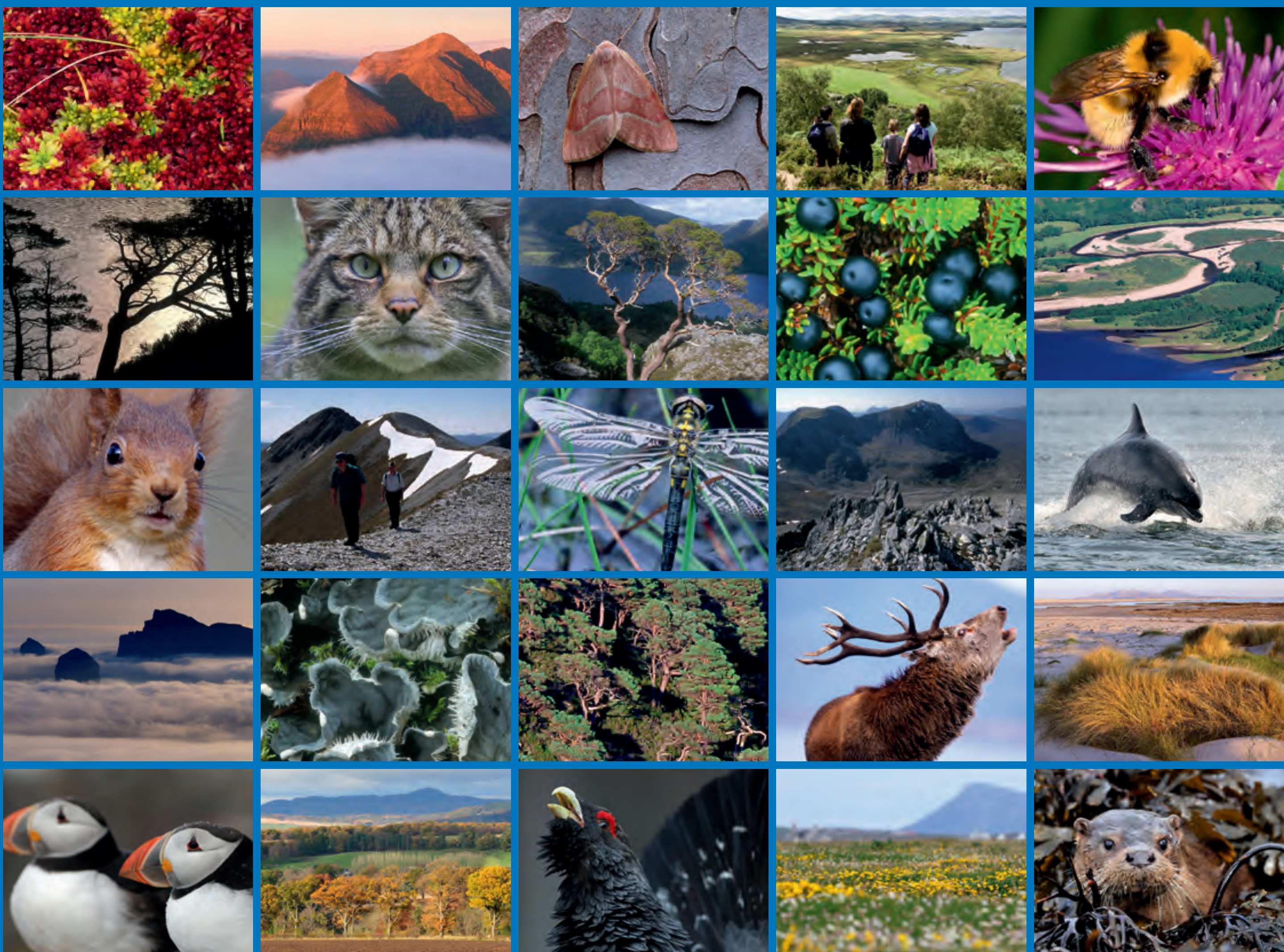
Scottish Natural Heritage
Commissioned Report No. 151

The establishment of site condition monitoring of the subtidal reefs of Loch Creran Special Area of Conservation



COMMISSIONED REPORT

Commissioned Report No. 151

The establishment of site condition monitoring of the subtidal reefs of Loch Creran Special Area of Conservation

(ROAME No. F02AA409)

For further information on this report please contact:

Graham Saunders
Maritime Group
Scottish Natural Heritage
2 Anderson Place
EDINBURGH
EH6 5NP
Telephone: 0131–446 2456
E-mail: graham.saunders@snh.gov.uk

This report should be quoted as:

Moore, C.G.[*], Saunders, G.R.[†], Harries, D.B.[*], Mair, J.M.[*], Bates C.R.[‡], and Lyndon, A.R[*]. (2006). The establishment of site condition monitoring of the subtidal reefs of Loch Creran Special Area of Conservation. Scottish Natural Heritage Commissioned Report No. 151 (ROAME No. F02AA409).

[*]*School of Life Sciences, Heriot-Watt University, Riccarton, Edinburgh EH14 4AS*
[†]*Maritime Group, Scottish Natural Heritage, 2 Anderson Place, Edinburgh EH6 5NP*
[‡]*School of Geography and Geosciences, University of St Andrews, St Andrews, Fife KY16 9AJ*

COMMISSIONED REPORT
Summary

The establishment of site condition monitoring of the subtidal reefs of Loch Creran Special Area of Conservation

Commissioned Report No. 151 (ROAME No. F02AA409)
Contractor: Heriot-Watt University
Year of publication: 2006

Background

Loch Creran lies 12km to the north of Oban on the west coast of Scotland. It was established as a Special Area of Conservation (SAC) in 2005 for the marine feature, reefs. The loch is of international conservation importance for its biogenic reefs. It is the only site in the UK known to support calcareous reefs produced by the serpulid worm, *Serpula vermicularis*, and the loch also contains beds of the horse mussel, *Modiolus modiolus*. Both reef types support diverse animal communities. Rocky reefs also occur within the loch and support diverse communities of algae and animals at a few locations.

It is a mandatory requirement of SACs that monitoring of a site is carried out (site condition monitoring) to identify deterioration in the condition of the features for which the site has been established. The purpose of the current study was to initiate site condition monitoring of the reefs of Loch Creran. This was done to establish a baseline biological data set that would facilitate the assessment of the condition of the reef habitats in the future and to allow a judgement to be formed on the current condition of these habitats. The approach taken to achieve these objectives was to assess the extent and distribution of serpulid reefs from observations by diver along 110 transects around the loch. Detailed studies were also performed at four of the major serpulid reef sites in the loch. Here, distribution was examined with sidescan sonar, reef density by video and the community of organisms associated with the habitat by diver survey of the reefs themselves and of the surrounding sediment. The distribution and abundance of *Modiolus* was examined along seven relocatable transects and, at one of the major mussel beds, the size structure of the population and associated community surveyed. Subtidal rocky reefs were surveyed by diver along relocatable transects at three sites.

Main findings

- Serpulid reefs were recorded along 72 of the 110 diver transects (66%).
- The reefs were present within a marginal band around the loch, the mean width of the band being 57m in the lower basin of the loch and 11m in the upper basin. Taking into account the coastline length of the loch, the area of this band throughout the loch was estimated to be 108ha.
- The serpulid reef band was effectively absent in the outer part of the loch. Significant interruptions in the reef band were also found at Creagan and off Rubha Mór.

- Sidescan sonar revealed extensive reef damage by bottom gear, presumed to be scallop dredges. This took the form of single and twin parallel tracks of c.3m width, which contained broken reef rubble. This damage resulted in a loss in habitat extent of 0.45ha, representing 10.9% of the reef band off Rubha Mór. Evidence of reef damage from mooring and aquaculture activities was also shown by sidescan sonar.
- Dense parallel tracks in the mud c.30cm wide were identified in part of the lower basin. These were considered to be caused by otter trawling. There was no evidence that this activity was causing reef damage.
- While it is clear that reduction in the extent of the serpulid reef habitat has been taking place due to various types of anthropogenic impact, cessation of the discharge of organic pollution from the alginate factory at Barcaldine in 1996 has been followed by some recovery of the reef habitat in that area.
- Serpulid reef abundance in terms of percentage coverage of the seabed was found to vary between 3% and 17% at four of the major reef sites in the loch. Comparison with previous data at one of these sites revealed no significant reduction in density between 2000 and 2005.
- Geographical variation in the diversity and composition of the community associated with the serpulid reefs were recorded, but at three of the major reef sites where previous data were available, no temporal change in diversity between 2001 and 2005 was found.
- *Modiolus* was found to have a widespread distribution within the loch, being recorded along 60 of the 110 peripheral diver transects (55%).
- Dense beds of *Modiolus* were found at four sites, with the greatest abundance in the current-swept Creagan Narrows, where *Modiolus* covered 34% of the seabed.
- For the upper basin *Modiolus* bed, where previous data are available from 1999, there is no evidence for a temporal change in extent or distribution of the bed.
- For the upper basin bed as a whole, no significant change in *Modiolus* abundance was found between 1999 and 2005; however, significant reductions were recorded at two sites near the centre of the bed.
- Analysis of the size frequency of the *Modiolus* population in the upper basin revealed poor recruitment to the population by young mussels. If present trends continue, it is to be expected that *Modiolus* abundance will decline in the future.
- Analysis of the community associated with the upper basin *Modiolus* bed revealed slight changes in diversity and composition between 1999 and 2005, though no evidence for anthropogenically-induced change.
- A reinterpretation of previous data for the loch suggests that all three *Modiolus* biotopes recorded in previous years were still present in 2005.
- The 2005 survey of subtidal rocky reefs revealed rich and interesting sites near the mouth of the loch. Current-swept sites in this area provided suitable conditions for dense kelp forests clothed in a rich attached community. Below these forests the rock supported scattered but spectacular massive sponge colonies. Lack of previous data prevents the analysis of temporal change in the rocky reef habitats of the loch but they appear to be in good condition.

For further information on this project contact:
Graham Saunders, Maritime Group, Scottish Natural Heritage, 2 Anderson Place, Edinburgh EH6 5NP.
Tel: 0131–446 2456

For further information on the SNH Research & Technical Support Programme contact:
The Advisory Services Co-ordination Group, Scottish Natural Heritage, 2 Anderson Place, Edinburgh EH6 5NP.
Tel: 0131–446 2400 or **ascg@snh.gov.uk**

Acknowledgements

We gratefully acknowledge the following people for assistance with the fieldwork: Dr Jane Hawkridge (JNCC) and from Heriot-Watt University, Dan Edwards, Andrew Mogg, Stuart Brown and Nick Moore. Sue Hamilton is thanked for assistance with faunal identification, Paul Wood for algal identification and Nick Moore for help with video analysis.

Contents

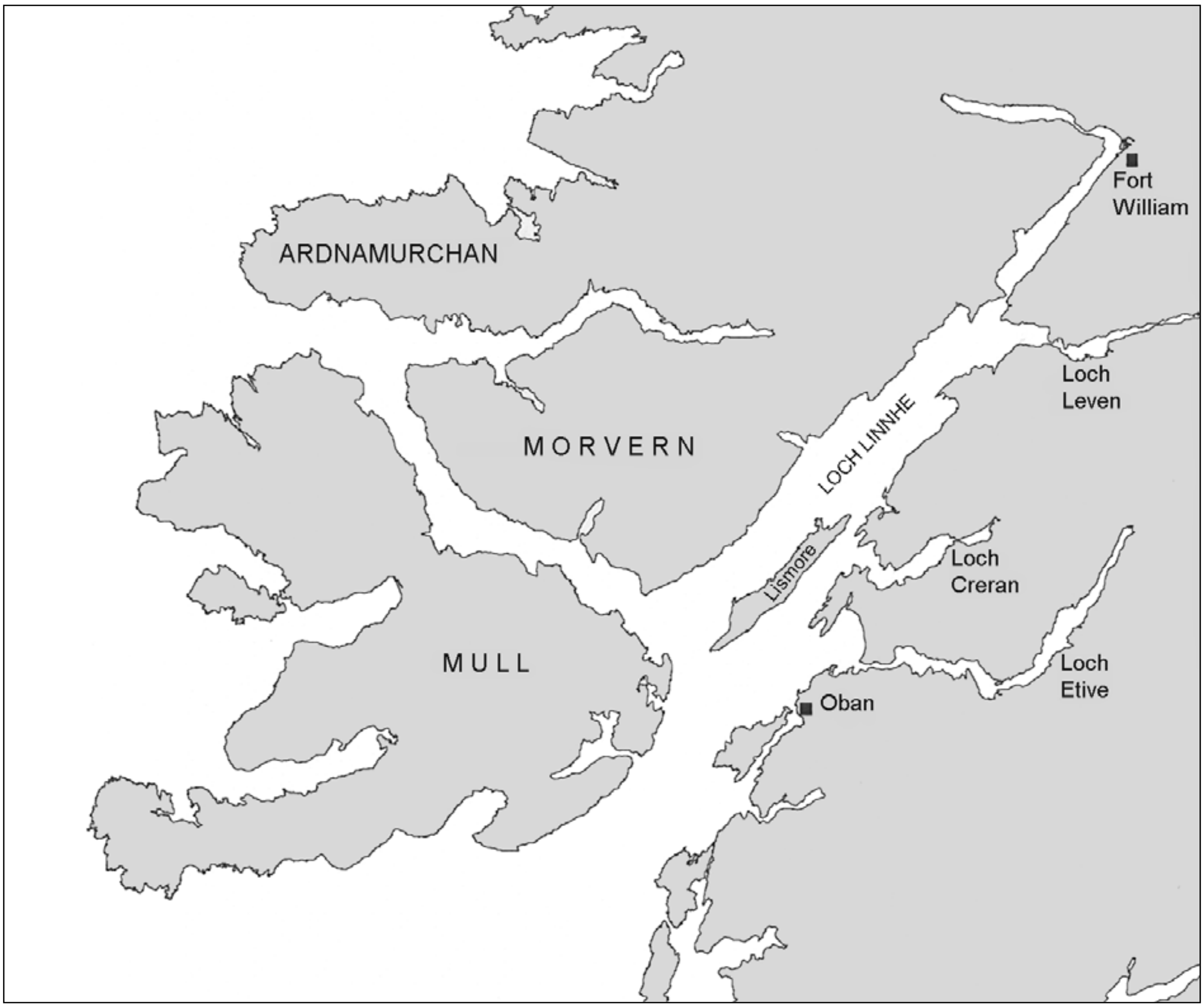
List of figures

List of tables

1 INTRODUCTION

Loch Creran lies 12km to the north of Oban on the west coast of Scotland (Figure 1). It was designated a Special Area of Conservation (SAC) under the EC Habitats Directive (92/43 EEC) in March 2005 in order to protect its qualifying feature, reefs. The SAC extends to the mouth of the loch (Figure 2) and includes the subtidal area to MLWS.

