiolus* beds.

Modiolus modiolus is a boreal species, largely absent from Southern Britain. In U.K. waters they are predominantly subtidal, but are known to occur intertidally further north, suggesting an intolerance of higher temperatures. Again it seems unlikely that any localised, rapid warming could occur in such a large body of water.

Viral, bacterial or fungal infection is a possibility. Mass mortalities of deep water mussels due to fungal infections have been described by Dover *et al.* (2007), whilst toxic dinoflagellate blooms have also been judged to be responsible for bivalve mass mortality in a Danish lagoon (Noe-Nygaard *et al.*, 1987). *Aeromonas* spp. and *Salmonicida* spp. bacteria are known to be virulent pathogens of several mussel species (e.g. Gu and Mitchell, 2002). Protistan parasites are also known to cause large mortalities in bivalve populations, in particular *Bonamia* spp. affecting *Ostrea edulis*. However, no studies have been found describing similar pathogen-induced declines in other *Modiolus* beds.

It is possible that large numbers of brittlestars are having an adverse impact on *Modiolus* feeding, out-competing for food and preventing access to food sources by blanketing. Whether this could directly result in high levels of mortality, or weaken mussels and allow opportunistic pathogens to become established is not known.

Removal by mobile fishing gear is considered unlikely given that large numbers of empty *Modiolus* shells remain attached on the seabed. No indications of disturbed seabed were found.

Predation of adult *Modiolus* as a cause of decline is considered unlikely, large *Modiolus* being largely predator free. Excessive predation on spat or juvenile *Modiolus* is possible but no evidence to support this was found.

There is no obvious cause to which the decline in *Modiolus*, if real, can be attributed. It is recommended that, if new evidence of further decline is found, then live *Modiolus* are collected for tissue sample analysis to try and exclude or identify some of the above potential causes. The current priority is considered to be to determine with greater confidence whether any decline or expansion of the current population is occurring now.

5. CONCLUSIONS

Taking all factors into consideration, it seems probable that there has been a decline in *Modiolus* between 1999 and 2004 within Kyle Akin, at least within the embayment west of Rubha Ard Treisnis where the dive transect was located. Whether there have been any significant changes in the population between 2004 and 2007, or whether the earlier decline was widespread or confined to the shallower survey area, cannot be determined from the data available. However, in the area surveyed, no evidence of significant further decline was found. The following key conclusions were reached:

- There most likely had been a significant decline in *Modiolus* in Kyle Akin between 1999 and 2004, within the embayment west of Rubha Ard Treisnis where the dive transect was located. Numbers recorded in this study are not significantly different from those of the 2004 study. However doubts over positional accuracy, the limited spread of quantitative data in relation to the size of the bed and the degree to which patchiness of the bed, low sample size and diver-error may have influenced the results place considerable doubt on the degree of change and whether it applied to the whole bed.
- The large number of attached, empty *Modiolus* shells previously recorded in 2004, was still evident in this survey.
- With no obvious indicator it is not possible to determine the cause of any decline in *Modiolus*. Viral, bacterial, fungal or other pathogens are considered possibilities, as is smothering or competition for resources. Damage from mobile fishing gear or predation of adult *Modiolus* are considered unlikely.
- From the drop-video survey, it seems that the *Modiolus* bed in Kyle Akin is extensive, but does not appear dense in any location surveyed.
- Mapping *Modiolus* density by remote video is not possible due to the low densities of *Modiolus*, the difficulty in discriminating between live and dead *Modiolus*, and the dense brittlestar bed covering much of the seabed in Kyle Akin. Presence or absence only can be discerned with any reliability.

6. RECOMMENDATIONS

From the findings of this study, the following recommendations for future monitoring are made:

- Future monitoring should be conducted around permanently marked stations in order to ensure confidence in accurate relocation, given the high degree of spatial variability within the bed. These stations need to be evenly spread across the entire known bed if findings are to be applied to the bed as a whole.
- A greater number of quadrat counts needs to be conducted at each station if anything other than very dramatic change is to be identified. Ten or more quadrats per station are recommended.
- Whole quadrat counts, as opposed to intersect counts, should be considered given the low densities encountered.
- *Modiolus* recruitment should be assessed using a significantly larger number of samples taken from across the known bed. These could be collected at each of the permanently marked stations.
- Stations within the current survey transect should be phased out given their non-random location on the bed.

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APPENDIX 1. DROP-VIDEO DATA

Date	Time down	Number assigned (GIS)	Target			On bottom			End of drift		
			Latitude (N)	Longitude (W)	waypoint	Latitude (N)	Longitude (W)	Waypoint	Latitude (N)	Longitude (W)	Waypoint
29/05/2007	Not logged	**1**	No target	No Target	No Target	57.2739205	-5.71228839	5	57.2739839	-5.71233345	6
29/05/2007	Not logged	**2**	No target	No Target	No Target	57.2742324	-5.71207207	7	57.2743834	-5.71245964	8
29/05/2007	Not logged	**3**	No target	No Target	No Target	57.274744	-5.7117566	9	57.2750315	-5.71233345	10
29/05/2007	Not logged	**4**	No target	No Target	No Target	57.2753531	-5.71164844	11	57.275587	-5.71245964	12
29/05/2007	Not logged	**5**	No target	No Target	No Target	57.2747002	-5.71052177	13	57.2741398	-5.71133297	14
29/05/2007	Not logged	**6**	57.273165	-5.71454173	Dt1	57.2731068	-5.71460482	16	57.2729021	-5.71414514	17
29/05/2007	16:35	**7**	57.273165	-5.71288327	A02	57.2731019	-5.71274807	18	57.2728972	-5.7122974	19
29/05/2007	16:40	**8**	57.273165	-5.71121579	A03	57.2731311	-5.71108961	20	57.2729801	-5.71050374	21
29/05/2007	16:47	**9**	57.273165	-5.70954832	A04	57.2731165	-5.70954832	22	57.2729508	-5.70917877	23
29/05/2007	16:55	**10**	57.273165	-5.70788085	A05	57.2732481	-5.70787183	24	57.2730824	-5.70718682	25
29/05/2007	17:00	**11**	57.273165	-5.70621337	A06	57.2728729	-5.70559145	26	57.2728095	-5.7054202	27
29/05/2007	17:30	**12**	57.273998	-5.71288327	A10	57.2740034	-5.71265793	28	57.2738621	-5.71209911	29
29/05/2007	17.5	**13**	57.273998	-5.71121579	A11	57.2737695	-5.71108961	30	57.2735599	-5.71042262	31
29/05/2007	17.55	**14**	57.273998	-5.70954832	A12	57.273901	-5.70911568	32	57.2738085	-5.70871008	33
29/05/2007	18:00	**15**	57.273998	-5.70788085	A13	57.2739741	-5.70779071	34	57.2737597	-5.7071778	35
29/05/2007	18:15	**16**	57.273998	-5.70621337	A14	57.2738279	-5.70595198	36	57.2735551	-5.70551934	37
30/05/2007	18:30	**17**	57.274832	-5.71288327	A18	57.2750072	-5.71288327	1	57.2754749	-5.71382066	2
30/05/2007	13:40	**18**	57.274832	-5.71121579	A19	57.2754896	-5.71170252	4	57.2759476	-5.71287426	5

30/05/2007	13:50	**19**	57.274832	-5.70954832	A20	57.274632	-5.70958437	6	57.2748122	-5.71042262	7
30/05/2007	14:00	**20**	57.274832	-5.70788085	A21	57.2750266	-5.70795295	8	57.2754262	-5.70863797	9
30/05/2007	14:05	**21**	57.274832	-5.70621337	A22	57.2748074	-5.70543822	10	57.2751436	-5.70476222	11
30/05/2007	15:10	**22**	57.274832	-5.7045459	A23	57.2749146	-5.70469011	12	57.2750754	-5.70371667	13
30/05/2007	15:20	**23**	57.274832	-5.70287842	A24	57.2750413	-5.70291448	14	57.2752118	-5.70250888	15
30/05/2007	15:30	**24**	57.275665	-5.71454173	A25	57.275587	-5.71446061	16	57.2759524	-5.71462285	17
30/05/2007	15:40	**25**	57.275665	-5.71288327	A26	57.2755431	-5.71282018	19	57.2758063	-5.7129013	20
30/05/2007	16:25	**26**	57.275665	-5.71121579	A27	57.2756406	-5.71090934	21	57.2758599	-5.71095441	22
30/05/2007	16:35	**27**	57.275665	-5.70954832	A28	57.2757673	-5.70945819	23	57.2761084	-5.70948523	24
30/05/2007	16:45	**28**	57.275665	-5.70788085	A29	57.2756162	-5.70755637	25	57.2759719	-5.70811519	26
30/05/2007	16:50	**29**	57.275665	-5.7045459	A31	57.2756552	-5.70451886	27	57.2756114	-5.70404115	28
30/05/2007	17:00	**30**	57.275665	-5.70287842	A32	57.2758794	-5.70228354	29	57.2758696	-5.70164359	30
31/05/2007	17:10	**31**				57.2736866	-5.71220727	2	57.2741739	-5.71236049	3
31/05/2007		**32**				57.2740618	-5.71204503	4	57.2741983	-5.7119639	5
31/05/2007	10:20	**33**				57.2740326	-5.71208108	6	57.2741642	-5.71227036	7
31/05/2007	10:25	**34**				57.2739839	-5.71213516	9	57.274057	-5.71252273	10
31/05/2007	10:40	**35**				57.2740131	-5.71223431	11	57.2742226	-5.71218924	12
31/05/2007	10:45	**36**				57.2740082	-5.71199996	13	57.2741008	-5.71197292	14
31/05/2007	11:00	**37**				57.273901	-5.71269399	19	57.2739644	-5.71273004	20
31/05/2007	11:20	**38**				57.2744322	-5.71233345	3	57.2745296	-5.71282018	4
31/05/2007	14:48	**39**				57.2742957	-5.71240556	5	57.2743981	-5.71269399	6
31/05/2007	14:55	**40**				57.2744029	-5.71187377	7	57.2744565	-5.71241457	8
31/05/2007	15:00	**41**				57.2745637	-5.71157633	10	57.2745053	-5.71193686	11
31/05/2007	15:20	**42**				57.2743201	-5.71123382	12	57.2742275	-5.71132396	13
31/05/2007	16:10	**43**				57.2742616	-5.71133297	14	57.2742226	-5.71127889	15
31/05/2007	16:15	**44**	57.274915	-5.71048571	16	57.2750364	-5.71081921	17	57.2751582	-5.71094539	19
31/05/2007	16:35	**45**				57.2749877	-5.7108823	20	57.2749974	-5.71123382	21

31/05/2007	16:40	**46**				57.2748756	-5.7104767	22	57.2746807	-5.71091835	23
31/05/2007	16:50	**47**	57.275285	-5.70996294	24	57.2752898	-5.71016123	25	57.2753531	-5.71005307	26
31/05/2007	17:05	**48**				57.2751874	-5.7100711	27	57.2751582	-5.71038656	28
31/05/2007	17:10	**49**				57.275587	-5.71068401	29	57.2754896	-5.71084625	30
31/05/2007	17:30	**50**				57.275894	-5.7115583	31	57.2761668	-5.71204503	32
31/05/2007	17:35	**51**				57.275168	-5.71112566	33	57.2751241	-5.71143212	34
31/05/2007	17:55	**52**				57.2745735	-5.71012518	35	57.2744029	-5.71065697	36
31/05/2007	18:15	**53**				57.274018	-5.7098728	37	57.2738815	-5.71022432	38
31/05/2007	18:20	**54**				57.2754896	-5.71190081	39	57.2753239	-5.71190081	40
31/05/2007	18:30	**55**				57.2736135	-5.71190081	41	57.2733358	-5.71159436	42
31/05/2007	18:40	**56**				57.2733163	-5.71163942	43	57.2732091	-5.71154929	44
06/06/2007	18:50	**57**	57.275499	-5.71671395	B01	57.2755724	-5.71700238	5	57.2757673	-5.71746206	6
06/06/2007	09:50	**58**	57.274832	-5.71671395	B03	57.2746758	-5.71664185	7	57.2749487	-5.71713758	8
06/06/2007	10:00	**59**	57.274413	-5.71671395	B04	57.2744273	-5.71676803	9	57.2745345	-5.7170835	10
06/06/2007	10:05	**60**	57.276079	-5.71671395	B05	57.2761327	-5.71674099	11	57.276084	-5.71725475	12
06/06/2007	10:10	**61**	57.277	-5.71671395	B06	57.277	-5.71671395		57.277	-5.71734489	13
06/06/2007	10:15	**62**	57.27258	-5.71071105	B07	57.2726243	-5.71072006	14	57.2726	-5.71095441	15
06/06/2007	10:26	**63**	57.272332	-5.71071105	B08	57.2722881	-5.71081921	16	57.2723368	-5.71126086	17
06/06/2007	10:30	**64**	57.272663	-5.70954832	B09	57.2726438	-5.70965648	18	57.272712	-5.71016123	19
06/06/2007	10:40	**65**	57.272001	-5.70804309	B10	57.2720396	-5.70809717	20	57.2720542	-5.7085929	21
06/06/2007	10:45	**66**	57.272663	-5.705961	B11	57.2726877	-5.70580777	22	57.2727315	-5.70592494	23
06/06/2007	11:10	**67**	57.271499	-5.70821434	B12	57.2715328	-5.70823237	24	57.2714938	-5.70825941	25
06/06/2007	11:15	**68**	57.271499	-5.7070426	B13	57.2714158	-5.70699754	26	57.2714548	-5.70679023	27

Number assigned (GIS)	Time down	Depth (s.l.)	Depth (cd)	*Modiolus* Present/absent	Comments
1	Not logged	24		Not possible to determine	Initial trials of drop video
2	Not logged	20		Not possible to determine	Initial trials of drop video
3	Not logged	16.7		Not possible to determine	Initial trials of drop video
4	Not logged	15		Not possible to determine	Initial trials of drop video
5	Not logged	22.7		Not possible to determine	Initial trials of drop video
6	16:35	19	15	Not possible to determine	coarse mixed sediment or sand, some red algae. Few empty *Modiolus* shells.
7	16:40	24.5	20	Not possible to determine	Dense *Modiolus*? Especially at start of drop.
8	16:47	27	22.6	Not possible to determine	Patchy *Modiolus*? Dense *Ophiothrix fragilis*.
9	16:55	26.6	22.2	Not possible to determine	Sparse small clumps of *Modiolus*? Plus large tunicates.
10	17:00	32	27.6	Present	*Modiolus* clumps underneath dense brittlestars.
11	17:30	45-47	40.6-43.6	Present (few scattered individuals)	Some *Modiolus*, *Ophiothrix fragilis*.
12	17.5	21	16.5	Present (one only observed)	*Modiolus*, *Ophiothrix fragilis*.
13	17.55	32.7	28.2	Present	*Modiolus*, *Ophiothrix fragilis*.
14	18:00	36	31.5	Present	Dense *Modiolus*? cobbles, and *Ophiothrix fragilis*.
15	18:15	39.2	34.7	Present (Few live present plus dead valves)	Very dense *Ophiothrix fragilis*, few *Modiolus* visible underneath.
16	18:30	48-55	43.6-51.6	Present (patchy bed?)	Dense *Ophiothrix fragilis* and patchy *Modiolus*.
17	13:40	11	9.5	Present (patchy bed?)	Kelp and bedrock current strong
18	13:50	17	15.5	Present (possibly forming a bed)	level bedrock, brittlestars, hydroids, *Alcyonium digitatum*.
19	14:00	28-22	26.5-20.5	Present (appears to be a bed)	bedrock, *Ophiothrix fragilis*, empty *Modiolus* (few live)
20	14:05	36-31	34-29	Present (possibly forming a bed)	*Ophiothrix fragilis* (dense?).

21	15:10	25-36-28-24	22-33-25-21	Present (few scattered individuals)	Dense *Ophiothrix fragilis*, big boulders/bedrock. Some *Modiolus*, *Ciona*, *Echinus*.
22	15:20	42-31	39-28	Absent	Rugged bedrock, boulders, *Ciona*, *Ascidia mentula*, *Echinus*, *Ophiothrix fragilis*.
23	15:30	42	39	Absent	Level bedrock, with boulders, *Ciona*, few *Ascidia mentula*, *Ophiothrix fragilis*.
24	15:40	12-15	9-12	Present (appears to be a bed)	Bedrock kelp, red algae *Ophiothrix fragilis*, hydroids, few *Modiolus* at end.
25	16:25	16.8	13.0	Present (possibly forming a bed)	*Ophiothrix fragilis*, dense red algae, *Asterias*, kelp park
26	16:35	19	15.2	Not possible to determine	Dense *Ophiothrix fragilis*, empty *Modiolus* shells, *Modiolus*?
27	16:45	24-15.2	21.2-11.4	Not possible to determine	Dense *Ophiothrix fragilis*, hydroids, *Echinus*, *Nemertesia ramosa*? Low bedrock.
28	16:50	24	20.2	Not possible to determine	Rocky outcrops onto sand, numerous shells including *Ensis*, *Modiolus*?
29	17:00	16	12	Absent	Sand with small boulders and cobbles.
30	17:10	24	19.7	Absent	Sediment few Virgularia, lots of empty shells.
31		23	20.1	Absent?	Same location (approximate) as Dt1. Dense brittlestars.
32	10:20	25	22.1	Absent?	Same location (approximate) as Dt2. Dense brittlestars.
33	10:25	23	20.1	Present (few visible)	Same location (approximate) as Dt3. Dense brittlestars and some *Modiolus*.
34	10:40	26.9	24.9	Not possible to determine	Same location (approximate) as Dt9. Dense brittlestars. (shot dragged during deployment)
35	10:45	24.1-20.6	22.1 - 18.6	Absent	Same location (approximate) as Dt9. Dense brittlestars
36	11:00	25.4-24.6	23.4-22.6	Present	Same location (approximate) as Dt9. Dense brittlestars. *Modiolus*.
37	11:20	21.3-20.6	19.3-18.6	Present	Same location (approximate) as Dt8. Dense brittlestars *Modiolus* clumps.
38	14:48	16.5-12.5	14.5-10.5	Absent	Kelp park, brittlestars
39	14:55	17-13.5	15-11.5	Present (bed?)	Brittlestars, cobbles, *Modiolus*.
40	15:00	19-14.5	17-12.5	Present	Brittlestars and cobbles
41	15:20	17	15	Present	Brittlestars
42	16:10	27.7	24.8	Present (approximately 4-8 per sq m)	Brittlestars
43	16:15	25.5	22.6	Present	Brittlestars
44	16:35	22.3	18.5	Present (few only noted)	Brittlestars, cobbles
45	16:40	21	17.2	Present	Brittlestars,

46	16:50	21.8	18.0	Present (few only noted)	
47	17:05	23	19.2	Present	Brittlestars, cobbles
48	17:10	27	23.2	Present	Brittlestars, cobbles
49	17:30	21.6	17.8	Present (few only noted)	Brittlestars, cobbles
50	17:35	23.2	19	Present (only 1-2 noted)	Brittlestars, cobbles
51	17:55	18	13.6	Present	Brittlestars
52	18:15	28-29.5	23.6-25.1	Present (appears to be a bed)	Brittlestars
53	18:20	34-35.1	29.1-30.2	Present	(Approximate location of previous station ROV10C, Heriot Watt study) brittlestars, empty *Modiolus* shells, live *Modiolus*.
54	18:30	18	13.1	Present	Brittlestars
55	18:40	30	25.1	Present	Brittlestars, *Modiolus*.
56	18:50	25.6	20.7	Present (few only noted)	Brittlestars, *Modiolus* shells
57	09:50	14	10	Present (few scattered individuals)	Kelp park with dense brittlestars
58	10:00	10-12	6-8	Present	Kelp park (*Alaria*, *L. digitata*, *L. saccharina*) with brittlestars
59	10:05	9	5	Not possible to determine	Kelp park, cobbles, gravel, some bedrock.
60	10:10	18	14	Present (few only noted)	Cobbles with dense brittlestars
61	10:15	24	20	Not possible to determine	No entry position recorded. Target logged as entry position. Dense brittlestars.
62	10:26	18-19	14-15	Not possible to determine	Coarse sand with cobbles.
63	10:30	12-13	8-9	Absent	Sand with cobbles and small boulders.
64	10:40	18-19	13.8-14.8	Absent	Coarse sand with cobbles.
65	10:45	Not logged		Not possible to determine	Sand with cobbles.
66	11:10	42	37.8	Not possible to determine	Gravel, cobbles, pebbles, patchy *Ophiothrix fragilis*.
67	11:15	18	13.8	Absent	Coarse sand with cobbles.
68	11:20	31	26.8	Absent	Sediment, few cobbles, numerous ascidians, shells.