Figure 1 The location of Loch Creran



Subtidal rocky reefs are found fringing part of the coastline of the loch in the form of boulders and bedrock and there are several large bedrock outcrops, some uncharted. Of greater importance are the biogenic reefs, which provide a biologically-derived hard substrate upon which a diverse community of organisms develops.

Although the calcareous tube-forming polychaete worm, *Serpula vermicularis*, is common in Europe, Loch Creran is the only known remaining location in the UK where mass aggregations of individuals occurs, producing reef-like structures growing to 1m in height (Figure 3). The loch is also the most important world site for these reefs in terms of areal coverage (Moore *et al*. 1998). Though more common than serpulid reefs, Loch Creran also contains some good examples of beds of the horse mussel, *Modiolus modiolus*.

Figure 2 Loch Creran showing the location of survey sites. Site names SVx, MMx and SRx should be preceded by 'LC05' for full site code

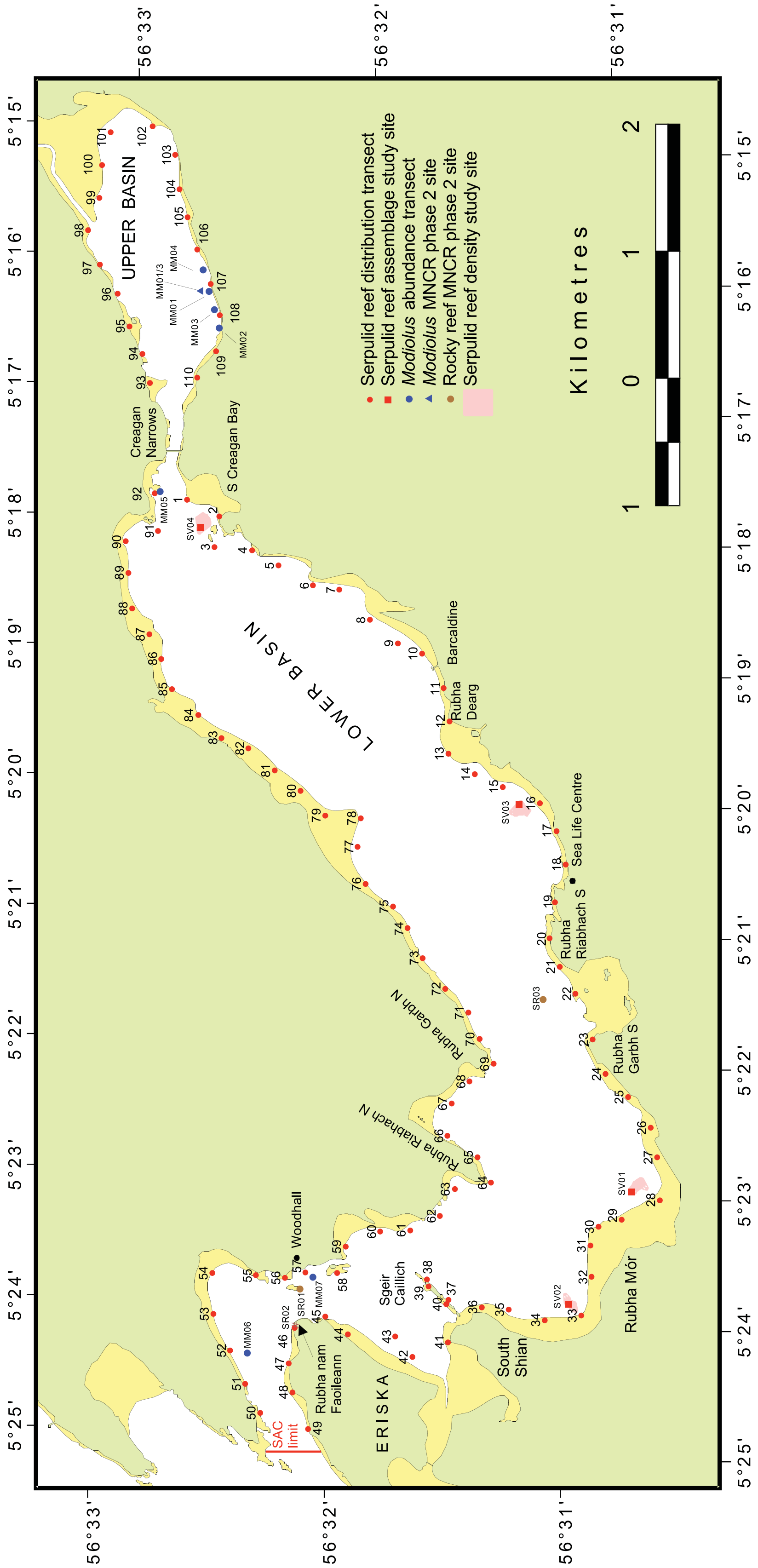
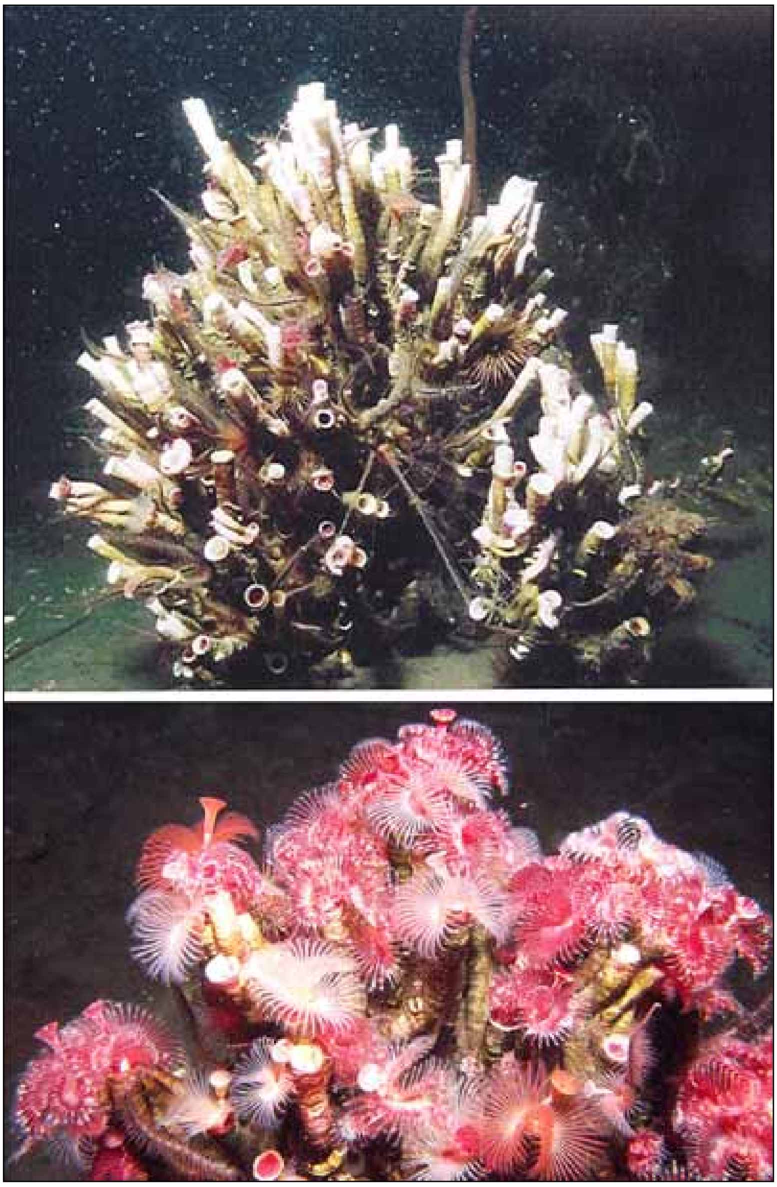


Figure 3 Serpulid reef. Upper photo showing structure of typical reef. Lower photo showing worm feeding crowns



The loch was surveyed by the MNCR in 1989 (Connor 1990), who carried out phase 2 surveys at 10 subtidal sites, which included examples of rocky reefs, serpulid reefs and *Modiolus* beds. The distribution and abundance of serpulid reefs was surveyed in 1994 (Moore, 1996; Moore *et al*., 1998). Comely (1978) studied the abundance and population structure of *Modiolus* at Creagan in 1974–76. Black *et al*. (2000) carried out broadscale mapping of the biotopes of the loch using AGDS in 1989–90 and Mair *et al*. (2000) studied the abundance, distribution, population structure and associated community of an upper basin *Modiolus* bed in 1999. Moore *et al*. (2003) measured the abundance of serpulid reefs at one site in 2000, as part of a programme of development of serpulid reef monitoring methods.

The fragile nature of serpulid reefs renders them particularly vulnerable to mechanical damage from several of man's activities. Activities carried out in the loch with strong potential for damage include fishing, aquaculture, boat mooring and the discharge of waste products. Otter trawling for *Nephrops* is regularly practised over the muddier sediments in the loch and scallop dredging has been reported to have taken place sporadically, including in the upper basin of the loch where both serpulid reefs and *Modiolus* beds would be threatened. Static fishing gear includes the occasional use of creels for *Nephrops* and velvet crabs, *Necora puber*, and weighted drums for whelks, *Buccinum undatum*. Oyster, mussel and salmon farming is carried out in the loch. Oyster farming is shore-based in sedimentary areas and is unlikely to impact the rocky or biogenic reefs. Mussel farming is also carried out over sedimentary seabeds, deeper than the fringing serpulid reefs and outwith the areas of dense *Modiolus*. The risk from mussel farming lies in possible damage from ancillary activities around the mussel farm, such as the mooring of vessels and work platforms. Salmon farming is known to have caused serpulid reef damage through the mooring of facilities, which causes damage through moving ground tackle and through the deposition of dead shells of the mussel, *Mytilus edulis*, from floating structures. Small boat moorings are present in some areas of serpulid reefs in the loch and these cause damage through scour of the mooring chain. Anchoring is a greater potential risk as this is uncontrolled, takes place over a similar depth range to that of the serpulid reefs, and fresh areas of reefs can be decimated during each anchoring event.

Under the Habitats Directive member countries are required to establish management schemes for the conservation of features for which SACs have been established. The conservation objectives define the desired favourable condition of each of the features of interest and the management of the SAC should aim to achieve favourable conservation status of these features. Condition monitoring of a site is carried out to provide information to enable judgements to be made about whether favourable condition of the interest features is being achieved. For the purposes of monitoring each feature is represented by a series of attributes, which are measurable indicators of the condition of the feature at the site. For each attribute (eg extent of a habitat or diversity of biotopes) a target value is set which is considered to correspond to the favourable conservation status of the feature.

In order to promote a uniform approach to the monitoring of the condition of features, guidance has been drawn up on the general approach to be taken in condition monitoring (Anon. 1998) and for specific habitats including littoral and sublittoral reefs (Inter-Agency Marine Monitoring Group 2004). The Inter-Agency Marine Monitoring Group (ibid.) lists the attributes of the habitats and corresponding targets that could form the basis of site condition monitoring.

The purpose of the current study is to initiate site condition monitoring of the designated features of the SAC. This will be done in such a way as to achieve the following objectives:

- to establish a baseline biological data set that will facilitate the assessment of the favourable condition status of the habitats in the future;
- to allow Scottish Natural Heritage to form a judgement on the current condition of these habitats.

The main approach taken to achieve these objectives was to assess the extent and distribution of serpulid reefs from observations by diver along 110 transects around the loch. Detailed studies were also performed at four of the major serpulid reef sites in the loch. Here, distribution was examined with sidescan sonar, reef density by video and the community of organisms associated with the habitat by diver survey of the reefs themselves and of the surrounding sediment. The distribution and abundance of *Modiolus* was examined along seven relocatable transects and, at one of the major mussel beds, the size structure of the population and associated community surveyed. Subtidal rocky reefs were surveyed by diver along relocatable transects at three sites.

2 METHODS

2.1 Bathymetric survey

The bathymetry of the loch was surveyed by bathymetric sidescan from 5–7 September 2005 from *R. V. Serpula*. The sidescan used was a Submetrix System 2000 (SEA Group Ltd., Frome, UK) with bow-mounted 117kHz transducers, combined with a TSS DMS–05 motion reference unit (TSS International Ltd., Watford, UK). Positional information was obtained by DGPS. All data was recorded on a PC with RTS2000 acquisition software (SEA Group Ltd.). Navigation was accomplished using Hypack Max Survey software (Hypack Inc., Middletown, USA). Tidal corrections were applied to the bathymetric sidescan data using TotalTide (Hydrographic Office, Taunton, UK). The survey line spacing was chosen that would give swath overlap and the acoustic data were continually monitored on the acquisition computer and a bottom coverage map produced in real-time in order to ensure full seafloor coverage. The output from the survey was in the form of a bathymetric grid with a horizontal resolution of 5m, from which contour maps were produced using Fledermaus software (IVS 3D, Fredericton, Canada).

The accuracy of sidescan bathymetric systems is limited by water depth. Although the periphery of the loch was surveyed close to the time of high water, it was subsequently found from comparison with tape measurements that errors of the order of 1m were sometimes present at depths <5m below chart datum. As greater accuracy was needed for the assessment of serpulid reef extent by the survey of distribution along peripheral transects (see below), the transects where serpulid reefs were present were depth surveyed in December 2005 by single beam sonar using a combined fishfinder / DGPS system (Lowrance M52I S / GPS, Lowrance Electronics Inc., Tulsa, USA) with a 200kHz transducer. This was stern mounted on a small inflatable, enabling coverage to span the full depth range of serpulid reefs. Depth and positional information every two seconds was beamed by Bluetooth to an Ipaq HX4700 pocket PC (Hewlett-Packard, Palo Alto, USA). Intensive single beam sonar surveys were also performed in December 2005 at four major serpulid reef sites, where reef distribution had previously been studied by sidescan (see below). For these sites the bathymetry was contoured in ArcView 3.2 (ESRI, Redlands, USA). The accuracy of the single beam system was checked against a weighted tape and found to agree to within 0.1m within the tested depth range of 1–15m.