APPENDIX 2. DIVE DATA

Dive No.	Date	Target			Position shot deployed				Comments	Photos	Divers
		Latitude	Longitude	Waypoint/ Station	Latitude	Longitude	Waypoint	Depth (m) CD			
1	02/06/2007	57.273901	-5.712252	Dt10	57.273901	-5.712252	1	27	2 x markers both buoyed		LBx & CD
2	02/06/2007	57.273467	-5.712865	Dt7	57.273467	-5.712883	2	22	2 x markers both buoyed		LBd & SH
3	02/06/2007	57.27317	-5.71355	Dt4	57.27319	-5.713586	3	19	2 x markers one buoyed		CM & LL
4	02/06/2007	57.276552	-5.714127	St A				16			LBd & SH
5	03/06/2007	57.274232	-5.713911	Dt10W	57.274232	-5.713902	4	13	No *Modiolus* Boulder reef and kelp park	Yes	LBx & CD
6	03/06/2007	57.273331	-5.710711	Dt10E	57.273336	-5.710738	5	28			CM & LL
7	03/06/2007	57.272956	-5.707971	St B	57.272961	-5.707944	6	27			LBd & SH
8	03/06/2007	57.272561	-5.714452	DT0	57.272532	-5.714497	8	12	No *Modiolus* as expected		LBx & CD
9	03/06/2007	57.273165	-5.714542	Dt1	57.273185	-5.714542	9	15			LBd & SH
10	04/06/2007	57.274832	-5.712883	A18				11			CM & LL
11	04/06/2007	57.272965	-5.713767	Dt3	Not logged separately as almost exactly on target			20	Seemed to be right on the boudary between *Modiolus* bed and sediment with only rare *Modiolus*. A distinct line between the two substrates could		LBx & CD

									be seen, with *Modiolus* to the North and sediment to the South. Quadrats fell in both substrates		
12	04/06/2007	57.273165	-5.711216	A03	57.27316	-5.711207	10	26			LBd & SH
13	04/06/2007	57.274535	-5.713424	WP11	57.27451	-5.713424	11	10	Target is halfway between Dt10W and A18 which are very close together but one has *Modiolus* and one doesn't. Wapoint 11 is where the divers went down, waypoints 13-16 follow their route		CM & LL
(13)	04/06/2007			(WP11)	57.274642	-5.713208	13		about 1 min after they touched they bottom - the divers were on a *Modiolus* bed so swam SW towards Dt10W		CM & LL
(13)	04/06/2007			(WP11)	57.274617	-5.713316	14		Additional points from dive 13		CM & LL
(13)	04/06/2007			(WP11)	57.274505	-5.713388	15		Additional points from dive		CM & LL

									13		
(13)	04/06/2007			(WP11)	57.274588	-5.713379	16		This point is believed to be the edge of bed. Where the line was pulled to indicate to the surface.		CM & LL
18	04/06/2007	57.273998	-5.712883	A10				17		Yes	LBx & CD
19	04/06/2007	57.273165	-5.712883	A02				21	Camera flooded during dive	Yes	LBd & SH
20	05/06/2007	57.273716	-5.712478	Dt9				25			CM & LL
21	05/06/2007	57.273628	-5.712667	Dt8				25		Yes	LBx & CD
22	05/06/2007	57.27337	-5.713127	Dt6	57.273375	-5.713136	19	21			LBd & SH
23	05/06/2007	57.273229	-5.713361	Dt5				22	*Modiolus* for size data collected (clump in bucket). Photographs taken.	Yes	CM & LL
24	05/06/2007	57.273219	-5.713694	St1	57.273233	-5.713694	20	Not logged	When they arrived on bottom the divers were about 10m from the permanent markers for Dt4 which is approximately where station 1 should have been in relation to the transect. *Modiolus* for		LBx & CD

									size data collected (clump in bucket).		
25	05/06/2007	57.273165	-5.709548	A04	57.27316	-5.709539	21	24.5			LBd & SH
26	06/06/2007	57.272663	-5.709548	B09	57.272663	-5.709548	28	16			CM & LL
27	06/06/2007	57.27258	-5.710711	B07	57.272566	-5.710693	29	16	No *Modiolus* bed - one individual spotted!		LBx & CD
28	06/06/2007	57.275158	-5.716714	B1-3	57.275129	-5.716714	31	10	Target halfway between B01 and B03 (B01 was within the shipping channel)		LBd & SH
29	06/06/2007	57.274832	-5.716714	B03	57.274817	-5.716723	32	7	Shell gravel, coarse shell sand, cobbles, kelp park.		CM & LL

Diver initials used in the above table: CD = Claire Dalgleish; CM = Colin Munro; LBx = Laura Baxter; LBd = Lin Baldock; LL = Lou Luddington; SH = Suzanne Henderson.

APPENDIX 3. QUADRAT COUNT DATA (2007, 2004 & 1999)

DATE	Station	GIS assigned No.	Depth (chart datum)	Time (BST)	Diver	Quadrat set	Count method	NOTES
Hstorical transect stations								
03/06/2007	**Dt0**	**8**	12	Not logged	Claire Dalgleish	A	Intersect counts	
03/06/2007	**Dt0**	**8**	12	Not logged	Laura Baxter	B	Intersect counts	No *Modiolus* seen
1999	**Dt0**						Intersect counts	
2004	**Dt0**						Intersect counts	
03/06/2007	**Dt1**	**9**	19.2		Lin Baldock	A	Intersect counts	
03/06/2007	**Dt1**	**9**	19.2		Suzanne Henderson	A	Intersect counts	Each surveyor counted separate sets of quadrats
1999	**Dt1**						Intersect counts	
2004	**Dt1**						Intersect counts	
04/06/2007	**Dt3**	**11**	20	11:20	Claire Dalgleish	A	Intersect counts and total counts	
1999	**Dt3**						Intersect counts	
2004	**Dt3**						Intersect counts	
02/06/2007	**Dt4**	**3**	22.5		Lou Luddington	A	Intersect counts	
02/06/2007	**Dt4**	**3**	22.5		Colin Munro	A	Intersect counts	
1999	**Dt4**						Intersect counts	

2004	**Dt4**						Intersect counts	
05/06/2007	**Dt6**	**22**	25	11:17	Lin Baldock	A	Intersect counts	
05/06/2007	**Dt6**	**22**	25	11:17	Suzanne Henderson	A	Intersect counts	
1999	**Dt6**						Intersect counts	
2004	**Dt6**						Intersect counts	
02/06/2007	**Dt7**	**2**	24.1		Lin Baldock	A	Intersect counts	
02/06/2007	**Dt7**	**2**	24.1		Suzanne Henderson	A	Intersect counts	
1999	**Dt7**						Intersect counts	
2004	**Dt7**						Intersect counts	
05-Jun-07	**Dt8**	**21**	28.7	10:34	Claire Dalgleish	A	Intersect counts and total counts	
1999	**Dt8**						Intersect counts	
2004	**Dt8**						Intersect counts	
05-Jun-07	**Dt9**	**20**	29.5	09:45	Colin Munro	A	Intersect counts and total counts	Plain of shelly silty sand. Few *Modiolus*, few *Ophiopholis*.
1999	**Dt9**						Intersect counts	
2004	**Dt9**						Intersect counts	
02/06/2007	**Dt10**	**1**	29.1	10:49	Claire Dalgleish	A	Intersect counts	
1999	**Dt10**						Intersect counts	
2004	**Dt10**						Intersect counts	

Other historical Stations								
02/06/2007	**StA**	**4**	20.6		Lin Baldock	A	Intersect counts	Dense *Limaria* bed. Empty *Modiolus* shells. No live *Modiolus* seen.
02/06/2007	**StA**	**4**	20.6		Suzanne Henderson	B	Intersect counts	
1999	**StA**						Intersect counts	
2004	**StA**				Diver #5	A	Intersect counts	(10 quadrats in total surveyed; each counted by both #5 & #6)
2004	**StA**				Diver #6	A		
03/06/2007	**StB**	**7**	28.9	14:24	Lin Baldock	A	Intersect counts	
03/06/2007	**StB**	**7**	28.9	14:24	Suzanne Henderson	A	Intersect counts	
1999	**StB**						Intersect counts	
2004	**StB**						Intersect counts	
							Intersect counts	
05/06/2007	**Stn1**	**24**	Not logged	14:32	Claire Dalgleish	A	Intersect counts	
1999	**Stn1**						Intersect counts	
2004	**Stn1**						Intersect counts	5
New Sites								
03/06/2007	**Dt10W**	**5**	16		Claire Dalgleish	A	Intersect counts	
03/06/2007	**Dt10W**	**5**	16		Laura Baxter	B	Intersect counts	
03/06/2007	**Dt10E**	**6**	29.6	13:18	Colin Munro	A	Intersect counts	Shelly mud with empty *Modiolus* shells. Dense *Ophiothrix fragilis*.
03/06/2007	**Dt10E**	**6**	29.6	13:18	Lou Luddington	B	Intersect counts	
04/06/2007	**A18**	**10**	14.5	09:29	Colin Munro	A + B	Intersect counts	Just east of String Rock. Very tideswept. Dense *Ophiothrix*, *Ophiopholis*, *Echinus*, kelp park (*L. digitata* & *L. hyperborea*), numerous scallop shells, *Modiolus* shells bound into clumps along with live *Modiolus*. *Modiolus* reef?
04/06/2007	**A18**	**10**	14.5	09:29	Lou Luddington	A	Intersect counts	
04/06/2007	**A03**	**12**	28.2	13:08	Lin Baldock	A + B	Intersect counts	