2.2 Serpulid reefs

2.2.1 Peripheral distribution survey

Serpulid reef distribution was determined by diver along 110 transects, approximately 250m apart, around the periphery of the loch from 11–25 July 2005 (Figure 2, Table A1). The diver swam on a compass bearing perpendicular to the shoreline from chart datum to a nominal depth of 14m. The transect continued beyond 14m if reefs were still present or ended before 14m at some sites where such a depth was not achievable or where a soft mud plain clearly beyond the lower limit of the reefs had been encountered. The ends of the transect line were fixed by DGPS from a surface vessel by recording the position of descent of the diver and, prior to ascent, the position of the diver marker buoy, following a signal from the diver.

Using a slate, the diver recorded the presence of the following categories of *Serpula vermicularis* within the band of visibility (approximately 4m either side) along the transect:

- Individual (non-reef forming) worms;
- Small reefs (5–50cm^2 in plan view);
- Medium reefs (50–500cm^2);
- Large reefs (>500cm^2).

To aid reef size assessment, these areas were marked on the slate. The diver recorded the depth after initial descent and prior to ascent. The depths of the shallow and deep limits of reef distribution were recorded. As scattered small reefs are often found beyond the limits of the principal reef band, the shallow and deep limits of medium and / or large reefs were also recorded. Notes were made of any evidence for anthropogenic damage of reefs. The opportunity was also taken to record observations of *Modiolus modiolus*. The maximum density of *Modiolus* over a contiguous area of at least 25m^2 was recorded on the SACFOR scale and the depth noted.

With knowledge of the positions of the transect ends and the depths of the upper and lower reef boundaries, it was planned to convert these depths to positions using the bathymetric survey. This would allow determination of the width of the reef band along each transect. As the accuracy of the bathymetric sidescan survey was found to suffer significant deterioration in shallow waters (<5m), this led to the resurvey of the bathymetry at the transect sites using single beam sonar from a small vessel (described above). By displaying the transect lines and bathymetry within Arcview, the positions of the reef boundaries perpendicular to the shoreline were determined. This allowed measurement of band width at each transect site, for both total reefs and for medium / large reefs.

Reef extent was determined using three methods. The first approach was an index measure based on the percentage of transects supporting reefs.

The second measure provided a spatial estimate of the reef biotope. This was based on determination of the total area of the reef band (both for total and for medium / large reefs) by multiplying the mean reef band width along transects by the length of the coastline. This length was actually taken as the length of the smoothed 5m contour, as this generally lies within the reef band.

The third measure also provides an estimate of spatial extent, although the approach was mainly developed to provide a pictorial illustration of reef coverage. Within Arcview, polygons were drawn linking the upper and lower reef boundaries of adjacent transects, using the bathymetric information to guide the positioning of polygon margins between transects.

2.2.2 Detailed studies at major sites

2.2.2.1 Sidescan sonar distribution survey

Four embayments, known to support extensive reef development, were surveyed from 6–8 September 2005 using a Klein 3000 sidescan sonar system at a frequency of 500kHz. These were Rubha Mór, South Shian, Sea Life Centre Bay and South Creagan. The sonar fish was towed from *RV Serpula* predominantly along linear tracks aligned with the main direction of the seabed contours. Along-track navigation was accomplished using Hypack Max Survey software. A track width of 35m to each side of the vessel was generally adopted and a track spacing of around 25m. Positional information was obtained by DGPS. The sonargrams were mosaiced using Sonarweb (Chesapeake Technology Inc., Mountain View, USA) and Seetrack (Seebyte Ltd, Edinburgh, UK).

Groundtruthing of the mosaics was achieved principally by use of a small, lightweight, dropdown video system suspended just above the seabed, the height being continuously adjusted to avoid collision with reef material. The mosaiced images were displayed in ArcView 3.2. The images were overlain with a framework of transect lines forming the basis for the video groundtruthing. Using the Arcview extension CMSGPS (Coulter Mapping Solutions Inc., Louisville, USA) the position of the survey vessel was superimposed in real time on the mosaic and was manoeuvred at slow speed along the desired track. To maintain verticality of the camera it was necessary to maintain a speed of less than one knot, which could be achieved by either wind-driven drift or the use of intermittent power. The video was recorded onto digital video tape, together with the position and time of each frame using a video overlay system fed by data from DGPS. The digital video was examined frame by frame using Adobe Premier (Adobe Systems Inc., San Jose, USA). Each frame was classified using the following categories:

- Serpulid reefs present;
- No living reefs but reef rubble present;
- Algae (principally kelp) present with no reefs visible;
- Boulders present and no reefs;
- Unclassified – where visibility was impaired.

The classified groundtruth data were superimposed on the mosaic in Arcview to facilitate the mapping of reef material. The periphery of the reef band identified from the mosaiced image and the groundtruth data were traced in ArcView. The set of overlapping sidescan image tracks was employed, not just the image of the track that is uppermost in Figures 8–14.

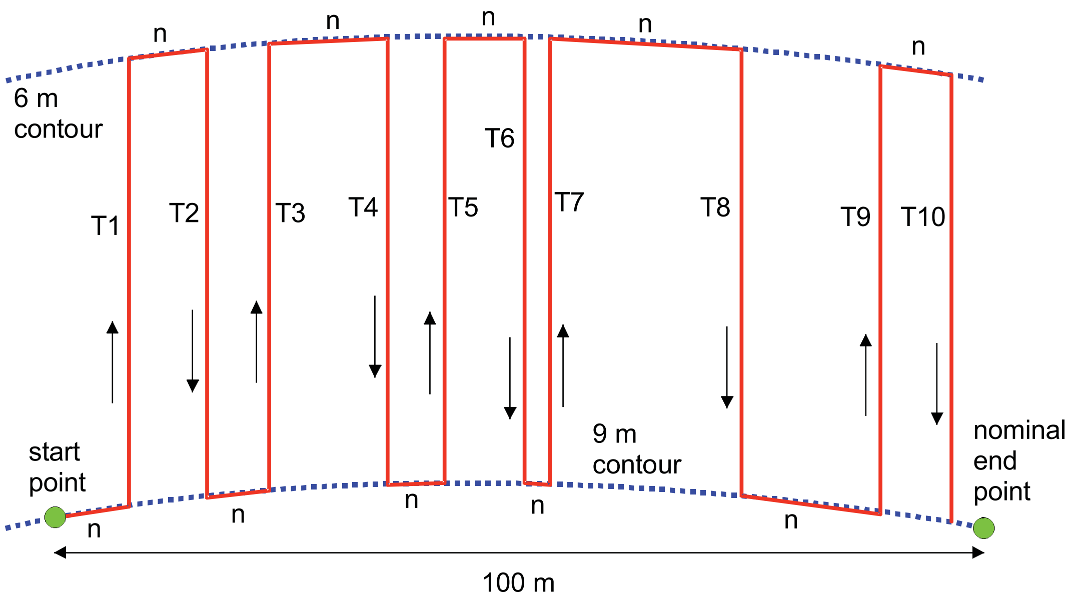
Table 1 Details of video quantification transect surveys of percentage reef cover. 10 video transects were carried out between the stated depth contours within a 100m section of the reef band between the positions given

Site	**South Shian**	**Rubha Mór**	**Sea Life Centre**	**South Creagan**
Survey date	24–Jul–05	23–Jul–05	25–Jul–05	26–Jul–05
Start position	56.51737ºN 5.39761ºW	56.51369ºN 5.38260ºW	56.52303ºN 5.33478ºW	56.54541ºN 5.30006ºW
Depth of start (m)	9	9	8	6
Transect bearing (ºT)	254	234	129	134
Depth at first transect end (m)	6	6	5	3
Nominal survey end position	56.51808ºN 5.39661ºW	56.51303ºN 5.38142ºW	56.52213ºN 5.33484ºW	56.54555ºN 5.29844ºW

2.2.2.2 Diver video density survey

Serpulid reef abundance was quantified from 23–26 July 2005 at four sites (Figure 2, Table 1) using the video technique of Moore *et al*. (2003). This involved performing 10 replicate video transects perpendicular to the seabed contours with the start and end of the transects defined by particular depth contours (Figure 4). Based on previous knowledge, at each site a typical 100m length of the reef band was selected beforehand and the transects were performed between depth contours within this band. The divers were dropped at one end of the 100m survey area and they worked their way across the area performing transects. To spread the transects randomly across the 100m section, a set of 10 random numbers between 0 and 100 was employed. Prior to the exercise, for each diver the relationship between distance covered and number of fin kicks was determined by repeatedly recording the number of fin kicks used in covering a distance of 25m at normal swimming speed. Based on this calibration the random numbers could be converted to fin kicks.

Figure 4 Schematic illustration of serpulid reef video quantification transects (T1–T10) from the start point to the nominal end point, 100m distant. Transects follow compass bearings between contours. Distance between transects (n) determined using random numbers converted into diver fin kicks.



At Rubha Mór and South Shian transects ran between the 6–9m contours. As reef distribution tends to become shallower with distance up the loch, the contours used at Sea Life Centre Bay were 5–8m and in South Creagan Bay 3–6m.

A lead diver performed navigation, leaving a second diver to concentrate on video recording. For example at Rubha Mór, the team commenced at 9m swimming up the slope on a compass bearing at a steady speed. The digital video camera (Panasonic DX110B) was pointed vertically downwards at a distance of 60cm above the seabed or above reef material. This distance was achieved using a 50cm plumb line.

On reaching the 6m contour, video recording ceased and the divers then swam the requisite number of fin kicks along the 6m contour, aided by the compass. Video recording restarted as the divers swam the next transect down to the 9m contour. To facilitate relocation of the study areas Table 1 provides the position of the start of the survey and the nominal end position, 100m distant on the same contour. The first transect bearing is given, the reciprocal bearing being used for the following transect.

The video footage was downloaded to computer and controlled using the video editing software, Adobe Premier. The video frame was overlaid with a horizontal row of 10 points and the presence or absence of intact reef material recorded for each point. Every fifth frame was so recorded, resulting in a matrix of 100 sampling points for each 2s (50 frames) of video, which corresponds approximately to the time interval between non-overlapping frames. The percentage of points overlying reef material gives an estimate of percentage cover of the seabed.

2.2.2.3 Biotope community survey

The species assemblage of the reef biotope was surveyed at four locations (Rubha Mór, South Shian, Sea Life Centre Bay and South Creagan Bay; Figure 2, Table 2) using two methods. At each location a site was selected that was believed to be representative of the main reef band in that area. The site was first marked by a diver moving a buoyed, shot line into a representative reef area and a 25m tape run out over the seabed from the shot. The depths at the ends of the tape and the tape direction were recorded by diver and the position of the shot fixed by DGPS. Being a three-dimensional habitat, serpulid reefs are not amenable to standard MNCR phase 2 surveying and so the habitat survey was split into a survey of the associated community living on the reefs and an MNCR phase 2 survey of the sedimentary habitat to within 0.5m of any reefs. The latter was confined to a band 4m to either side of the tape, whereas the former was slightly more wide-ranging depending upon availability of suitable reefs.

For the MNCR phase 2 survey, diver records of SACFOR abundance of the biota was supplemented by video and stills photography illustrating the general nature of the habitat and species composition within the surveyed band.

For the survey of the reef biota, a diver was supplied with a checklist of species on a slate, compiled from a preliminary survey carried out during the current fieldtrip and from previous similar surveys. 10 serpulid reefs were selected within a size range of 30–50cm maximum width. For each reef the depth and the presence of all species seen was recorded. No quantitative biological data was attempted.

2.3 *Modiolus* beds

2.3.1 Peripheral distribution survey

As mentioned above, advantage was taken of the peripheral diver survey of serpulid reefs along 110 transects throughout the loch (Figure 2, Table A1) to gain a better understanding of *Modiolus* distribution and to identify the areas suitable for monitoring *Modiolus* abundance along transects. Along each transect the maximum density of *Modiolus* over a contiguous area of at least 25m^2 was recorded on the SACFOR scale and the depth noted.

2.3.2 Detailed studies at major sites

To facilitate comparisons of the status of the *Modiolus* beds in the loch with the previous 1999 study by Mair *et al*. (2000), the methodology was largely based on that used by the previous study.

2.3.2.1 Density survey

The positions of the four downslope upper basin transects worked in 1999 (T1–T4 in Mair *et al*. 2000) were relocated. The positions of the inshore stations are shown in Figure 2 and of both transect ends in Table 2. A more detailed illustration of the location of the transects is provided in the Transect Relocation Forms in the Appendix. For each transect a buoyed, shot line was placed at the inner end. An anchor attached to a 200m calibrated line (5m increments with station markers every 20m) was lowered to the seabed at the position of the inshore transect marker and the line run out from the survey vessel along the direction of the transect. According to the length of the corresponding 1999 transect, the groundline had been previously adjusted in length so that the same number of stations were run out. A buoyed, shot line was attached to the outer end of the transect line. The positions of the ends of the transect line were recorded by DGPS and the transect bearing. For relocational purposes still photographs were taken of the inshore marker and the adjacent coastline from different angles, with the position of the camera and the bearing of the view being recorded. One of these photographs included a view along the line of the transect running inshore and including both inner and outer transect marker buoys.

Table 2 Details of transects worked for community surveys of serpulid, *Modiolus* and rocky habitats

Transect	Type	Name/site no.	Latitude	Longitude	Bearing (°T)	Depth (m)	Date
LC05SV01	MNCR serpulid reef	Rubha Mór	56.51378	–5.38290	324	7.6 – 8.0	23–Jul–05
LC05SV02		South Shian	56.51782	–5.39768	219	7.7 – 7.8	24–Jul–05
LC05SV03		Sea Life Centre	56.52252	–5.33368	114	6.5 – 6.6	25–Jul–05
LC05SV04		South Creagan	56.54533	–5.29932	24	5.7 – 6.1	26–Jul–05
LC05SR01	MNCR rocky reef	Woodhall	56.53663	–5.39695	257	–3.5 – 14.0	20–Jul–05
LC05SR02		Rubha nam Faoileann	56.53683	–5.40148	24	–4.6 – 15.4	21–Jul–05
LC05SR03		Rubha Riabhach S	56.52037	–5.35858	14	5.4 – 17.0	22–Jul–05
LC05MM01	*Modiolus* abundance estimation	0	56.54548	–5.26897	0	5.5	17–Jul–05
LC05MM01		3	56.54593	–5.26893	0	15.5	17–Jul–05
LC05MM01		5	56.54625	–5.26890	0	26.8	17–Jul–05
LC05MM02		0	56.54445	–5.27348	344	6.5	19–Jul–05
LC05MM02		6	56.54553	–5.27390	344	26.9	19–Jul–05
LC05MM03		0	56.54495	–5.27127	349	4.8	19–Jul–05
LC05MM03		4	56.54562	–5.27147	349	25	19–Jul–05
LC05MM04		0	56.54608	–5.26632	344	7.5	19–Jul–05
LC05MM04		4	56.54673	–5.26647	344	29	19–Jul–05
LC05MM05		0	56.54832	–5.29488	200	5.2	25–Jul–05
LC05MM05		3	56.54782	–5.29520	200	10.5	25–Jul–05
LC05MM06		0	56.54010	–5.40537	329	10.1	26–Jul–05
LC05MM06		7	56.53900	–5.40413	329	28.4	26–Jul–05
LC05MM07		0	56.53573	–5.39528	264	9.5	26–Jul–05
LC05MM07		7	56.53580	–5.39730	264	22.9	26–Jul–05

Two divers recorded the abundance of *Modiolus* at stations every 20m using a square 0.25m^2 quadrat with cross strings at 10cm intervals creating a total of 16 intersections within the quadrat frame. The divers worked on different sides of the transect line, each within a 5m wide band. At each station the depth was recorded and each diver counted the number of intersections overlying live *Modiolus* within five randomly placed quadrats.

The same methodology was employed to record *Modiolus* abundance at three sites in the lower basin (Creagan, Creran Mouth and North Shian) not previously studied (Figure 2, Table 2).

2.3.2.2 Population structure

In the vicinity of the *Modiolus* clump collection (see below) five 0.25m^2 quadrats were cleared of all *Modiolus*, the material being placed into separate bags. The length of all live *Modiolus* was measured using digital vernier callipers for subsequent length / frequency analysis. The material was returned alive to the site, apart from the retention of the very small number of spat present for confirmation of identification in the laboratory.

2.3.2.3 Biotope community survey

To allow temporal comparisons with the 1999 survey, detailed examination of the *Modiolus* bed along transect T1 (LC05MM01 in 2005) was undertaken employing the same methodology. Station 3 (MM01 / 3 in Figure 2), a central and characteristic region of the bed, was marked with a buoyed, shot line and an MNCR phase 2 survey carried out between depths of 12 and 15m within a band extending to approximately 25m each side of the transect line. In addition to the recording of SACFOR abundance estimates, digital still photographs were taken of the general habitat and species. Digital video was also taken of the whole transect but with detailed coverage of station 3 in order to characterise the habitat and the community.

To supplement the *in situ* recording of the community, clumps of live *Modiolus* shells were taken for laboratory enumeration of the associated biota. Four replicate clumps were taken from a position approximately 20m to the east of station 3. Clumps were selected by diver that would just fit into a 5 litre bucket. The bucket was sealed before transport to the surface. In the laboratory the volume of the clump was determined by displacement and the associated biota retained on a 0.5mm mesh sieve counted and identified.

2.4 Rocky reef MNCR phase 2 surveys

Relocatable survey transects were established at three sites, Rubha nam Faoileann, Woodhall and Rubha Riabhach S (Table 2, Figure 2). To mark the transect fixed, relocatable points were established at the top of the shore using conspicuous features at the first two sites. The reef at Rubha Riabhach S is entirely subtidal and so the station marker was a metal piton driven into a rock crevice. The position of the marker (or marker buoy in the case of the latter site) was recorded by DGPS and several photographs taken of it (or of the marker buoy) from different viewpoints, with the position of the camera recorded by DGPS and the bearing to the marker taken with a sight-bearing compass.

The transect was marked by a 200m calibrated line (1m increments) attached to the station marker. The line followed a constant bearing down the rock slope, the end being attached to a buoyed, shot line.

The transect was split up into a series of zones which were defined in terms of differences in the composition of the biological community and / or by changes in substrate type. Zone boundaries along the line were recorded in terms of distance along the line and vertical height relative to the station marker. At the sites with shore-based station markers, heights along the transect relative to the station marker were obtained by measuring the height of the station marker above the water level at a given time using a surveyors' level. The depth was also measured at intermediate distances along the transect line, enabling a detailed profile of the transect to be subsequently drawn.

A band 4m either side of the tape from the upper limit of the kelp zone to the base of the reef was surveyed by one diver. Within each zone records were taken of substrate type and biota using the MNCR SACFOR scale of abundance, with collection of material for laboratory examination where *in situ* identification was not possible. Abundance was assessed over the zone as a whole, except where stated otherwise. Subtidally, a digital video camera (Sony DCR–TRV900 in an Amphibico Navigator 900 housing) and a digital still camera (Sony DSC–707 in an Amphibico Surveyor 707 housing) were used to make representative visual recordings of the transect zones. Biotopes were subsequently allocated to each zone using Connor *et al*. (2004).

2.5 General methods

All depths given in this report have been converted to depth below chart datum using tidal rise values calculated by TotalTide (Hydrographic Office, Taunton) for the secondary port of Barcaldine Pier for the lower basin below Creagan Narrows and for Loch Creran Head for the upper basin. All latitude and longitude positional information uses the WGS84 datum.

3 RESULTS

3.1 Bathymetric survey

The bathymetry of the loch based on the bathymetric sidescan survey is presented in Figures 5–6. Detail of the bathymetry acquired by single beam sonar at the four sites where serpulid reef distribution was examined by sidescan sonar is presented in Figures 8–14.

3.2 Serpulid reefs

3.2.1 Peripheral distribution survey

Reefs were recorded along 72 of the 110 diver transects (65.5%), with medium and / or large reefs present at 55 sites (50%) (Figure 7, Table A2). Reefs were not recorded farther down the loch than Sgeir Caillich, apart from a single instance of reefs on a groundchain at 13.8m off the western side of Sgeir Caillich.

The distribution of serpulid reefs, taking into account the width of the reef band along the diver transects, is shown in Figures 16–17. Reef development is clearly much greater in the lower part of the loch between Barcaldine and Sgeir Caillich, with a generally broad reef band. A major interruption in distribution is present at Rubha Mór. Above Barcaldine, although the band width is generally reduced to less than 50m, reefs are present along most of the coastline, including in the vicinity of the disused Kelco alginate plant effluent pipe at Barcaldine. Reefs are absent in the stronger currents in the vicinity of Creagan Narrows and are poorly represented in the upper basin of the loch. Based on the polygon areas illustrated in Figure 16, the total areal coverage of the reef biotope in the loch is 97.16ha for all reef sizes and 50.65ha for seabed occupied by medium and large reefs.

The mean width of the serpulid band in the lower basin, excluding the outer part of the loch where the reef band was effectively absent, was 57.45m. The equivalent figure for the upper basin was 11.39m. The length of the smoothed 5m contour for the corresponding regions was 17,932m and 4740m. This produces estimates for habitat coverage of 103.02ha and 5.40ha for the lower and upper basins respectively. The total figure of 108.42ha is 11.26ha greater than that estimated from polygon area measurement. For the area occupied by medium and large reefs the mean band widths are 31.43 and 0.89m for the lower and upper basins respectively, which provides a total extent estimate of 56.79ha, which is 6.14ha greater than the polygon estimate.

3.2.2 Detailed studies at major sites

3.2.2.1 Sidescan sonar distribution survey

Rubha Mór

The main reef band delineated in Figure 8 occupies an area of 4.15ha. The band appears to continue eastward beyond the eastward boundary shown on the figure, although sidescan coverage is not good here. Moving west and north from this point high reef density is clearly attained and the belt width extends to around 130m. There appears to be a sharp reduction in reef density towards the northern limit of the band. Reefs then virtually disappear or become very sparse for a considerable stretch of coastline (at least 400m),

Figure 5 Plan view of the three-dimensional model of the bathymetry of the lower basin of Loch Creran produced by Fledermaus

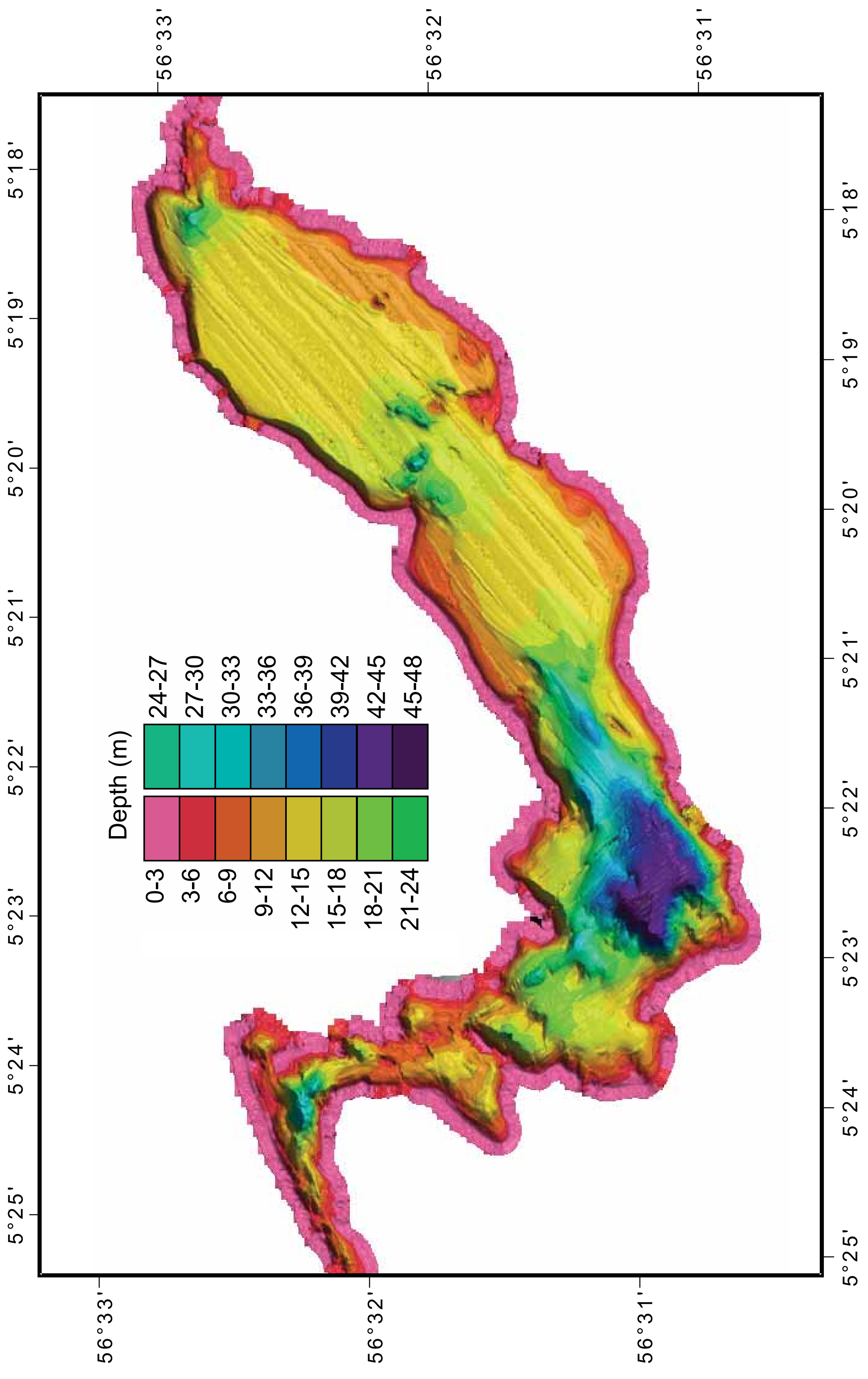


Figure 6 Plan view of the three-dimensional model of the bathymetry of the upper basin of Loch Creran produced by Fledermaus