04/06/2007	**A03**	**12**	28.2	13:08	Suzanne Henderson	A + B	Intersect counts	
04/06/2007	**WP11**	**13**	11.7	14:12	Colin Munro	A	Intersect counts and total counts	Edge of bed (upper limit) WP 11. Kelp park (*L digitata. & L. hyperborea*.). *O. nigra* bed underneath. Few *Ophiopholis*. Shell gravel, dense *Limaria* bed through dive area. *Echinus*, numerous scallop shells and *Nephrops* carapaces (discards?).
04/06/2007	**WP11**	**13**	11.7	14:12	Lou Luddington	A	Intersect counts	
04/06/2007	**A10**	**18**	18.5		Claire Dalgleish	A	Intersect counts	Very dense bed
04/06/2007	**A02**	**19**	23.6	16:20	Lin Baldock	A	Intersect counts	Much dead *Modiolus* (80% cover). Few Ophiuriods.
04/06/2007	**A02**	**19**	23.6	16:20	Suzanne Henderson	A	Intersect counts	
05-Jun-07	**AO4**	**25**	26.4	11:17	Suzanne Henderson	A	Intersect counts	Mixed sediment. Ophuriods.
05-Jun-07	**AO4**	**25**	26.4	11:17	Lin Baldock	A	Intersect counts	
06/06/2007	**B09**	**26**	19.2		Colin Munro	A	Intersect counts and total counts	Fine sand with shell fragments. Cobbles, small boulders, red foliose algae, *Nemertesia antenina*, *Antedon* sp (also *Leptometra celtica*?), numerous tunicates (*Ascidia mentula*, *Ascidiella*, *Corella*, *Polycarpa pomaria*, *Clavelina*).
06/06/2007	**B09**	**26**	19.2		Lou Luddington	A	Intersect counts	
06/06/2007	**B07**	**27**	18	14:54	Laura Baxter	A	Intersect counts	Coarse silty sand with occasional pebbles and cobbles.
06/06/2007	**B07**	**27**	18	14:54	Claire Dalgleish	A	Intersect counts	
06/06/2007	**B01-3**	**28**	11.5		Lin Baldock	A	Intersect counts	Clean gravel, pebbles, gravel, kelp park, patchy dense cover of the brittlestar *Ophiothrix fragilis*.
06/06/2007	**B01-3**	**28**	11.5		Suzanne Henderson	A	Intersect counts	
06/06/2007	**B03**	**29**	8.7		Colin Munro	A	Intersect counts and total counts	Shell gravel, coarse shell sand with cobbles. Kelp park: *L. digitata* and *Alaria esculenta*;

06/06/2007	**B03**	**29**	8.7		Lou Luddington	A	Intersect counts	slightly shallower *L. saccharina*. Numerous *Modiolus*, *Ophiocomina nigra*. One large *Palinurus elephas* seen.

Station	**Divers**	**Quadrat set**	**Count method**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Dt0	Claire Dalgleish	A	Intersect	No *Modiolus*									
Dt0	Laura Baxter	B	Intersect	No *Modiolus*									
Dt3	Claire Dalgleish	A	Intersect	3	3	0	0	1					
Dt3	Claire Dalgleish	A	Total	8	8	2	1	2					
Dt4	Lou Luddington	A	Intersect	1	6	1	1	1	3	0	2	0	
Dt4	Colin Munro	B	Intersect	1	0	1	1	No data	0	0	4	2	2
Dt6	Lin Baldock	A	Intersect	4	2	1	6	2	4	2	2	1	4
Dt6	Suzanne Henderson	A	Intersect	4	2	2	2	1	3	3	3	1	6
Dt7	Lin Baldock	A	Intersect	1	1	2	2	2	3	2	1	5	
Dt7	Suzanne Henderson	B	Intersect	4	1	1	3	2	1	3	4		
Dt8	Claire Dalgleish	A	Intersect	4	4	5	3	2					
Dt8	Claire Dalgleish	A	Total	6	2	14	10	9					
Dt9	Colin Munro	A	Intersect	2	2	1	0	0	2	1			
Dt9	Colin Munro	A	Total	4	3	3	3	2	9	3			
Dt10	Claire Dalgleish	A	Intersect	2	2	3	6	3					
StA	Lin Baldock	A	Intersect	0	0	0	0	0					
StA	Suzanne Henderson	B	Intersect	0	0	0	0	0					
StB	Lin Baldock	A	Intersect	2	1	2	1	1					

StB	Suzanne Henderson	B	Intersect	1	0	1	0	1					
St1	Claire Dalgleish	A	Intersect	5	1	2	4	4					
Dt10W	Claire Dalgleish	A	Intersect	No *Modiolus*									
Dt10W	Laura Baxter	B	Intersect	No *Modiolus*									
Dt10E	Colin Munro	A	Intersect	2	0	1	0	0	1	1			
Dt10E	Lou Luddington	B	Intersect										
Dt1	Lin Baldock	A	Intersect	0	0	1	0	1					
Dt1	Suzanne Henderson	B	Intersect	0	0	0	0	0					
A18	Colin Munro	A	Intersect	2	3	1	1	0	3	2	2	2	2
A18	Colin Munro	B	Intersect	2	3	missed	2	4	4	0	2	1	1
A18	Lou Luddington	A	Intersect	2	4	2	1	2	2	1	1	2	
A03	Lin Baldock	A	Intersect	2	0	3	1	1					
A03	Lin Baldock	B	Intersect	1	1	2	1						
A03	Suzanne Henderson	A	Intersect	0	0	0	2	2					
A03	Suzanne Henderson	B	Intersect	1	0	2	1						
WP11	Colin Munro	A	Intersect	1	0	0	1	0	0	0	0	1	2
WP11	Colin Munro	A	Total	1	0	0	2	1	0	0	0	4	5
WP11	Lou Luddington	B	Intersect	1	2	0	2	1	0	0	0	0	0
A10	Claire Dalgleish	A	Intersect	1	2	2	1	4					
A2	Lin Baldock	A	Intersect	3	3	3	3	3					
A2	Suzanne Henderson	B	Intersect	2	1	2	4	1					
AO4	Suzanne Henderson	A	Intersect	0	1	4	3	2	2	1			
AO4	Lin Baldock	B	Intersect	4	2	2	4	1	1	2			
B9	Colin Munro	A	Intersect	0	5	0	0	0	0	0	0		

B09	Colin Munro	A	Total	0	8	0	0	0	0	0	0		
B09	Colin Munro	B	Intersect	0	0	0	0	0	0	0	0		
B09	Colin Munro	B	Total	0	0	0	3	1	0	1	2		
B09	Lou Luddington	A	Intersect		1	0	0	0	0	0	0	0	0
B09	Lou Luddington	B	Intersect	1	2	3	1	0	2	0	0	0	1
B07	Claire Dalgleish	A	Intersect	0	0	0	0	0					
B07	Claire Dalgleish	B	Intersect	0	0	0	0	0					
B07	Laura Baxter	A	Intersect	0	0	0	0	0					
B07	Laura Baxter	B	Intersect	0	0	0	0	0					
B01-3	Lin Baldock	A	Intersect	6	2	2	2	4	5	5	7	2	2
B01-3	Suzanne Henderson	B	Intersect	3	0	2	2	2	1	1	5	1	2
B03	Colin Munro	A	Intersect	2	0	0	6	0	0	0	0	0	0
B03	Colin Munro	A	Total	7	0	0	21	3	0	0	3	1	2
B03	Lou Luddington	B	Intersect	0	1	2	1	0	0	3	1	0	1

Notes

Quadrat sets. Where the two divers carried a quadrat each, each throwing and surveying separate quadrats, these are identified as quadrats A and B, and counts assigned to each quadrat (and diver). Where only a single quadrat was thrown and surveyed, this is identified as quadrat A. Where an A is recorded for both divers on a single dive, this indicates that the quadrat was randomly thrown, then independent counts were performed by each diver in turn. A + B indicates that each diver threw a quadrat, surveyed it, then changes places with their dive buddy to survey the other quadrat before it was picked up and thrown again.

Count method. Intersect counts indicate that only counts of live *Modiolus* directly beneath the string intersects of the strung quadrats were recorded. The quadrats had 16 intersects, thus the maximum possible score was 16. Intersect and total counts indicate that intersect counts, as above, were recorded plus counts of all live *Modiolus* within the quadrat.

APPENDIX 4. DESCRIPTIVE ANALYSIS - COUNT DATA FOR PRESENCE ON INTERSECTS.

Data source: 2007 *Modiolus* dive survey raw quadrat count data

Station	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
Dt0	10	0	0.000	0.000	0.000	0.000
Dt3	5	0	1.400	1.517	0.678	1.883
Dt4	18	0	1.444	1.580	0.372	0.786
Dt6	20	0	2.750	1.517	0.339	0.710
Dt7	17	0	2.235	1.251	0.304	0.643
Dt8	5	0	3.600	1.140	0.510	1.416
Dt9	7	0	1.143	0.900	0.340	0.832
Dt10	5	0	3.200	1.643	0.735	2.040
StA	10	0	0.000	0.000	0.000	0.000
StB	10	0	1.000	0.667	0.211	0.477
St1	5	0	3.200	1.643	0.735	2.040
Dt10W	10	0	0.000	0.000	0.000	0.000
Dt10E	7	0	0.714	0.756	0.286	0.699
Dt1	10	0	0.200	0.422	0.133	0.302
A18	38	0	1.684	1.093	0.177	0.359
A03	18	0	1.111	0.900	0.212	0.448
WP11	20	0	0.550	0.759	0.170	0.355
A10	5	0	2.000	1.225	0.548	1.521
A02	10	0	2.500	0.972	0.307	0.695
A04	14	0	2.071	1.269	0.339	0.733
B09	32	0	0.469	1.107	0.196	0.399
B07	20	0	0.000	0.000	0.000	0.000
B1-3	20	0	2.800	1.881	0.421	0.880
B03	20	0	0.850	1.496	0.335	0.700

Column	Range	Max	Min	Median	25%	75%
Dt0	0.000	0.000	0.000	0.000	0.000	0.000
Dt3	3.000	3.000	0.000	1.000	0.000	3.000
Dt4	6.000	6.000	0.000	1.000	0.000	2.000
Dt6	5.000	6.000	1.000	2.000	2.000	4.000
Dt7	4.000	5.000	1.000	2.000	1.000	3.000
Dt8	3.000	5.000	2.000	4.000	2.750	4.250
Dt9	2.000	2.000	0.000	1.000	0.250	2.000
Dt10	4.000	6.000	2.000	3.000	2.000	3.750
StA	0.000	0.000	0.000	0.000	0.000	0.000
StB	2.000	2.000	0.000	1.000	1.000	1.000
St1	4.000	5.000	1.000	4.000	1.750	4.250
Dt10W	0.000	0.000	0.000	0.000	0.000	0.000
Dt10E	2.000	2.000	0.000	1.000	0.000	1.000
Dt1	1.000	1.000	0.000	0.000	0.000	0.000
A18	4.000	4.000	0.000	2.000	1.000	2.000
A03	3.000	3.000	0.000	1.000	0.000	2.000
WP11	2.000	2.000	0.000	0.000	0.000	1.000
A10	3.000	4.000	1.000	2.000	1.000	2.500

A02	3.000	4.000	1.000	3.000	2.000	3.000
A04	4.000	4.000	0.000	2.000	1.000	3.000
B09	5.000	5.000	0.000	0.000	0.000	0.000
B07	0.000	0.000	0.000	0.000	0.000	0.000
B1-3	7.000	7.000	0.000	2.000	2.000	4.500
B03	6.000	6.000	0.000	0.000	0.000	1.000