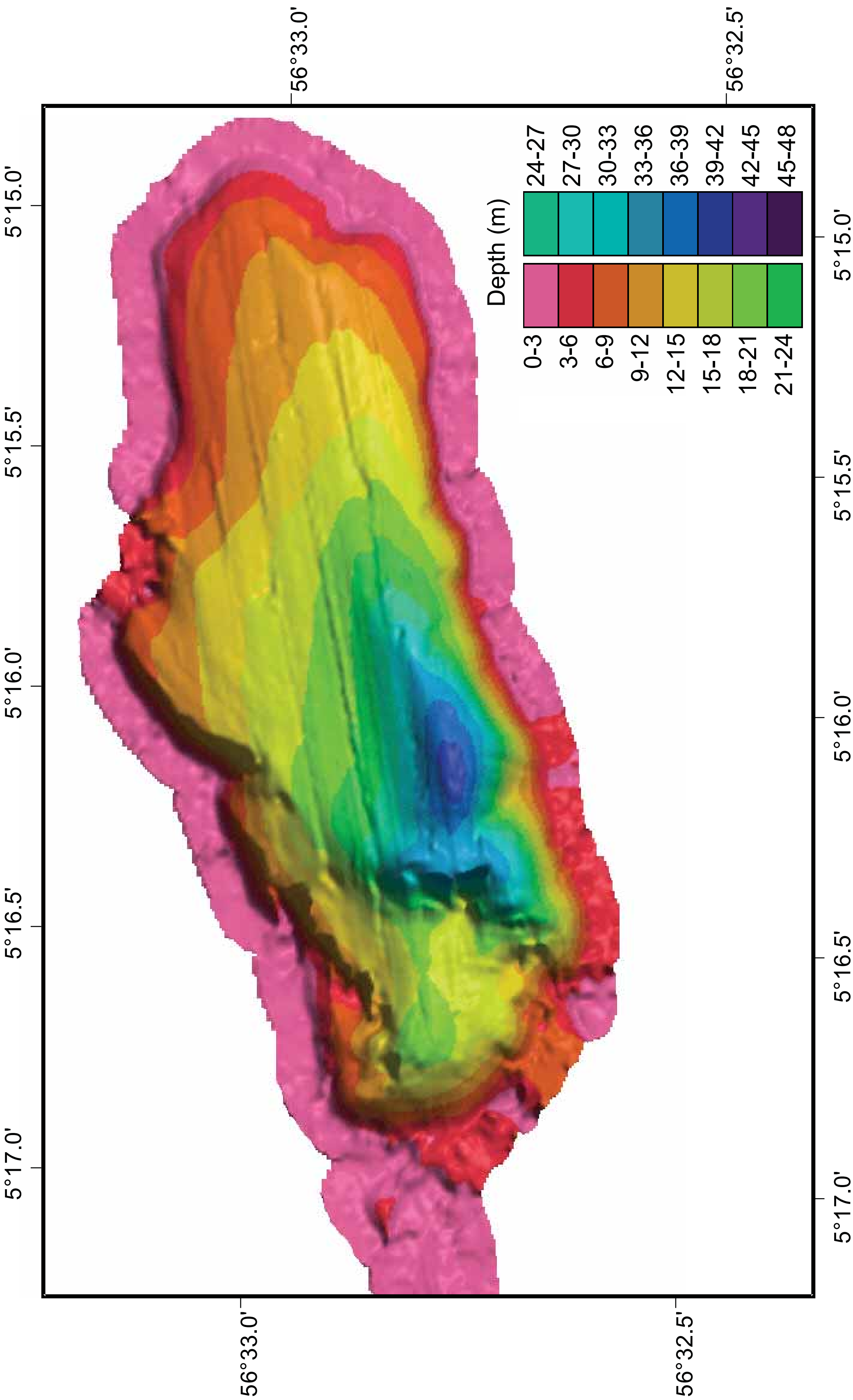
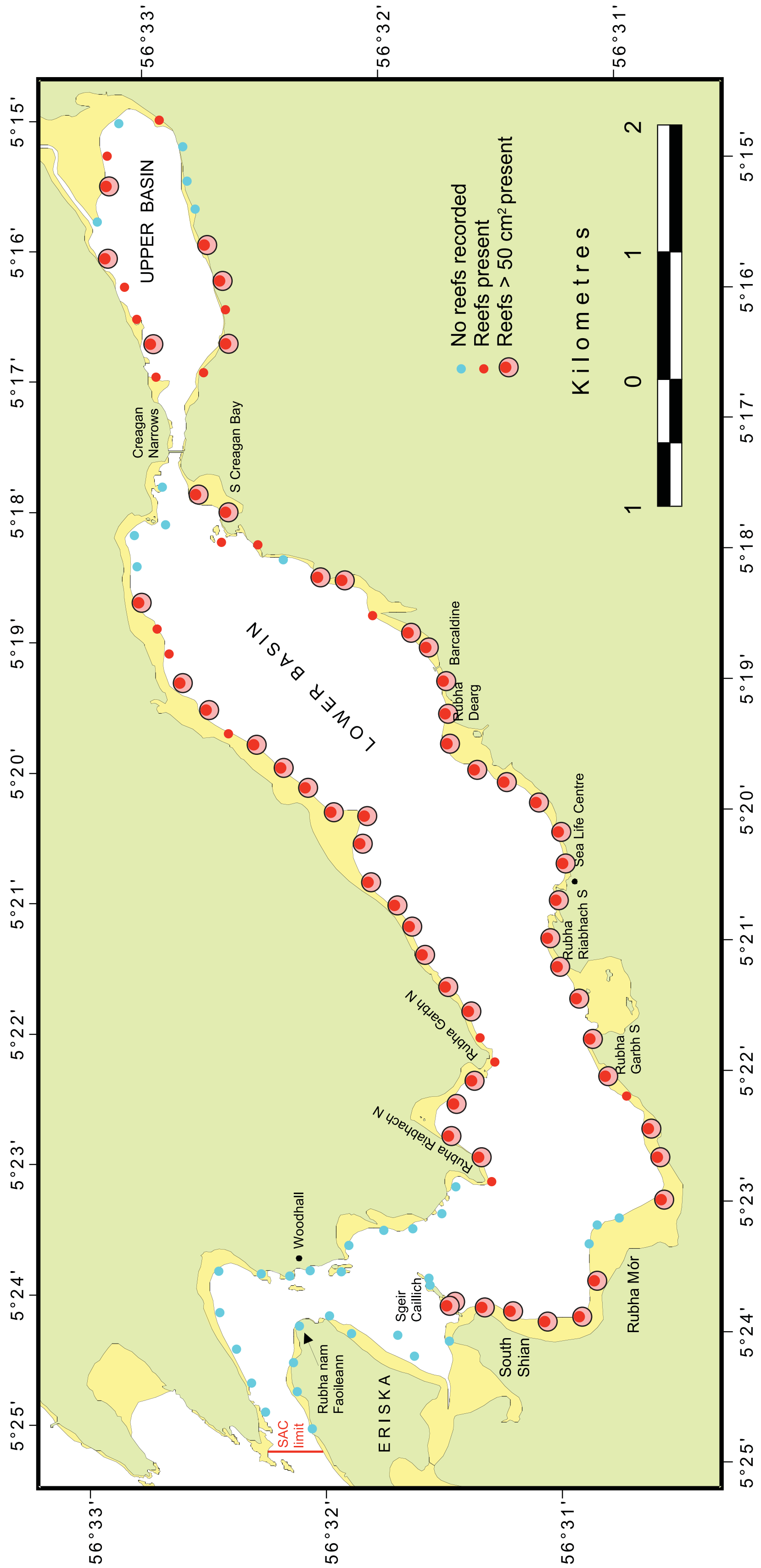


Figure 7 Presence of serpulid reefs and of just medium and large reefs (>50cm^2 plan area) along 110 transects around Loch Creran



apart from the presence of a small dense patch of around 0.21ha. The mosaic indicates that the shallow reef boundary off Rubha Mór occurs generally at 4–5m and the deep margin at around 10–11m. Evidence of extensive anthropogenic reef damage is revealed by sidescan in the form of single and twin parallel tracks of width c.3m (Figure 9). Diver and video groundtruthing reveals these tracks to consist of broken reef rubble material, presumably caused by scallop dredging.

South Shian

The reef band delineated in Figure 10 occupies an area of 4.36ha. The southeastern and northern limits of delineation are purely on the basis of sidescan coverage. Within the band of largely dense reefs there are some sharply defined areas lacking reefs. Particularly conspicuous are two patches near the northern limit of coverage (Figure 11), the larger one circular in shape with a diameter of c.35m and occupying 0.11ha, the smaller patch of 0.03ha but continuing northwards. Both patches are apparently accompanied by mooring weights and would appear to be caused by fishfarm activities. The sidescan image indicates a band width of around 120m is attained at this site, with the shallow margin generally between 4–5m. Towards the south of the area the deep reef margin lies between 10–12m, similar to that at the nearby Rubha Mór, but this margin reduces to around 7.5m closer to the fishfarm site, where a fairly linear boundary edge, despite the curving contours, and the apparent presence of mooring tackle possibly implicates the impact of previous anthropogenic impact in this area.

Sea Life Centre Bay

Sidescan identifies a band of reefs in this bay occupying 4.58ha (Figure 12). The band becomes much broader in the northeastern half of the bay, reaching a width of 130m, but distribution then ceases abruptly, being presumably influenced by freshwater from the stream, Dearg Abhainn, discharging into the loch at Rubha Dearg. The mosaic indicates the presence of dense reefs between depths of around 4–8m. Some boulder patches are present below the lower reef boundary (Figure 13). About 80m from the lower reef boundary dense trawl tracks are discernible on the sidescan image (Figure 13). Diver observations revealed these tracks to be troughs approximately 30cm wide and 10–15cm deep with the troughs supporting many specimens of the seapen, *Virgularia mirabilis*.

South Creagan

This bay is the smallest of the sites studied and consequently supports the smallest area of reefs. Reefs are clearly discernible on the sidescan image within an area of 0.59ha in a band about 150m in length by 40m wide (Figure 14). This represents the densest known area of reefs in the upper half of the loch above Barcaldine. The vertical distribution of reefs is comparatively shallow with the lower margin closely following the 6m contour. The shallow margin is less distinct: reefs clearly become much sparser above 4m, although scattered reefs are present to 2.5m. The sidescan image provides no evidence of anthropogenic reef damage.

The mosaiced sidescan images presented in Figures 8–14 were generated by Seetrack software. Mosaics were also produced using Sonarweb and an example is shown in Figure 15 for the South Shian area. Sonarweb was found to produce mosaics that were well-balanced in terms of contrast and brightness but lacked the detail necessary for mapping. This is shown by a comparison of Figures 10 and 11 (Seetrack) with Figure 15.

Figure 8 Sidescan mosaic of Rubha Mór showing video groundtruth observations and depth contours. Reef band delineated by orange pecked line

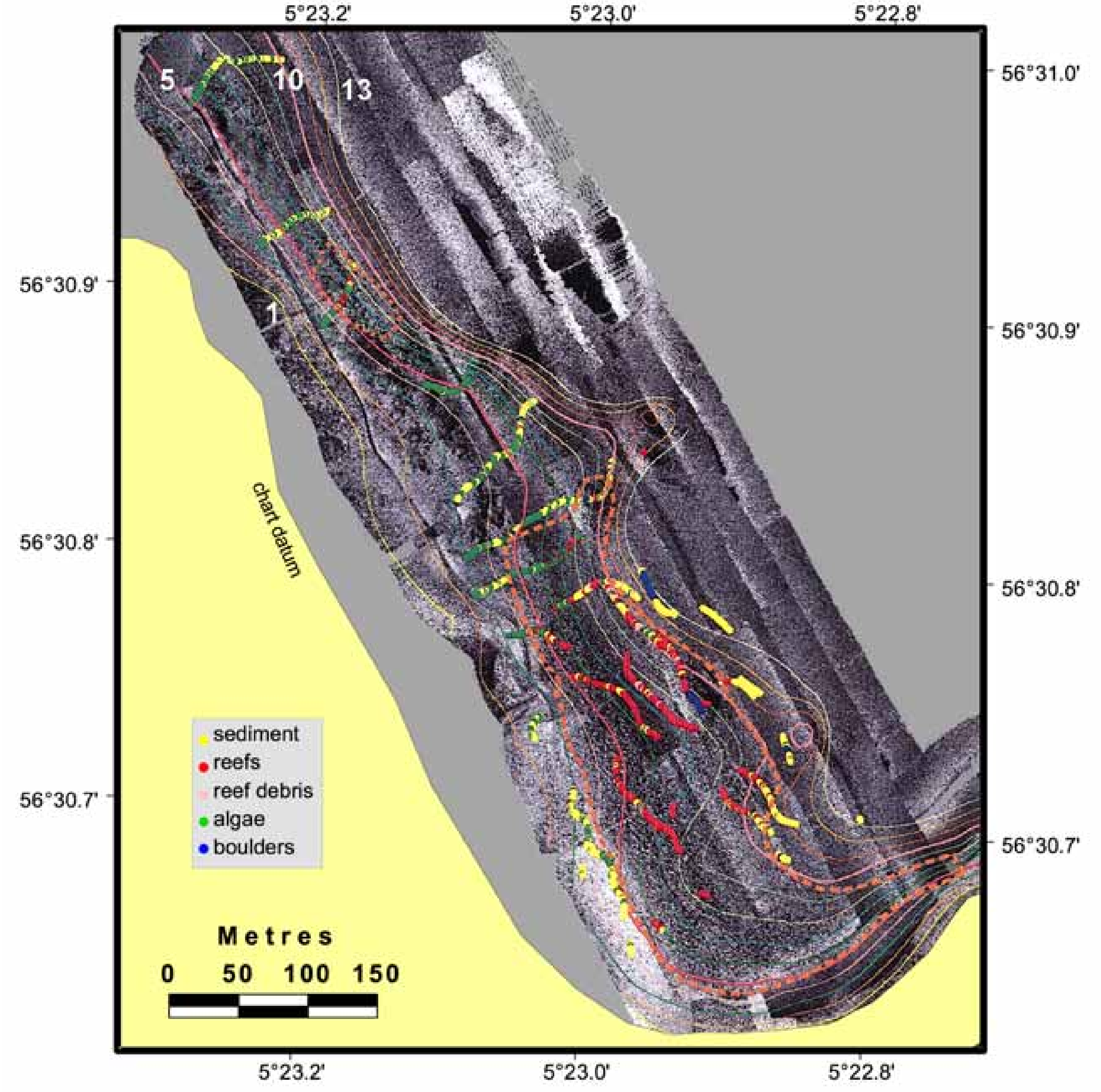


Figure 9 Selected area of sidescan mosaic of Rubha Mór showing video groundtruth observations, depth contours and dredge tracks (arrowed). Reef band delineated by orange pecked line

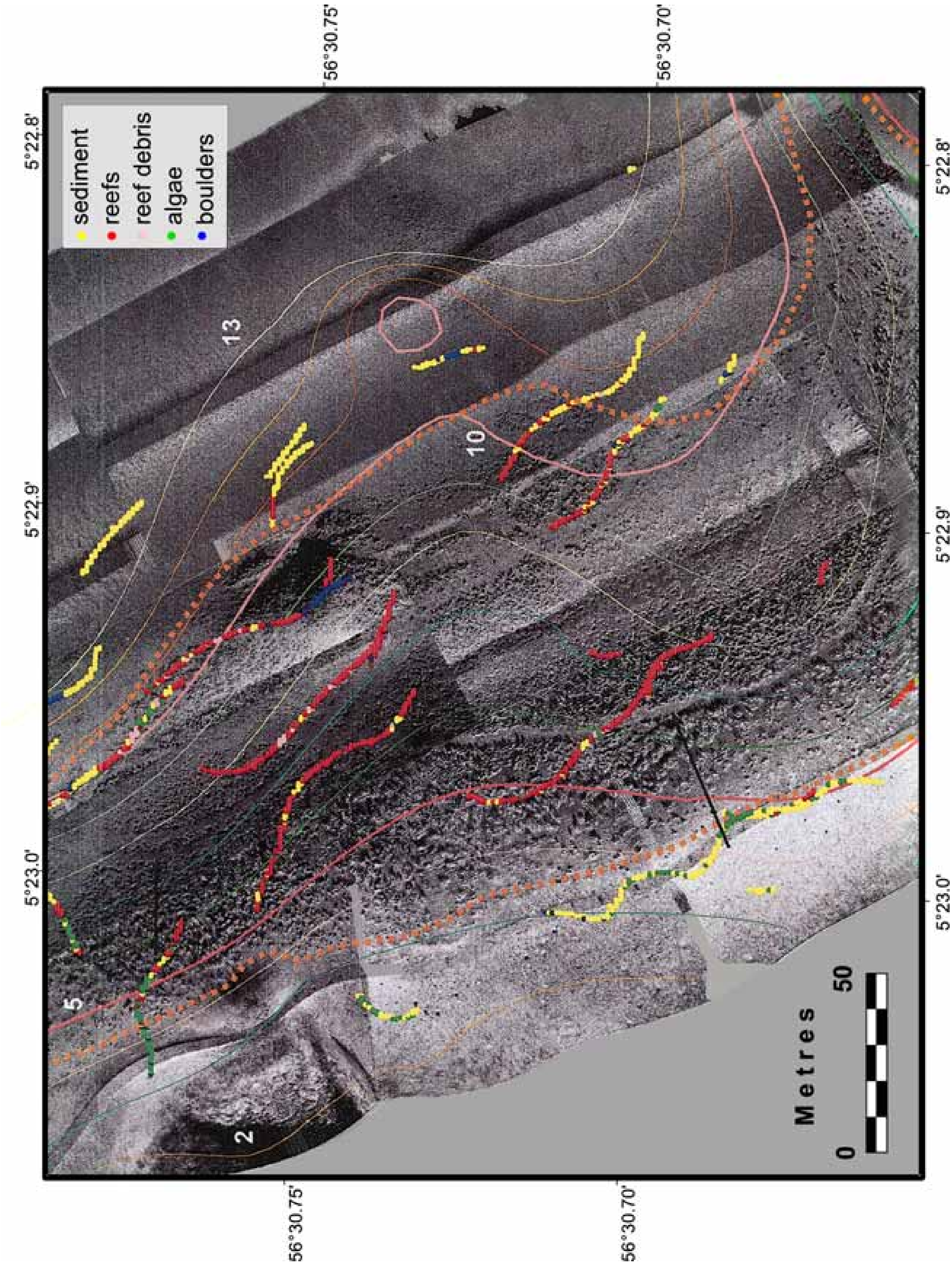


Figure 10 Sidescan mosaic of South Shian showing video groundtruth observations and depth contours. Reef band delineated by orange pecked line