Column	**Skewness**	**Kurtosis**	**K-S Dist.**	**K-S Prob.**	**Sum**	**Sum of Squares**
Dt0	0.000	-2.571	0.000	<0.001	0.000	0.000
Dt3	0.315	-3.081	0.254	0.329	7.000	19.000
Dt4	1.675	3.131	0.277	<0.001	26.000	80.000
Dt6	0.872	0.175	0.239	0.004	55.000	195.000
Dt7	0.798	-0.210	0.222	0.026	38.000	110.000
Dt8	-0.405	-0.178	0.237	0.414	18.000	70.000
Dt9	-0.353	-1.817	0.258	0.170	8.000	14.000
Dt10	1.736	3.251	0.348	0.047	16.000	62.000
StA	0.000	-2.571	0.000	<0.001	0.000	0.000
StB	0.000	0.0804	0.300	0.011	10.000	14.000
St1	-0.518	-1.687	0.287	0.193	16.000	62.000
Dt10W	0.000	-2.571	0.000	<0.001	0.000	0.000
Dt10E	0.595	-0.350	0.256	0.177	5.000	7.000
Dt1	1.779	1.406	0.482	<0.001	2.000	2.000
A18	0.286	-0.0157	0.228	<0.001	64.000	152.000
A03	0.307	-0.617	0.216	0.026	20.000	36.000
WP11	1.017	-0.371	0.366	<0.001	11.000	17.000
A10	1.361	2.000	0.300	0.149	10.000	26.000
A2	-0.454	-0.516	0.297	0.013	25.000	71.000
A04	0.374	-0.728	0.237	0.032	29.000	81.000
B09	2.902	9.086	0.445	<0.001	15.000	45.000
B07	0.000	-2.235	0.000	<0.001	0.000	0.000
B1-3	0.848	-0.161	0.315	<0.001	56.000	224.000
B03	2.482	7.042	0.315	<0.001	17.000	57.000

APPENDIX 5. DESCRIPTIVE STATISTICS: PERCENTAGE PRESENCE AT INTERSECTS

Data source: 2007 *Modiolus* dive survey, percentage occurrence in quadrat data

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
Dt0	10	0	0.000	0.000	0.000	0.000
Dt3	5	0	8.750	9.479	4.239	11.769
Dt4	18	0	9.028	9.876	2.328	4.911
Dt6	20	0	17.188	9.484	2.121	4.439
Dt7	17	0	13.971	7.822	1.897	4.022
Dt8	5	0	22.500	7.126	3.187	8.848
Dt9	7	0	7.143	5.623	2.125	5.201
Dt10	5	0	20.000	10.270	4.593	12.752
StA	10	0	0.000	0.000	0.000	0.000
StB	10	0	6.250	4.167	1.318	2.981
St1	5	0	20.000	10.270	4.593	12.752
Dt10W	10	0	0.000	0.000	0.000	0.000
Dt10E	7	0	4.464	4.725	1.786	4.369
Dt1	10	0	1.250	2.635	0.833	1.885
A18	38	0	10.526	6.832	1.108	2.246
A03	18	0	6.944	5.627	1.326	2.798
WP11	20	0	3.438	4.745	1.061	2.221
A10	5	0	12.500	7.655	3.423	9.505
A2	10	0	15.625	6.074	1.921	4.345
A04	14	0	12.946	7.930	2.119	4.579
B09	32	0	2.930	6.917	1.223	2.494
B07	20	0	0.000	0.000	0.000	0.000
B1-3	20	0	17.500	11.754	2.628	5.501
B03	20	0	5.313	9.353	2.091	4.377

Column	Range	Max	Min	Median	25%	75%
Dt0	0.000	0.000	0.000	0.000	0.000	0.000
Dt3	18.750	18.750	0.000	6.250	0.000	18.750
Dt4	37.500	37.500	0.000	6.250	0.000	12.500
Dt6	31.250	37.500	6.250	12.500	12.500	25.000
Dt7	25.000	31.250	6.250	12.500	6.250	18.750
Dt8	18.750	31.250	12.500	25.000	17.188	26.563
Dt9	12.500	12.500	0.000	6.250	1.563	12.500
Dt10	25.000	37.500	12.500	18.750	12.500	23.438
StA	0.000	0.000	0.000	0.000	0.000	0.000
StB	12.500	12.500	0.000	6.250	6.250	6.250
St1	25.000	31.250	6.250	25.000	10.938	26.563
Dt10W	0.000	0.000	0.000	0.000	0.000	0.000
Dt10E	12.500	12.500	0.000	6.250	0.000	6.250
DT1	6.250	6.250	0.000	0.000	0.000	0.000
A18	25.000	25.000	0.000	12.500	6.250	12.500
A03	18.750	18.750	0.000	6.250	0.000	12.500
WP11	12.500	12.500	0.000	0.000	0.000	6.250
A10	18.750	25.000	6.250	12.500	6.250	15.625

A02	18.750	25.000	6.250	18.750	12.500	18.750
A04	25.000	25.000	0.000	12.500	6.250	18.750
B09	31.250	31.250	0.000	0.000	0.000	0.000
B07	0.000	0.000	0.000	0.000	0.000	0.000
B1-3	43.750	43.750	0.000	12.500	12.500	28.125
B03	37.500	37.500	0.000	0.000	0.000	6.250

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
Dt0	0.000	-2.571	0.000	<0.001	0.000	0.000
Dt3	0.315	-3.081	0.254	0.329	43.750	742.188
Dt4	1.675	3.131	0.277	<0.001	162.500	3125.000
Dt6	0.872	0.175	0.239	0.004	343.750	7617.188
Dt7	0.798	-0.210	0.222	0.026	237.500	4296.875
Dt8	-0.405	-0.178	0.237	0.414	112.500	2734.375
Dt9	-0.353	-1.817	0.258	0.170	50.000	546.875
Dt10	1.736	3.251	0.348	0.047	100.000	2421.875
StA	0.000	-2.571	0.000	<0.001	0.000	0.000
StB	0.000	0.0804	0.300	0.011	62.500	546.875
St1	-0.518	-1.687	0.287	0.193	100.000	2421.875
Dt10W	0.000	-2.571	0.000	<0.001	0.000	0.000
Dt10E	0.595	-0.350	0.256	0.177	31.250	273.438
Dt1	1.779	1.406	0.482	<0.001	12.500	78.125
A18	0.286	-0.0157	0.228	<0.001	400.000	5937.500
A03	0.307	-0.617	0.216	0.026	125.000	1406.250
WP11	1.017	-0.371	0.366	<0.001	68.750	664.063
A10	1.361	2.000	0.300	0.149	62.500	1015.625
A02	-0.454	-0.516	0.297	0.013	156.250	2773.438
A04	0.374	-0.728	0.237	0.032	181.250	3164.063
B09	2.902	9.086	0.445	<0.001	93.750	1757.813
B07	0.000	-2.235	0.000	<0.001	0.000	0.000
B1-3	0.848	-0.161	0.315	<0.001	350.000	8750.000
B03	2.482	7.042	0.315	<0.001	106.250	2226.563

APPENDIX 6. DESCRIPTIVE STATISTICS OF PERCENTAGE ABUNDANCE OF ALL QUADRATS COMBINED

Data source: 2007 *Modiolus* dive survey, combined percentage abundance in quadrat data

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
%	336	0	8.333	9.331	0.509	1.001

Column	Range	Max	Min	Median	25%	75%
%	43.750	43.750	0.000	6.250	0.000	12.500

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
%	1.203	1.124	0.213	<0.001	2800.000	52500.000

APPENDIX 7. DESCRIPTIVE STATISTICS OF PERCENTAGE ABUNDANCE OF 11 PREVIOUSLY SURVEYED STATIONS

Data source: 2007 *Modiolus* dive survey, combined percentage n quadrat data

Column	Size	Missing	Mean	Std Dev	Std. Error	C.I. of Mean
% prev sites	11	0	11.348	7.927	2.390	5.326

Column	Range	Max	Min	Median	25%	75%
% prev sites	22.500	22.500	0.000	9.028	6.473	19.297

Column	Skewness	Kurtosis	K-S Dist.	K-S Prob.	Sum	Sum of Squares
% prev sites	-0.0639	-1.283	0.161	0.533	124.829	2044.98

APPENDIX 8. STATISTICAL ASSESSMENT OF CHANGES IN COUNTS (PER FIVE QUADRATS) SINCE 1999.

Normality Test: Passed (P = 0.076)
Equal Variance Test: Passed (P = 0.055)

Years	Name	N	Missing	Mean	Std Dev	SEM
1999	10	0	28.300	13.073	4.134	
2004	10	0	14.776	8.798	2.782	
2007	10	0	9.990	5.885	1.861	

Source of Variation	DF	SS	MS	F	P
Between Sites	9	1696.872	188.541		
Between Years	2	1803.535	901.767	19.107	<0.001
Residual	18	849.506	47.195		
Total	29	4349.913			

The differences in the mean values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001). To isolate the group or groups that differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.050: 1.000

All Pairwise Multiple Comparison Procedures (Holm-Sidak method):
Overall significance level = 0.05

Comparisons for factor:

Comparison	Diff of Means	t	Unadjusted P	Critical Level	Significant?
1999 vs. 2007	18.310	5.960	0.0000122	0.017	Yes
1999 vs. 2004	13.524	4.402	0.000344	0.025	Yes
2004 vs. 2007	4.786	1.558	0.137	0.050	No

APPENDIX 9. IDENTIFICATION OF ANY DIFFERENCE IN *MODIOLUS* NUMBERS AT SURVEY SITES 2007

One Way Analysis of Variance
Data source: 2007 all raw counts in quadrat data

Normality Test: Failed (P < 0.050)

Test execution ended by user request, ANOVA on Ranks begun

Kruskal-Wallis One Way Analysis of Variance on Ranks
Wednesday, September 19, 2007, 12:16:16

Data source: 2007 all raw counts in quadrat data

Site	N	Missing	Median	25%	75%
Dt0	10	0	0.000	0.000	0.000
Dt3	5	0	1.000	0.000	3.000
Dt4	18	0	1.000	0.000	2.000
Dt6	20	0	2.000	2.000	4.000
Dt7	17	0	2.000	1.000	3.000
DT8	5	0	4.000	2.750	4.250
Dt9	7	0	1.000	0.250	2.000
Dt10	5	0	3.000	2.000	3.750
StA	10	0	0.000	0.000	0.000
StB	10	0	1.000	1.000	1.000
St1	5	0	4.000	1.750	4.250
NEW SITES					
Dt10W	10	0	0.000	0.000	0.000
Dt10E	7	0	1.000	0.000	1.000
Dt1	10	0	0.000	0.000	0.000
A18	38	0	2.000	1.000	2.000
A03	18	0	1.000	0.000	2.000
WP11	20	0	0.000	0.000	1.000
A10	5	0	2.000	1.000	2.500
A02	10	0	3.000	2.000	3.000
A04	14	0	2.000	1.000	3.000
B09	32	0	0.000	0.000	0.000
B07	20	0	0.000	0.000	0.000
B01-3	20	0	2.000	2.000	4.500
B03	20	0	0.000	0.000	1.000