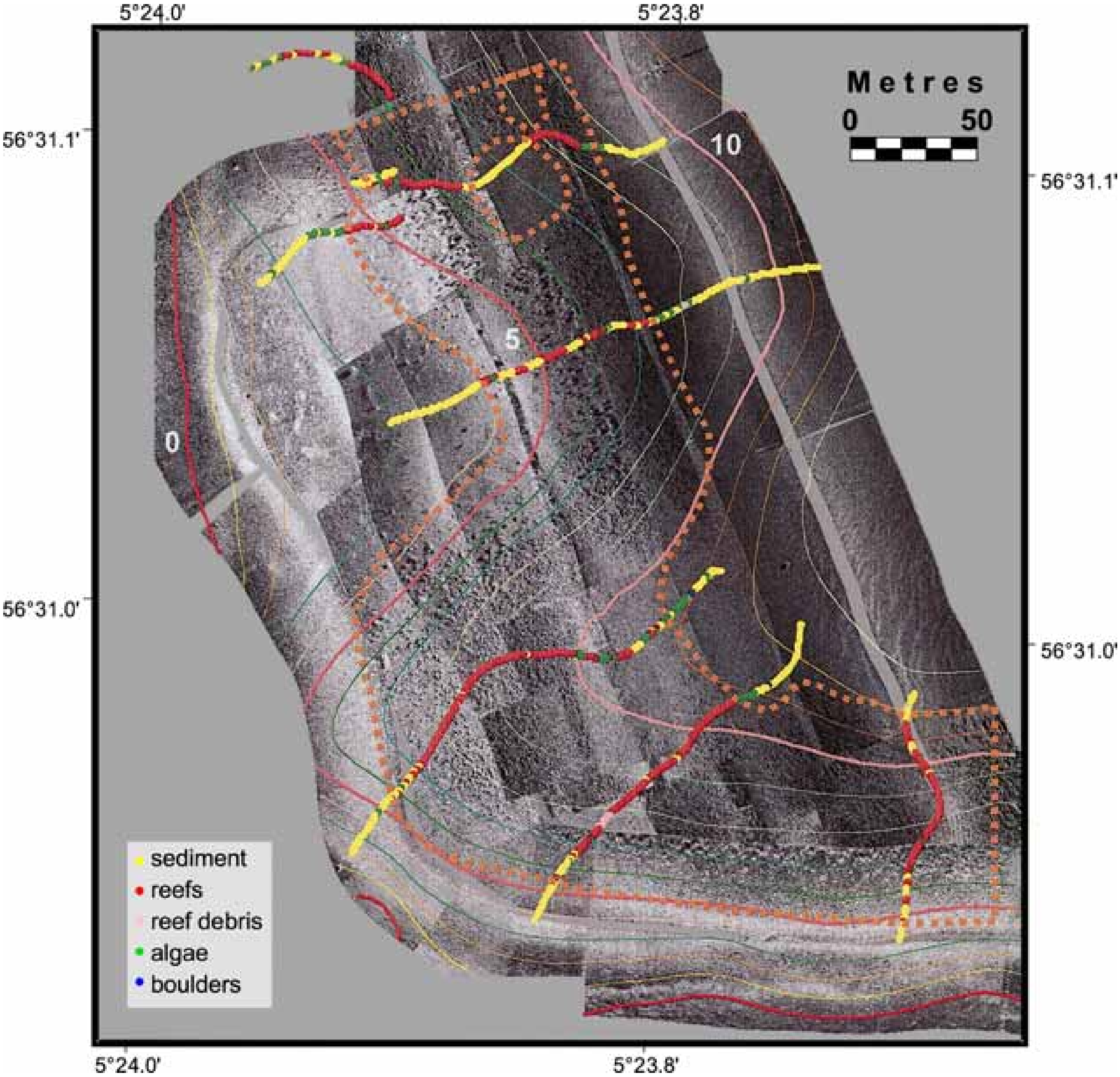


Figure 11 Selected area of sidescan mosaic of South Shian showing video groundtruth observations and depth contours. Reef band delineated by orange pecked line. Note the large reef-impoverished areas near the top of the image

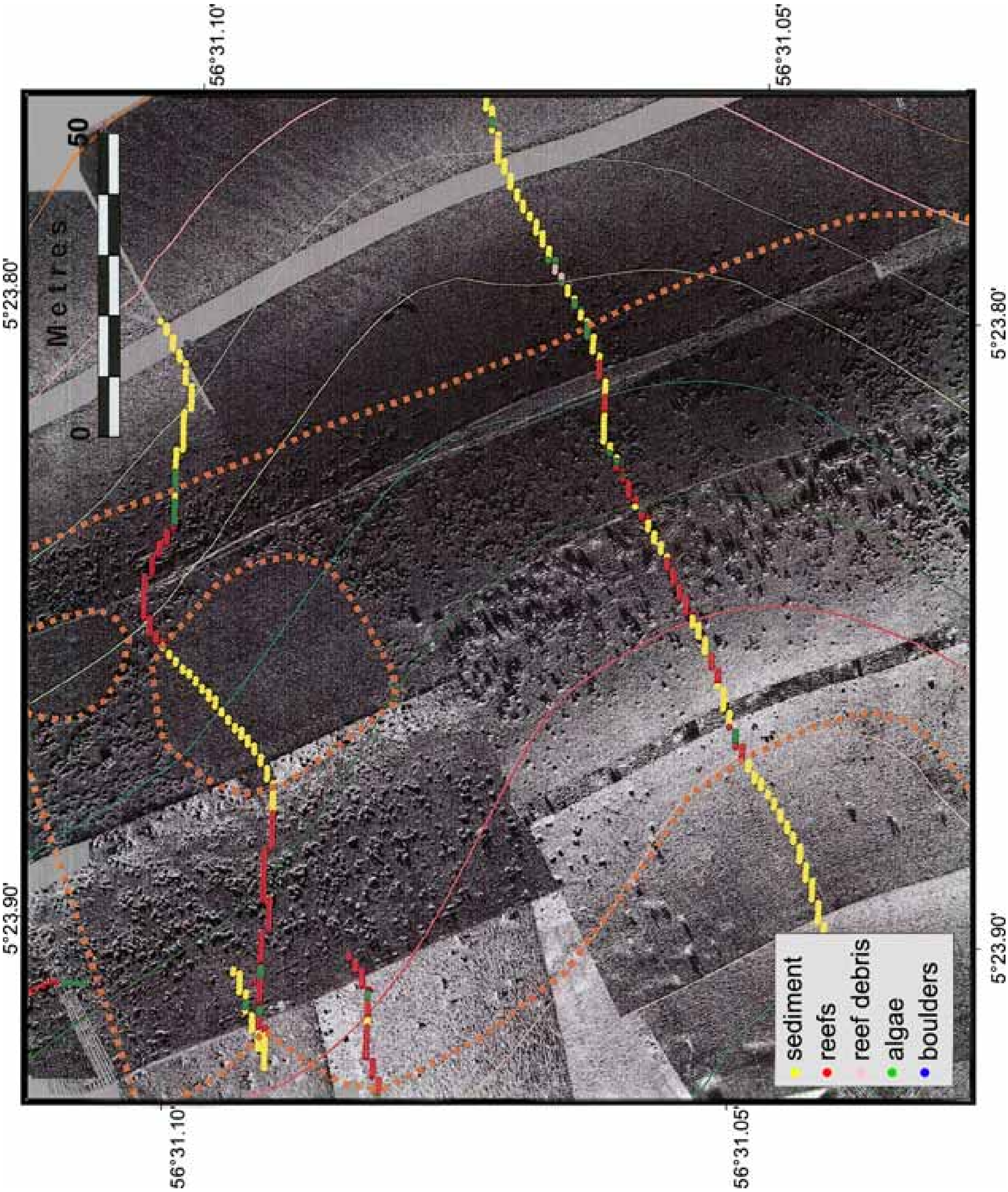


Figure 12 Sidescan mosaic of Sea Life Centre Bay showing video groundtruth observations and depth contours. Reef band delineated by orange pecked line

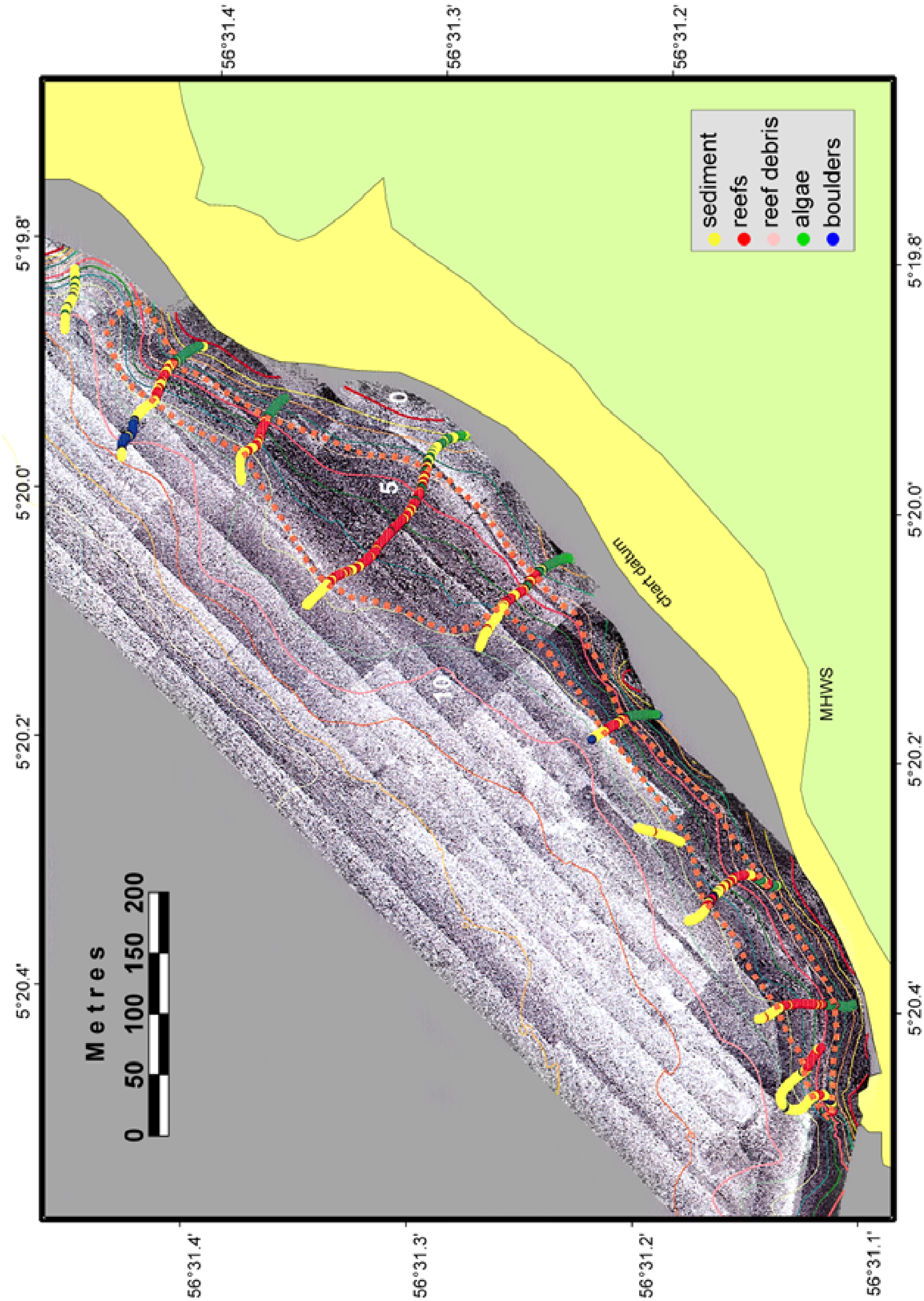


Figure 13 Selected area of sidescan mosaic of Sea Life Centre Bay showing video groundtruth observations and depth contours. Reef band delineated by orange pecked line. Note the dense trawl tracks in the top lefthand corner of the image