H = 181.900 with 23 degrees of freedom. (P = <0.001)

The differences in the median values among the treatment groups are greater than would be expected by chance; there is a statistically significant difference (P = <0.001)

All Pairwise Multiple Comparison Procedures (Dunn's Method):

NS= not significant

Comparison	Diff of Ranks	Q	P<0.05
Dt8 vs Dt10W	229.000	4.304	Yes
Dt8 vs StA	229.000	4.304	Yes
Dt8 vs B07	229.000	4.715	Yes
Dt8 vs Dt0	229.000	4.304	Yes
Dt8 vs Dt1	208.500	3.919	Yes
Dt8 vs B09	193.484	4.142	Yes
Dt8 vs WP11	177.275	3.650	NS
Dt8 vs B03	166.725	3.433	NS
Dt8 vs DT10E	160.214	2.817	NS
Dt8 vs StB	132.700	2.494	NS
Dt8 vs A03	128.444	2.616	NS
Dt8 vs Dt9	125.143	2.200	NS
Dt8 vs Dt3	119.500	1.945	NS
Dt8 vs Dt4	119.444	2.432	NS
Dt8 vs A18	89.974	1.947	NS
Dt8 vs A10	69.400	1.130	NS
Dt8 vs A04	69.179	1.367	NS
Dt8 vs DT7	58.353	1.181	NS
Dt8 vs B01-3	46.500	0.957	NS
Dt8 vs Dt6	38.725	0.797	NS
Dt8 vs A02	37.950	0.713	NS
Dt8 vs St1	24.000	0.391	NS
Dt8 vs Dt10	17.400	0.283	NS
Dt10 vs Dt10W	211.600	3.977	Yes
Dt10 vs StA	211.600	3.977	Yes
Dt10 vs B07	211.600	4.357	Yes
Dt10 vs Dt0	211.600	3.977	Yes
Dt10 vs Dt1	191.100	3.592	NS
Dt10 vs B09	176.084	3.770	NS
Dt10 vs WP11	159.875	3.292	NS
Dt10 vs B03	149.325	3.074	NS
Dt10 vs Dt10E	142.814	2.511	NS
Dt10 vs StB	115.300	2.167	NS
Dt10 vs A03	111.044	2.261	NS
Dt10 vs Dt9	107.743	1.894	NS
Dt10 vs Dt3	102.100	1.662	NS
Dt10 vs Dt4	102.044	2.078	NS
Dt10 vs A18	72.574	1.570	NS
Dt10 vs A10	52.000	0.846	NS
Dt10 vs A4	51.779	1.023	NS
Dt10 vs Dt7	40.953	0.829	NS
Dt10 vs B01-3	29.100	0.599	NS
Dt10 vsDt06	21.325	0.439	NS
Dt10 vs A02	20.550	0.386	NS
St1 vs Dt10W	205.000	3.853	Yes
St1 vs StA	205.000	3.853	Yes
St1 vs B07	205.000	4.221	Yes
St1 vs Dt0	205.000	3.853	Yes
St1 vs Dt1	184.500	3.468	NS
St1 vs B09	169.484	3.628	NS
St1 vs WP11	153.275	3.156	NS
St1 vs B03	142.725	2.939	NS
St1 vs Dt10E	136.214	2.395	NS
St1 vs StB	108.700	2.043	NS
St1 vs A03	104.444	2.127	NS
St1 vs Dt9	101.143	1.778	NS
St1 vs Dt3	95.500	1.554	NS
St1 vs Dt4	95.444	1.944	NS

St1 vs A18	65.974	1.428	NS
St1 vs A10	45.400	0.739	NS
St1 vs A4	45.179	0.893	NS
St1 vs Dt7	34.353	0.695	NS
St1 vs B01-3	22.500	0.463	NS
St1 vs Dt6	14.725	0.303	NS
St1 vs A02	13.950	0.262	NS
A02 vs Dt10W	191.050	4.398	Yes
A02 vs StA	191.050	4.398	Yes
A02 vs B07	191.050	5.078	Yes
A02 vs Dt0	191.050	4.398	Yes
A02 vs Dt1	170.550	3.926	NS
A02 vs B09	155.534	4.420	NS
A02 vs WP11	139.325	3.703	NS
A02 vs B03	128.775	3.423	NS
A02 vs Dt10E	122.264	2.554	NS
A02 vs STB	94.750	2.181	NS
A02 vs A03	90.494	2.362	NS
A02 vs Dt9	87.193	1.821	NS
A02 vs Dt3	81.550	1.533	NS
A02 vs Dt4	81.494	2.127	NS
A02 vs A18	52.024	1.507	NS
A02 vs A10	31.450	0.591	NS
A02 vs A04	31.229	0.776	NS
A02 vs Dt7	20.403	0.527	NS
A02 vs B01-3	8.550	0.227	NS
A02 vs Dt6	0.775	0.0206	NS
Dt6 vs Dt10W	190.275	5.058	Yes
Dt6 vs DtA	190.275	5.058	Yes
Dt6 vs B07	190.275	6.194	Yes
Dt6 vs Dt0	190.275	5.058	Yes
Dt6 vs Dt1	169.775	4.513	NS
Dt6 vs B09	154.759	5.589	NS
Dt6 vs WP11	138.550	4.510	NS
Dt6 vs B03	128.000	4.167	NS
Dt6 vs Dt10E	121.489	2.848	NS
Dt6 vs StB	93.975	2.498	NS
Dt6 vs A03	89.719	2.843	NS
Dt6 vs Dt9	86.418	2.026	NS
Dt6 vs Dt3	80.775	1.663	NS
Dt6 vs Dt4	80.719	2.558	NS
Dt6 vs A18	51.249	1.910	NS
Dt6 vs A10	30.675	0.632	NS
Dt6 vs A04	30.454	0.900	NS
Dt6 vs Dt7	19.628	0.613	NS
Dt6 vs B01-3	7.775	0.253	NS
B01-3 vs Dt10W	182.500	4.851	Yes
B01-3 vs StA	182.500	4.851	Yes
B01-3 vs B07	182.500	5.941	Yes
B01-3 vs Dt0	182.500	4.851	Yes
B01-3 vs Dt1	162.000	4.306	NS
B01-3 vs B09	146.984	5.308	NS
B01-3 vs WP11	130.775	4.257	NS
B01-3 vs B03	120.225	3.914	NS
B01-3 vs 10E	113.714	2.666	NS
B1-3 vsSt B	86.200	2.291	NS
B01-3 vs A03	81.944	2.596	NS
B01-3 vs Dt9	78.643	1.844	NS
B01-3 vs Dt3	73.000	1.503	NS
B01-3 vs Dt4	72.944	2.311	NS

B01-3 vs A18	43.474	1.620	NS
B01-3 vs A10	22.900	0.471	NS
B01-3 vs A04	22.679	0.670	NS
B01-3 vs Dt7	11.853	0.370	NS
Dt7 vs Dt10W	170.647	4.408	Yes
Dt7 vs StA	170.647	4.408	Yes
Dt7 vs B07	170.647	5.325	Yes
Dt7 vs Dt0	170.647	4.408	Yes
Dt7 vs Dt1	150.147	3.879	NS
Dt7 vs B09	135.131	4.635	NS
Dt7 vs WP11	118.922	3.711	NS
Dt7 vs B03	108.372	3.382	NS
Dt7 vs Dt10E	101.861	2.335	NS
Dt7 vs StB	74.347	1.920	NS
Dt7 vs A03	70.092	2.134	NS
Dt7 vs Dt9	66.790	1.531	NS
Dt7 vs Dt3	61.147	1.237	NS
Dt7 vs DT4	61.092	1.860	NS
DT7 vs A18	31.621	1.116	NS
DT7 vs A10	11.047	0.224	NS
Dt7 vs A04	10.826	0.309	NS
A04 vs Dt10W	159.821	3.974	Yes
A04 vs StA	159.821	3.974	Yes
A04 vs B07	159.821	4.722	Yes
A04 vs Dt0	159.821	3.974	Yes
A04 vs Dt1	139.321	3.464	NS
A04 vs B09	124.306	3.994	NS
A04 vs WP11	108.096	3.193	NS
A04 vs B03	97.546	2.882	NS
A04 vs Dt10E	91.036	2.025	NS
A04 vs StB	63.521	1.579	NS
A04 vs A03	59.266	1.712	NS
A04 vs Dt9	55.964	1.245	NS
A04 vs Dt3	50.321	0.994	NS
A04 vs Dt4	50.266	1.452	NS
A04 vs A18	20.795	0.685	NS
A4 vs A10	0.221	0.00438	NS
A10 vs Dt10W	159.600	3.000	NS
A10 vs StA	159.600	3.000	NS
A10 vs B07	159.600	3.286	NS
A10 vs Dt0	159.600	3.000	NS
A10 vs Dt1	139.100	2.614	NS
A10 vs B09	124.084	2.656	NS
A10 vs WP11	107.875	2.221	NS
A10 vs B03	97.325	2.004	NS
A10 vs Dt10E	90.814	1.597	NS
A10 vs StB	63.300	1.190	NS
A10 vs A03	59.044	1.202	NS
A10 vs Dt9	55.743	0.980	NS
A10 vs Dt3	50.100	0.815	NS
A10 vs Dt4	50.044	1.019	NS
A10 vs A18	20.574	0.445	NS
A18 vs Dt10W	139.026	4.027	NS
A18 vs StA	139.026	4.027	NS
A18 vs B07	139.026	5.181	NS
A18 vs Dt0	139.026	4.027	NS
A18 vs Dt1	118.526	3.433	NS
A18 vs B09	103.511	4.441	NS
A18 vs WP11	87.301	3.253	NS
A18 vs B03	76.751	2.860	NS