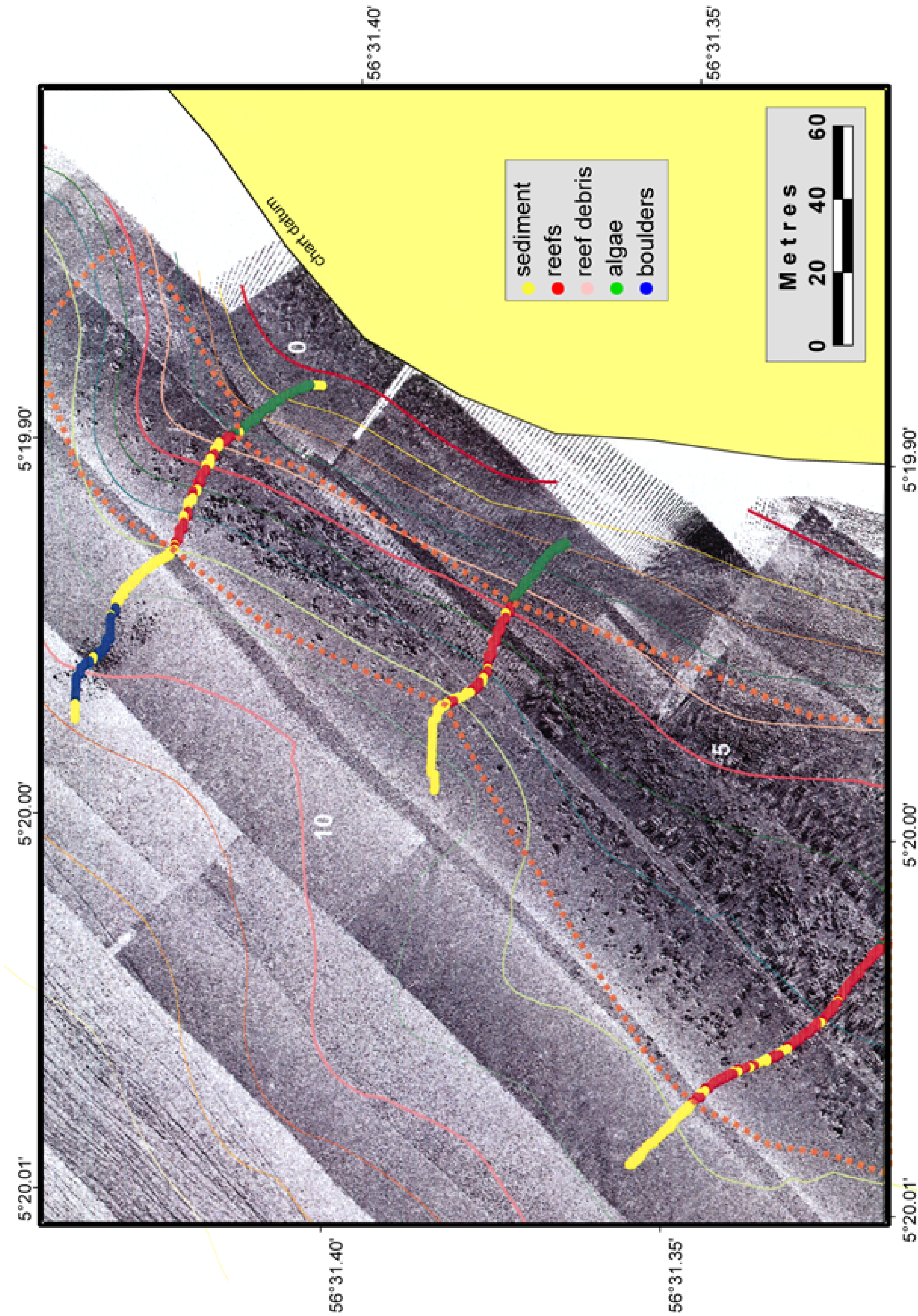


Figure 14 Sidescan mosaic of South Creagan Bay showing video groundtruth observations and depth contours. Reef band delineated by orange pecked line

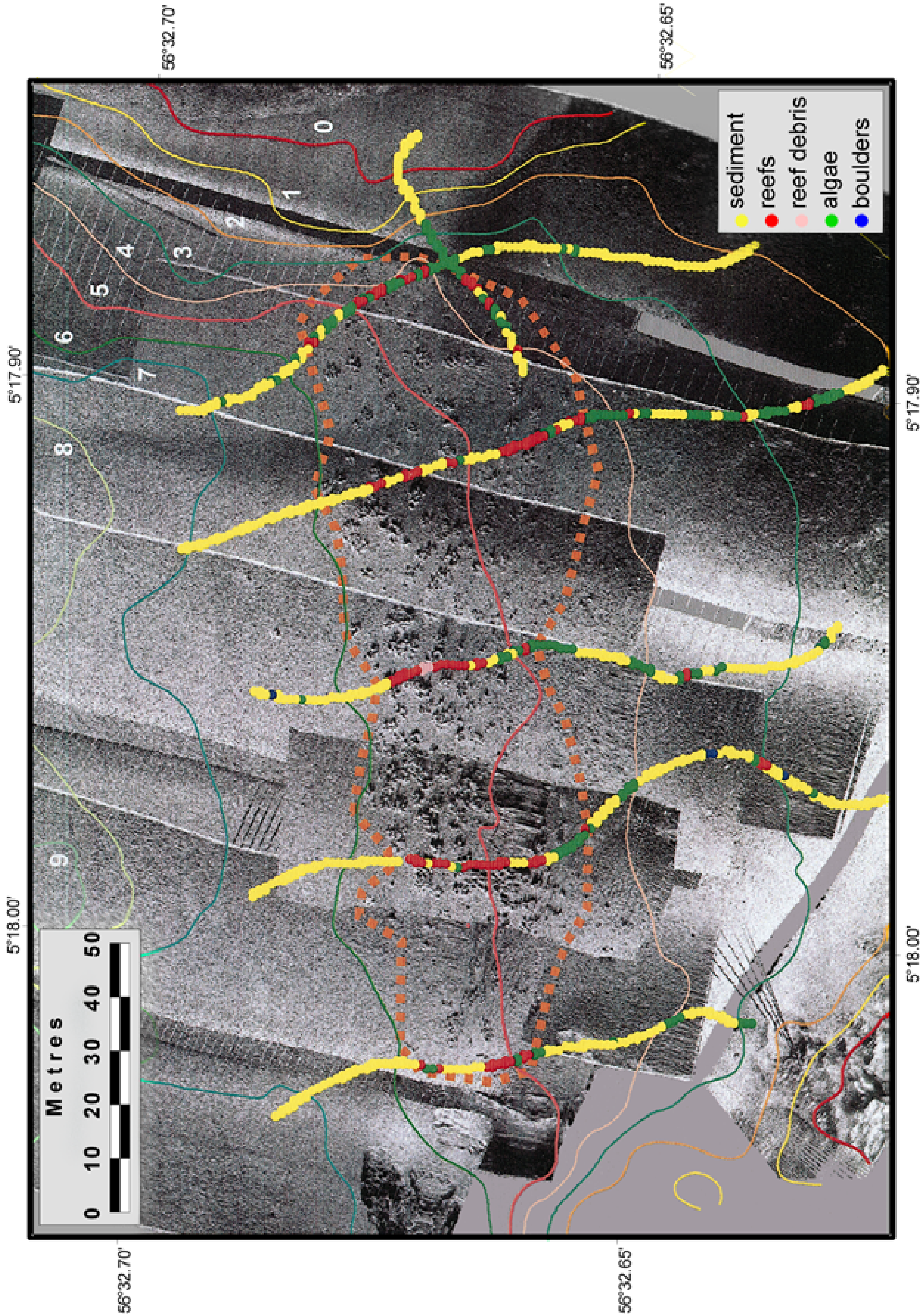


Figure 15 Sidescan sonar mosaic of South Shian produced by Sonarweb software. The serpulid reef band is discernible by the lighter, stippled texture. The pecked line delineates the band as identified from the Seetrack software mosaic

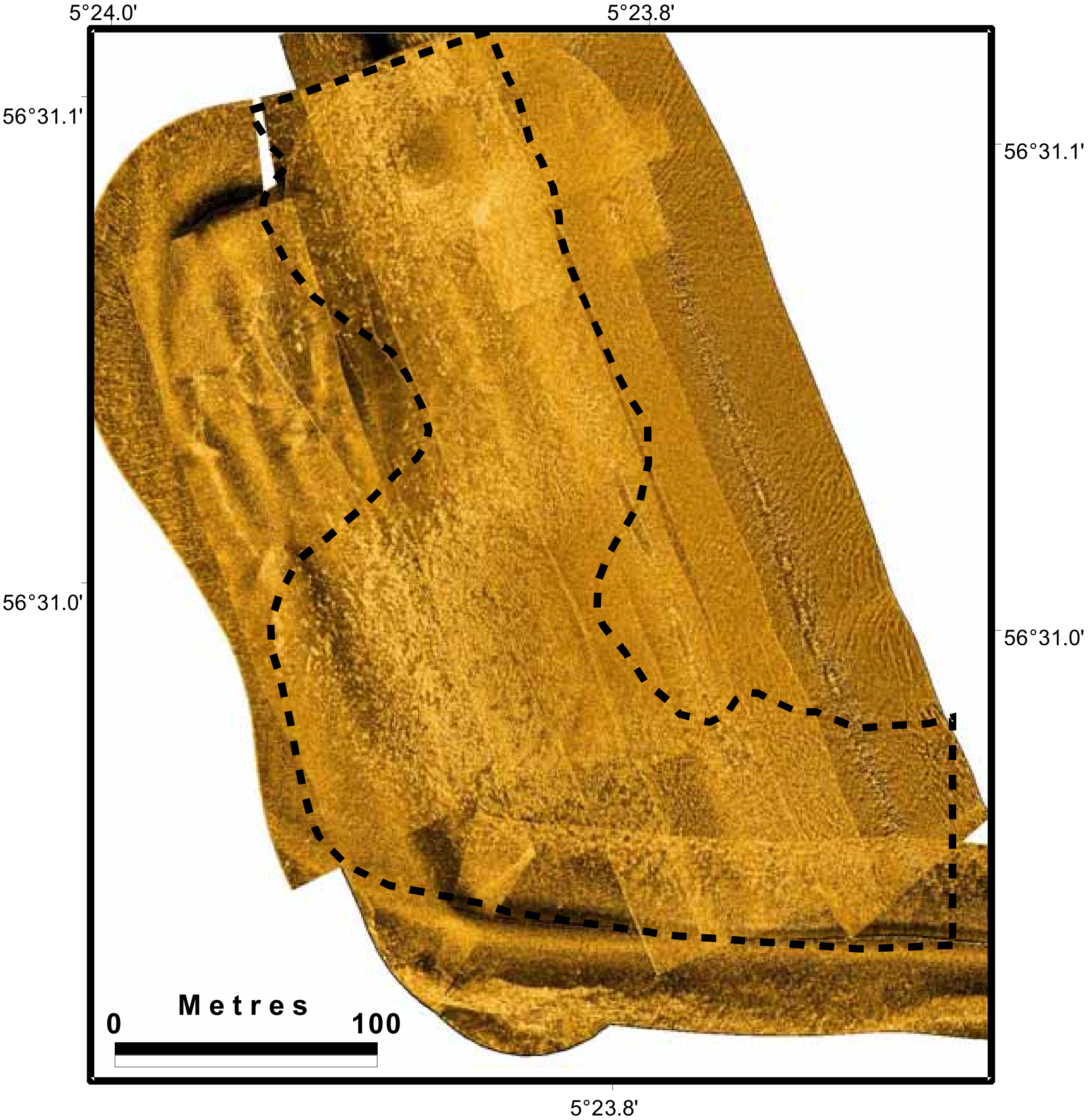


Figure 16 Distribution of serpulid reefs (all reefs and reefs >50cm^2 plan area) in Loch Creran, based on records from 110 diver transects

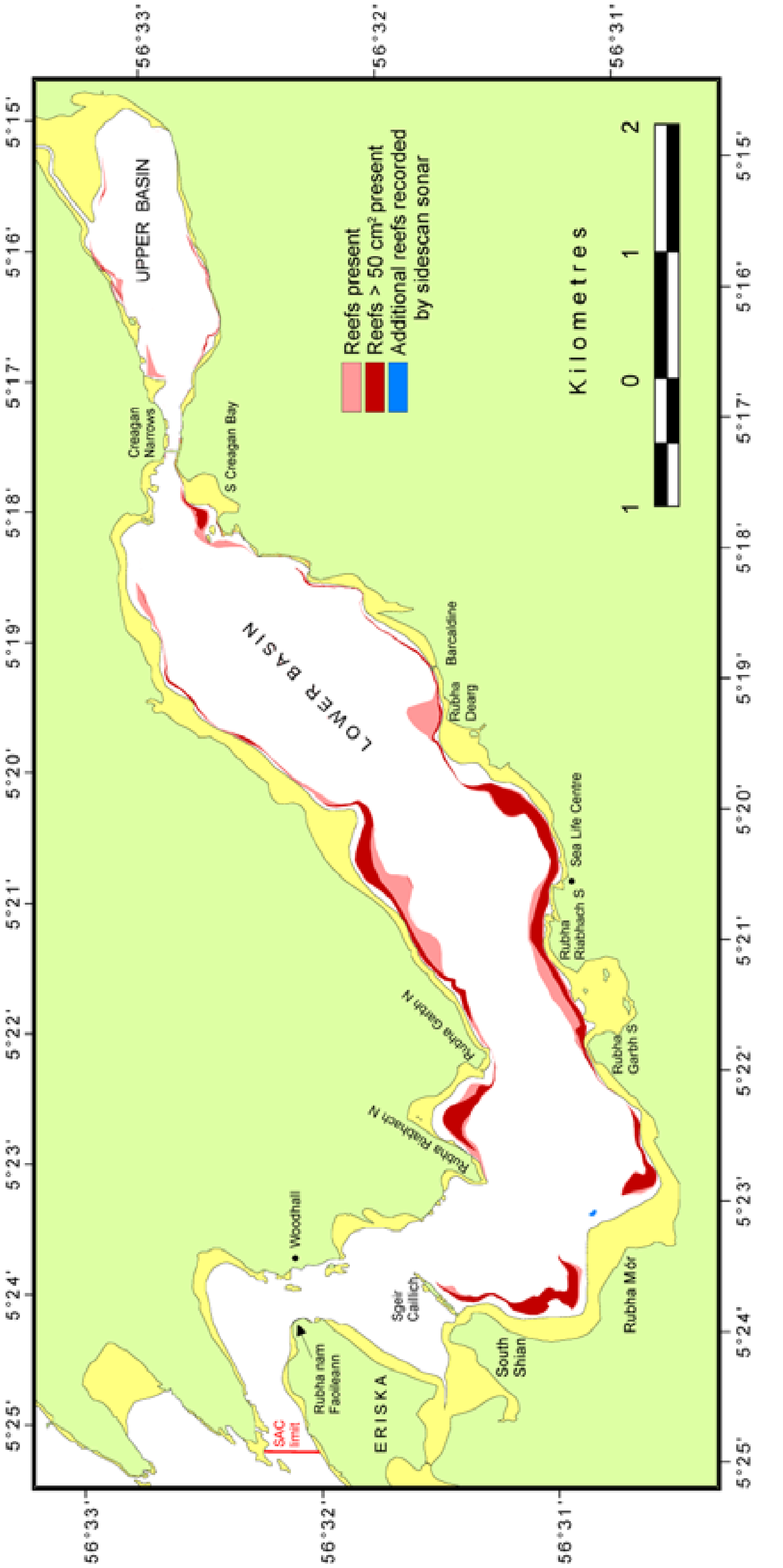
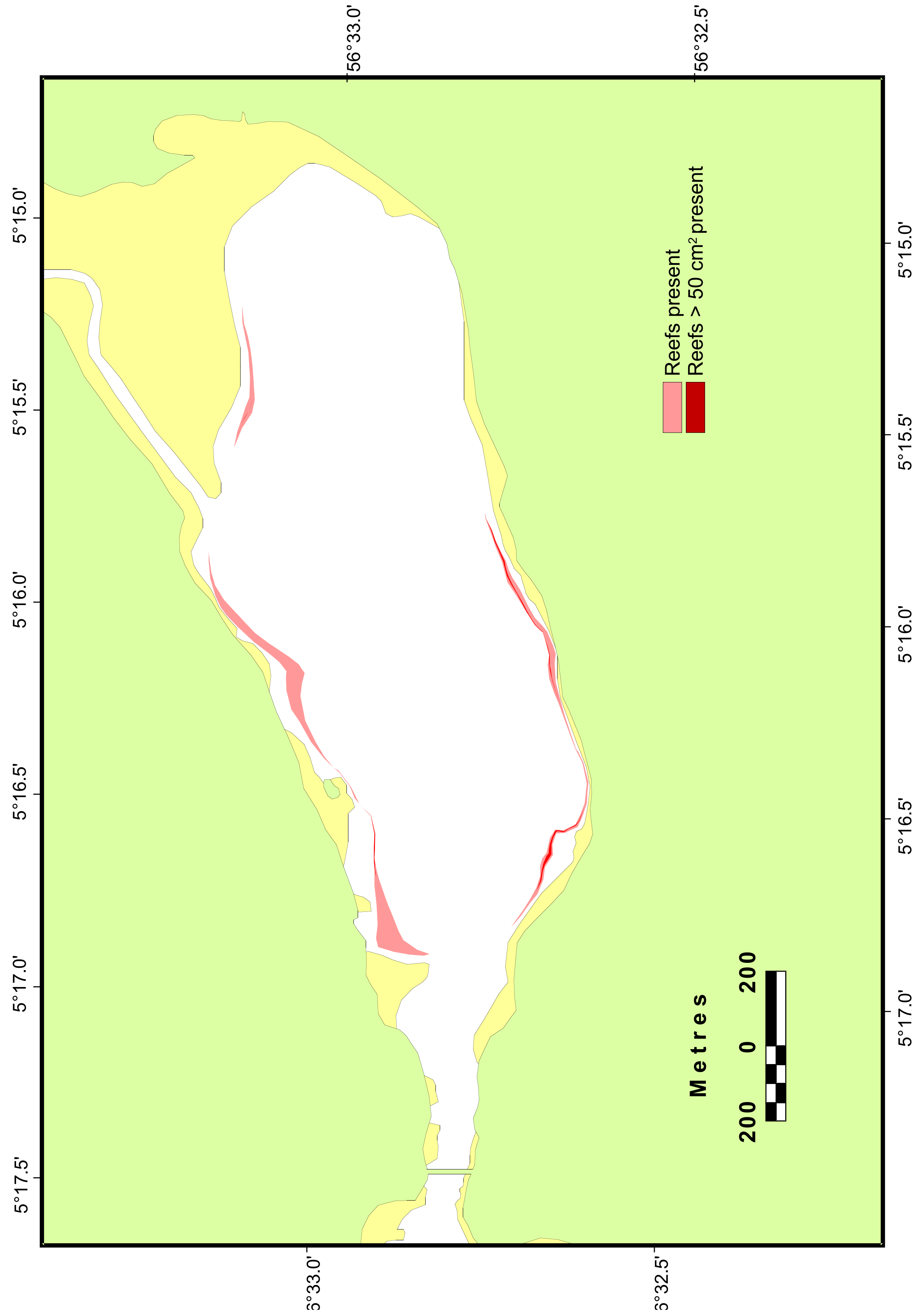