A18 vs Dt10E	70.241	1.758	NS
A18 vs StB	42.726	1.238	NS
A18 vs A03	38.471	1.384	NS
A18 vs Dt9	35.169	0.880	NS
A18 vs Dt3	29.526	0.639	NS
A18 vs Dt4	29.471	1.060	NS
Dt4 vs Dt10W	109.556	2.860	NS
Dt4 vs StA	109.556	2.860	NS
Dt4 vs B07	109.556	3.471	NS
Dt4 vs Dt0	109.556	2.860	NS
Dt4 vs Dt1	89.056	2.324	NS
Dt4 vs B09	74.040	2.587	NS
Dt4 vs B03	47.281	1.498	NS
Dt4 vs Dt10E	40.770	0.942	NS
Dt4 vs StB	13.256	0.346	NS
Dt4 vs A03	9.000	0.278	NS
Dt4 vs Dt9	5.698	0.132	NS
Dt4 vs Dt3	0.0556	0.00113	NS
Dt3 vs Dt10W	109.500	2.058	NS
Dt3 vs StA	109.500	2.058	NS
Dt3 vs B07	109.500	2.254	NS
Dt3 vs Dt0	109.500	2.058	NS
Dt3 vs Dt1	89.000	1.673	NS
Dt3 vs B09	73.984	1.584	NS
Dt3 vs WP11	57.775	1.190	NS
Dt3 vs B03	47.225	0.972	NS
Dt3 vs Dt10E	40.714	0.716	NS
Dt3 vs StB	13.200	0.248	NS
Dt3 vs A03	8.944	0.182	NS
Dt3 vs Dt9	5.643	0.0992	NS
Dt9 vs Dt10W	103.857	2.170	NS
Dt9 vs StA	103.857	2.170	NS
Dt9 vs B07	103.857	2.435	NS
Dt9 vs DT0	103.857	2.170	NS
Dt9 vs Dt1	83.357	1.741	NS
Dt9 vs B09	68.342	1.686	NS
Dt9 vs WP11	52.132	1.222	NS
Dt9 vs B03	41.582	0.975	NS
Dt9 vs Dt10E	35.071	0.675	NS
Dt9 vs StB	7.557	0.158	NS
Dt9 vs A03	3.302	0.0763	NS
A03 vs Dt10W	100.556	2.625	NS
A03 vs StA	100.556	2.625	NS
A03 vs B07	100.556	3.186	NS
A03 vs Dt0	100.556	2.625	NS
A03 vs Dt1	80.056	2.090	NS
A03 vs B09	65.040	2.273	NS
A03 vs WP11	48.831	1.547	NS
A03 vs B03	38.281	1.213	NS
A03 vs Dt10E	31.770	0.734	NS
A03 vs StB	4.256	0.111	NS
StB vs Dt10W	96.300	2.217	NS
StB vs StA	96.300	2.217	NS
StB vs B07	96.300	2.560	NS
StB vs Dt0	96.300	2.217	NS
StB vs Dt1	75.800	1.745	NS
StB vs B09	60.784	1.727	NS
StB vs WP11	44.575	1.185	NS
StB vs B03	34.025	0.904	NS
StB vs Dt10E	27.514	0.575	NS

Dt10E vs Dt10W	68.786	1.437	NS
Dt10E vs StA	68.786	1.437	NS
Dt10E vs B07	68.786	1.612	NS
Dt10E vs Dt0	68.786	1.437	NS
Dt10E vs Dt1	48.286	1.009	NS
Dt10E vs B09	33.270	0.821	NS
Dt10E vs WP11	17.061	0.400	NS
Dt10E vs B03	6.511	0.153	NS
B03 vs Dt10W	62.275	1.655	NS
B03 vs DtA	62.275	1.655	NS
B03 vs B07	62.275	2.027	NS
B03 vs Dt0	62.275	1.655	NS
B03 vs Dt1	41.775	1.110	NS
B03 vs B09	26.759	0.966	NS
B03 vs WP11	10.550	0.343	NS
WP11 vs Dt10W	51.725	1.375	NS
WP11 vs StA	51.725	1.375	NS
WP11 vs B07	51.725	1.684	NS
WP11 vs Dt0	51.725	1.375	NS
WP11 vs Dt1	31.225	0.830	NS
WP11 vs B09	16.209	0.585	NS
B09 vs Dt10W	35.516	1.009	NS
B09 vs StA	35.516	1.009	NS
B09 vs B07	35.516	1.283	NS
B09 vs Dt0	35.516	1.009	NS
B09 vs Dt1	15.016	0.427	NS
Dt1 vs Dt10W	20.500	0.472	NS
Dt1 vs StA	20.500	0.472	NS
Dt1 vs B07	20.500	0.545	NS
Dt1 vs Dt0	20.500	0.472	NS
Dt0 vs 10W	0.000	0.000	NS
Dt0 vs StA	0.000	0.000	NS
Dt0 vs B07	0.000	0.000	NS
B07 vs Dt10W	0.000	0.000	NS
B07 vs StA	0.000	0.000	NS
StA vs Dt10W	0.000	0.000	NS

Note: The multiple comparisons on ranks do not include an adjustment for ties.

APPENDIX 10. COMPARISONS OF TWO DIVERS RECORDINGS OF *MODIOLUS* COUNTS FROM THE SAME QUADRATS.

SITE DT4

Normality Test: Failed (P < 0.050)

Wilcoxon Signed Rank Test

Group	N	Missing	Median	25%	75%
L Luddington	8	0	1.000	0.500	2.500
C Munro	8	0	1.000	0.000	1.500

W= -4.000 T+ = 3.000 T-= -7.000 P(est.)= 0.581 P(exact)= 0.625

The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.625).

SITE DT6

Normality Test: Passed (P = 0.165)

Paired t test

Treatment Name	N	Missing	Mean	Std Dev	SEM
L. Baldock	10	0	2.800	1.619	0.512
S. Henderson	10	0	2.700	1.494	0.473
Difference	10	0	0.1000	1.663	0.526

t = 0.190 with 9 degrees of freedom. (P = 0.853)

95 percent confidence interval for difference of means: -1.090 to 1.290

The change that occurred with the treatment is not great enough to exclude the possibility that the difference is due to chance (P = 0.853)

Site Dt7

Paired t-test:

Normality Test: Passed (P = 0.635)

Treatment Name	N	Missing	Mean	Std Dev	SEM
L. Baldock	8	0	1.750	0.707	0.250
S. Henderson	8	0	2.375	1.302	0.460
Difference	8	0	-0.625	1.768	0.625

t = -1.000 with 7 degrees of freedom. (P = 0.351)

95 percent confidence interval for difference of means: -2.103 to 0.853

The change that occurred with the treatment is not great enough to exclude the possibility that the difference is due to chance (P = 0.351)

Site: StB

Normality Test: Failed (P < 0.050)
Wilcoxon Signed Rank Test

Group	**N**	**Missing**	**Median**	**25%**	**75%**
L. Baldock	5	0	1.000	1.000	2.000
S. Henderson	5	0	1.000	0.000	1.000

W= -10.000 T+ = 0.000 T-= -10.000 P(est.)= 0.072 P(exact)= 0.125

The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.125).

Site Dt1

[Normality Test: Failed (P < 0.050)**]**

Wilcoxon Signed Rank Test

Group	**N**	**Missing**	**Median**	**25%**	**75%**
L. Baldock	5	0	0.000	0.000	1.000
S. Henderson	5	0	0.000	0.000	0.000

W= -3.000 T+ = 0.000 T-= -3.000 P(est.)= 0.346 P(exact)= 0.500

The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.500).

Site: A18
Paired t-test:
Normality Test: Passed (P = 0.117)

Treatment Name	**N**	**Missing**	**Mean**	**Std Dev**	**SEM**
L. Luddington	18	0	1.500	0.985	0.232
C. Munro	18	0	1.944	1.162	0.274
Difference	18	0	-0.444	1.381	0.326

t = -1.365 with 17 degrees of freedom. (P = 0.190)
95 percent confidence interval for difference of means: -1.131 to 0.243

The change that occurred with the treatment is not great enough to exclude the possibility that the difference is due to chance (P = 0.190)
Power of performed test with alpha = 0.050: 0.133

Site A03 Paired t-test:

[Normality Test: Failed (P < 0.050)**]**

Wilcoxon Signed Rank Test

Group	**N**	**Missing**	**Median**	**25%**	**75%**
L. Luddington	9	0	1.000	1.000	2.000
S. Henderson	9	0	1.000	0.000	2.000

W= -7.000 T+ = 4.000 T-= -11.000 P(est.)= 0.410 P(exact)= 0.438

The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.438).

Site WP11

Normality Test: Failed (P < 0.050)

Wilcoxon Signed Rank Test

Group	**N**	**Missing**	**Median**	**25%**	**75%**
C. Munro10	0	0.000	0.000	1.000	
L. Luddington	10	0	0.000	0.000	1.000

W= 2.000 T+ = 8.500 T-= -6.500 P(est.)= 0.890 P(exact)= 0.813

The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.813).

Site A02: Paired t-test:

Normality Test: Passed (P = 0.149)

Treatment Name	**N**	**Missing**	**Mean**	**Std Dev**	**SEM**
L. Luddington	5	0	3.000	0.000	0.000
S. Henderson	5	0	2.000	1.225	0.548
Difference	5	0	1.000	1.225	0.548

t = 1.826 with 4 degrees of freedom. (P = 0.142)

95 percent confidence interval for difference of means: -0.521 to 2.521

The change that occurred with the treatment is not great enough to exclude the possibility that the difference is due to chance (P = 0.142)

Site A04 Paired t-test:
Normality Test: Passed (P = 0.230)

Treatment Name	N	Missing	Mean	Std Dev	SEM
S. Henderson	7	0	1.857	1.345	0.508
L. Baldock	7	0	2.286	1.254	0.474
Difference	7	0	-0.429	1.988	0.751

t = -0.570 with 6 degrees of freedom. (P = 0.589)
95 percent confidence interval for difference of means: -2.267 to 1.410

The change that occurred with the treatment is not great enough to exclude the possibility that the difference is due to chance (P = 0.589)

Site B09 Paired t-test:
Normality Test: Failed (P < 0.050)
Wilcoxon Signed Rank Test

Group	N	Missing	Median	25%	75%
C. Munro	16	0	0.000	0.000	0.000
L. Luddington	16	0	0.000	0.000	1.000

W= 14.000 T+ = 21.000 T-= -7.000 P(est.)= 0.268 P(exact)= 0.297

The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.297).

Site B01-3
Paired t-test:
Normality Test: Passed (P = 0.454)

Treatment Name	N	Missing	Mean	Std Dev	SEM
L. Luddington	10	0	3.700	1.947	0.616
S. Henderson	10	0	1.900	1.370	0.433
Difference	10	0	1.800	1.549	0.490

t = 3.674 with 9 degrees of freedom. (P = 0.005)

95 percent confidence interval for difference of means: 0.692 to 2.908

The change that occurred with the treatment is greater than would be expected by chance; there is a statistically significant change (P = 0.005)

Site B03:
Normality Test: Failed (P < 0.050)
Wilcoxon Signed Rank Test:

Group	N	Missing	Median	25%	75%
C. Munro	10	0	0.000	0.000	0.000
L. Luddington	10	0	1.000	0.000	1.000

W= 5.000 T+ = 16.500 T-= -11.500 P(est.)= 0.733 P(exact)= 0.688

The change that occurred with the treatment is not great enough to exclude the possibility that it is due to chance (P = 0.688).

Notes.

Dt0, StA, Dt10W omitted from comparisons as no *Modiolus* recorded. Dt9, Dt10E omitted as records for C. Munro only. Dt3, Dt8, Dt10, St1, A10 omitted as records for C. Dalgleish only.

APPENDIX 11. STATION NAMES (2007, 2004 & 1999)

	Alternative station names used for dive stations in 1999, 2004 and 2007 surveys						
GIS Dive No. (2007)	2007	2004	1999	GIS Dive No. (2007)	2007	2004	1999
8	DT0	T1/0	T1/0	**19**	A02	-	-
9	Dt1	T1/1	T1/1	**12**	A03	-	-
	-	T1/2	T1?2	**25**	A04	-	-
11	Dt3	T1/3	T1/3	**18**	A10	-	-
3	Dt4	T1/4	T1/4	**10**	A18	-	-
23	Dt5	T1/5	T1/5	**28**	B1-3	-	-
22	Dt6	T1/6	T1/6	**29**	B03	-	-
2	Dt7	T1/7	T1/7	**27**	B07	-	-
21	Dt8	T1/8	T1/8	**26**	B09	--	--
20	Dt9	T1/9	T1/9	**13**	WP11	-	-
1	Dt10	T1/10	T1/10	**14**	WP11	-	-
6	Dt10E	-	-	**15**	WP11	-	-
5	Dt10W	-	-	**16**	WP11	-	-
24	St1	Station 1	Station 1	**17**	WP11	-	-
4	St A	Station A	Station A				
7	St B	Station B	Station B				

- indicates this station was not surveyed in that year.

APPENDIX 12. Photo Log

Camera	Photo number	Location Latitude (WGS84)	Location Longitude (WGS84)	Specific or general	General location	Subject	Title	Date	Photographer
Nikonos V, 15mm lens, YS120 flash	IMG1	57.27318959	-5.71358631	S	Kyle of Lochalsh	Quadrat	Dt4, Quadrat 1	02/06/2007	Colin Munro
Nikonos V, 15mm lens, YS120 flash	IMG2	57.27318959	-5.71358631	S	Kyle of Lochalsh	Quadrat	Dt4, Quadrat 2	02/06/2007	Colin Munro
Nikonos V, 15mm lens, YS120 flash	IMG3	57.27318959	-5.71358631	S	Kyle of Lochalsh	Quadrat	Dt4, Quadrat 3	02/06/2007	Colin Munro
Nikonos V, 15mm lens, YS120 flash	IMG4	57.27318959	-5.71358631	S	Kyle of Lochalsh	Quadrat	Dt4, Quadrat 4	02/06/2007	Colin Munro
Nikonos V, 15mm lens, YS120 flash	IMG5	57.27318959	-5.71358631	S	Kyle of Lochalsh	Quadrat	Dt4, Quadrat 5	02/06/2007	Colin Munro
Nikonos V, 15mm lens, YS120 flash	IMG6	57.27318959	-5.71358631	S	Kyle of Lochalsh	Quadrat	Dt4, Quadrat 6	02/06/2007	Colin Munro
Nikonos V, 15mm lens, YS120 flash	IMG7	57.27318959	-5.71358631	S	Kyle of Lochalsh	Quadrat	Dt4, Quadrat 7	02/06/2007	Colin Munro
Nikonos V, 15mm lens, YS120 flash	IMG8	57.27423238	-5.71390178	S	Kyle of Lochalsh	Quadrat	Dt10W Quadrat not known	03/06/2007	Laura Baxter
Nikonos V, 15mm lens, YS120 flash	IMG9	57.27423238	-5.71390178	S	Kyle of Lochalsh	Surveyor working	Diver (C. Dalgleish)	03/06/2007	Laura Baxter
Nikonos V, 15mm lens, YS120 flash	IMG10	57.27423238	-5.71390178	S	Kyle of Lochalsh	Quadrat	Dt10W Quadrat not known	03/06/2007	Laura Baxter
Nikonos V, 15mm lens, YS120 flash	IMG11	57.27423238	-5.71390178	S	Kyle of Lochalsh	Quadrat	Dt10W Quadrat not known	03/06/2007	Laura Baxter
Nikonos V, 15mm lens, YS120 flash	IMG12	57.27423238	-5.71390178	S	Kyle of Lochalsh	Quadrat	Dt10W Quadrat not known	03/06/2007	Laura Baxter
Nikonos V, 15mm lens, YS120 flash	IMG13	57.27316523	-5.71288327	S	Kyle of Lochalsh	Quadrat	A02, Quadrat 1	04/06/2007	Lin Baldock
Nikonos V, 15mm lens, YS120 flash	IMG14	57.27316523	-5.71288327	S	Kyle of Lochalsh	Quadrat	A02, Quadrat 2	04/06/2007	Lin Baldock
Nikon F4, Aquatica housing, no flash (failed)	IMG15	57.273229	-5.713361	S	Kyle of Lochalsh	Quadrat	Dt5, Quadrat 1.	05/06/2007	Colin Munro
Nikon F4, Aquatica housing, no flash (failed)	IMG16	57.273229	-5.713361	S	Kyle of Lochalsh	Quadrat	Dt5, Quadrat 2.	05/06/2007	Colin Munro

Nikon F4, Aquatica housing, no flash (failed)	IMG17	57.273229	-5.713361	S	Kyle of Lochalsh	Quadrat	Dt5, Quadrat 3.	05/06/2007	Colin Munro
Nikon F4, Aquatica housing, no flash (failed)	IMG18	57.273229	-5.713361	S	Kyle of Lochalsh	Habitat, Close up	*Ophiothrix fragilis* and *Modiolus* on shelly mixed sediment. (Dt 5)	05/06/2007	Colin Munro
Nikon F4, Aquatica housing, no flash (failed)	IMG19	57.273229	-5.713361	S	Kyle of Lochalsh	Surveors working	Diver (L. Luddington) surveying strung quadrat. (Dt 5)	05/06/2007	Colin Munro
Nikon F4, Aquatica housing, no flash (failed)	IMG20	57.273229	-5.713361	S	Kyle of Lochalsh	Quadrat	Dt 5, Quadrat 4. *Ophiothrix fragilis*, *Modiolus* shells and *Munida rugosa*.	05/06/2007	Colin Munro
Nikon F4, Aquatica housing, no flash (failed)	IMG21	57.273229	-5.713361	S	Kyle of Lochalsh	Habitat, Close up	*Ophiothrix fragilis* and *Modiolus* on mixed sediment (Dt5)	05/06/2007	Colin Munro
Nikon F4, Aquatica housing, no flash (failed)	IMG22	57.273229	-5.713361	S	Kyle of Lochalsh	Surveors working	Diver (L. Luddington) surveying strung quadrat. (Dt 5)	05/06/2007	Colin Munro
Nikon F4, Aquatica housing, no flash (failed)	IMG23	57.273229	-5.713361	S	Kyle of Lochalsh	Surveors working	Collecting *Modiolus* clump sample (Dt 5)	05/06/2007	Colin Munro
Nikon F4, Aquatica housing, no flash (failed)	IMG24	57.273229	-5.713361	S	Kyle of Lochalsh	Habitat, Wide angle	*Ophiothrix fragilis* and *Modiolus* on mixed sediment (Dt 5)	05/06/2007	Colin Munro
Nikon F4, Aquatica housing, no flash (failed)	IMG25	57.273229	-5.713361	S	Kyle of Lochalsh	Habitat, Close up	*Ophiothrix fragilis* and *Modiolus* on mixed sediment. Some *Ascidia mentula*.	05/06/2007	Colin Munro
Sony DSC707 in Amphibico housing	DSC05906	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A10, quadrat not known	04/06/2007	Laura Baxter
Sony DSC707 in Amphibico housing	DSC05908	57.273998	-5.712883	s	Kyle of Lochalsh	Diver surveying	Diver surveying	04/06/2007	Laura Baxter
Sony DSC707 in Amphibico housing	DSC05910	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A10, quadrat not known	04/06/2007	Laura Baxter
Sony DSC707 in Amphibico housing	DSC05912	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A10, quadrat not known	04/06/2007	Laura Baxter
Sony DSC707 in Amphibico housing	DSC05915	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A10, quadrat not known	04/06/2007	Laura Baxter

Sony DSC707 in Amphibico housing	DSC05917	57.273998	-5.712883	s	Kyle of Lochalsh	Habitat	Habitat shot	04/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05918	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A10, quadrat not known	04/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05921	57.273998	-5.712883	s	Kyle of Lochalsh	Habitat	Habitat shot	04/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05922	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A02, quadrat not known	04/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05923	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A02, quadrat not known	04/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05924	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A02, quadrat not known	04/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05925	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A02, quadrat not known	04/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05926	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A02, quadrat not known	04/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05927	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A02, quadrat not known	04/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05928	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A02, quadrat not known	04/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05929	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	A02, quadrat not known	04/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05951	57.273998	-5.712883	s	Kyle of Lochalsh	Close up	Dt8, close up, brittlestars	05/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05952	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	Dt8, quadrat unknown	05/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05953	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	Close up, brittlestars, Luidia.	05/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05954	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	Close up, brittlestars.	05/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05955	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	Dt8, quadrat unknown	05/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05958	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	Close up, brittlestars, Hysa sp.	05/06/2007Laura Baxter
Sony DSC707 in Amphibico housing	DSC05959	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	Dt8, quadrat unknown	05/06/2007Laura Baxter

Sony DSC707 in Amphibico housing	DSC05961	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	Dt8, quadrat unknown	05/06/2007	Laura Baxter
Sony DSC707 in Amphibico housing	DSC05962	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	Dt8, quadrat unknown	05/06/2007	Laura Baxter
Sony DSC707 in Amphibico housing	DSC05963	57.273998	-5.712883	s	Kyle of Lochalsh	Quadrat	Close up, Ophiothrix fragilis.	05/06/2007	Laura Baxter