Figure 17 Distribution of serpulid reefs (all reefs and reefs >50cm^2 plan area) in the upper basin of Loch Creran, based on records from 18 diver transects



3.2.2.2 Diver video density survey

Table 3 shows the percentage cover of the seabed by serpulid reefs along each of the 10 replicate transects at the four study sites. Oneway analysis of variance shows that mean cover at the sites is highly significantly different ($p<0.001$) and a *posteriori* Tukey tests show a trend of increasing density with passage down the loch. Density is significantly lower in South Creagan Bay (mean, 2.8%) than all other sites and is lower in Sea Life Centre Bay (8.9%) than Rubha Mór (14.3%) or South Shian (16.9%), which are not significantly different.

Table 3 Percentage cover of the seabed by serpulid reefs along 10 replicate video transects at four sites

Replicate	Rubha Mór	South Shian	Sea Life Centre	South Creagan
1	12.82	14.11	12.34	5.11
2	8.58	10.03	8.81	2.29
3	14.64	21.55	10.17	3.65
4	3.71	16.10	11.13	3.31
5	18.37	22.54	8.19	2.13
6	17.76	19.03	3.79	2.46
7	18.51	17.70	13.97	1.79
8	19.18	25.15	6.08	3.11
9	16.20	9.85	2.97	2.78
10	12.83	12.76	11.53	1.32
mean	14.26	16.88	8.90	2.80

3.2.2.3 Biotope community survey

Table 4 summarises the physical and principal biological characteristics of the sedimentary area surrounding serpulid reefs at the four study sites, whilst the detailed SACFOR species abundance information is presented in Table A3.

As is typical for the loch, the reefs at three of the sites have developed in an area of muddy sand. The bay at South Creagan is the most wave sheltered of these sites and, although the transect is somewhat shallower than the other sites, this shelter is reflected in the muddier sediment. The diver observation of lower serpulid cover at this site (Table 4) is in agreement with the results of the video quantification study. A common feature of all sites is the brown diatomaceous film covering the sediment, in which the polychaete, *Melinna palmata*, is generally a dominant species. Species richness appears to be similar at three of the sites (31–34 taxa), with rather fewer taxa (23) recorded at South Shian.

The detailed presence / absence records of taxa found on 10 reefs at each of the four sites are given in Tables A4–A7. These data are summarised in terms of frequency of occurrence in Table 5, which also shows the total number of taxa recorded and the mean species richness per reef at each site.

Species richness differs significantly between sites (Kruskal-Wallis test, $p=0.001$). The Sea Life Centre Bay reefs have significantly greater species richness (mean no. taxa, 15), than both the Rubha Mór and South Creagan reefs, with respective mean richness values of 11.5 and 10.6 (*a posteriori* Kruskal-Wallis q test, $p<0.05$).

Table 4 Summary of MNCR phase 2 surveys of the sedimentary areas at four serpulid reef sites

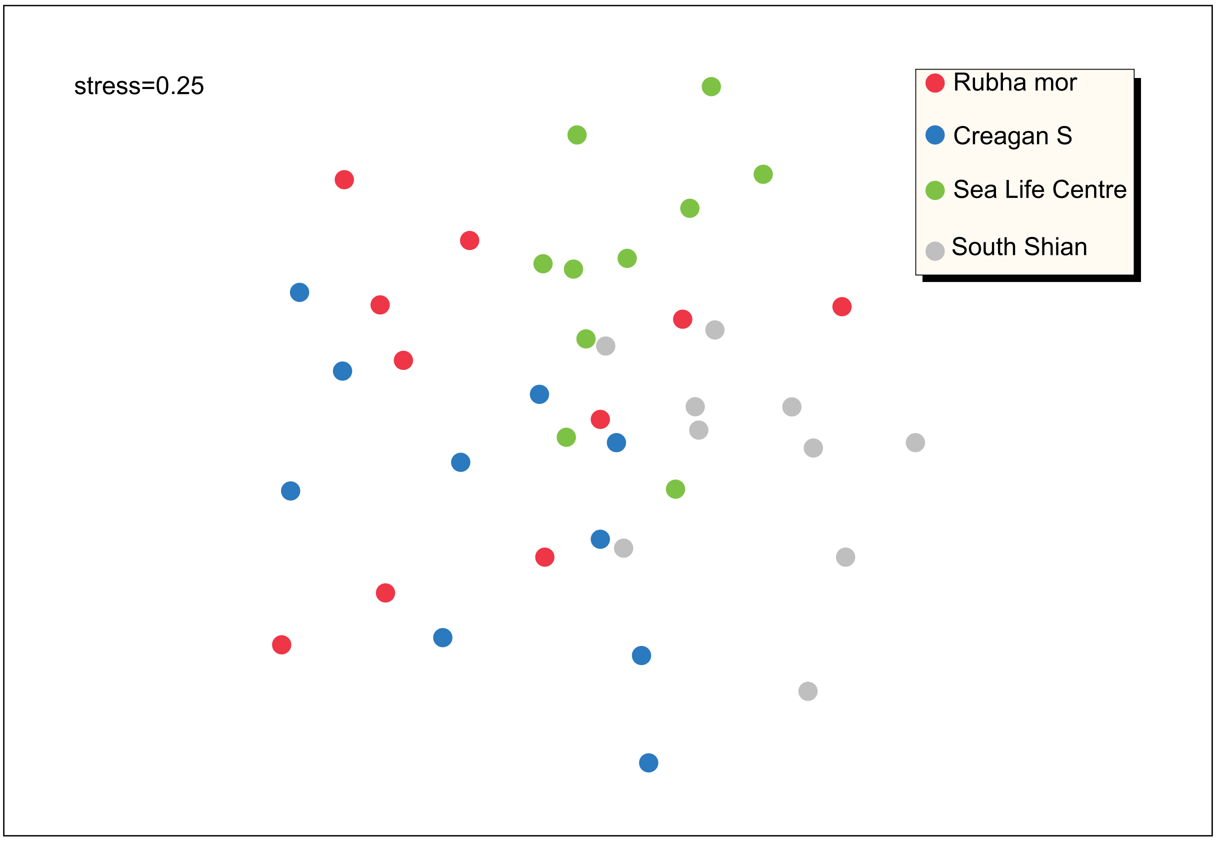
Site	Depth transect start (m)	Depth transect end (m)	Bearing (°T)	Substrate	Main biota	Notes
Rubha Mór LC05SV01	7.6	8	324	Muddy sand with shell gravel (especially *Serpula* tube debris) and scattered pebbles	Brown diatomaceous film and casts of *Melinna palmata*	General area with ~50% reef cover; most of the sediment likely to be directly influenced by neighbouring reefs.
South Shian LC05SV02	7.7	7.8	199	Firm muddy sand	Brown diatomaceous film, *Virgularia* & infaunal polychaetes	
Sea Life Centre LC05SV03	6.6	6.5	114	Muddy sand with pebbles (10–20%) and serpulid tube fragments (10–20%)	Brown diatomaceous film, infaunal polychaetes and scattered *Pyura*	Reefs in the area have been subject to damage by movement of aquaculture cages & groundlines. Consequently, many fragmented serpulid tubes on sediment surface providing refuge & substrate for a wider range of biota than might otherwise be present on the sediment.
South Creagan LC05SV04	5.7	6.1	24	Slightly sandy mud with serpulid tube fragments & shells (5–10%)	Brown diatomaceous film, *Amphiura filiformis*, infaunal polychaetes and scattered *Philine* & *Modiolus*	Reefs in more widely separated clumps with less overall cover than other sites. Also sediment appeared finer and with lower proportion of shells and pebbles.

The multidimensional scaling analysis in Figure 18 compares reef communities in terms of species composition. This shows much overlap in species composition towards the centre of the plot, although there does appear to be some grouping of replicates according to provenance. This is confirmed by the ANOSIM test which indicates a significant difference in composition between all sites (p=0.001). However, few species show marked differences between sites, except *Ectocarpaceae* indet., which was only common at South Shian and *Diplosoma listerianum* only common in Sea Life Centre Bay. *Antedon bifida* was only recorded at South Creagan. *Ophiothrix fragilis* and *Pyura microcosmus* were recorded on every reef at every site (Table 5).

Table 5 Frequency of occurrence of taxa on 10 serpulid reefs at four sites

Taxa	Rubha Mór	South Shian	Sea Life Centre	South Creagan
Esperiopsis fucorum	3	1	5	0
Haliclona cinerea	0	1	0	0
Kirchenpaueria pinnata	4	7	10	2
Obelia dichotoma	7	10	10	9
Eupolymnia nebulosa	9	10	10	10
Pomatoceros spp.	1	0	1	3
Protula tubularia	0	0	4	3
Caridea indet.	0	1	0	0
Pagurus bernhardus	1	0	4	4
Galathea spp.	3	2	1	0
Munida rugosa	1	2	0	0
Porcellanidae indet.	0	0	1	0
Hyas araneus	0	0	2	0
Inachus sp.	0	0	3	0
Macropodia	3	1	2	0
Liocarcinus depurator	2	5	2	0
Necora puber	1	0	1	1
Gibbula cineraria	0	1	0	0
Calliostoma zizyphinum	0	1	0	0
Buccinum undatum	0	1	1	0
Chlamys varia	7	8	7	10
Arctica islandica	0	1	0	0
Antedon bifida	0	0	0	2
Henricia sanguinolenta	0	2	0	0
Asterias rubens	5	3	4	3
Ophiothrix fragilis	10	10	10	10
Psammechinus miliaris	6	9	10	9
Clavelina lepadiformis	1	0	0	0
Diplosoma listerianum	0	1	9	1
Ciona intestinalis	4	2	4	4
Corella parallelogramma	0	0	1	4
Ascidiella aspersa	0	0	1	1
Ascidia mentula	7	10	10	5
Ascidia virginea	4	5	6	3
Pyura microcosmus	10	10	10	10
Gobiesocidae sp.	0	1	0	0
Syngnathus acus	0	0	1	0
Pholis gunnellus	1	0	0	0
Pomatoschistus minutus	1	2	3	0
Pomatoschistus pictus	3	0	4	0
Rhodophyceae indet. (filamentous)	9	7	9	6
Ceramium sp.	0	0	1	0
Phycodrys rubens	10	2	3	3
Ectocarpaceae indet.	0	9	0	0
Desmarestia aculeata	1	0	0	0
Laminaria saccharina	1	1	0	3
Total no. taxa	27	30	32	22
Mean no. taxa/reef	11.5	12.6	15.0	10.6

Figure 18 Non-metric multidimensional scaling ordination of 10 serpulid reefs from four sites based on presence/absence data of associated biota



3.3 *Modiolus* beds

3.3.1 Peripheral distribution survey

Figure 19 and Table A2 show the maximum abundance of *Modiolus* recorded by divers along the 110 peripheral transects around the margin of the loch. *Modiolus* was observed on 60 transects (55%) with a distribution from the mouth to the head of the loch. Although mostly present in low density (occasional or rare), areas of high density were recorded in the low currents of the upper basin, and at several sites subject to strong current action in the lower basin, especially just below Creagan Narrows and in the entrance channel around Eriska Island. These findings informed the selection of suitable sites for *Modiolus* abundance monitoring.

Figure 19 Maximum abundance of *Modiolus* on the SACFOR scale recorded by diver along 110 transects

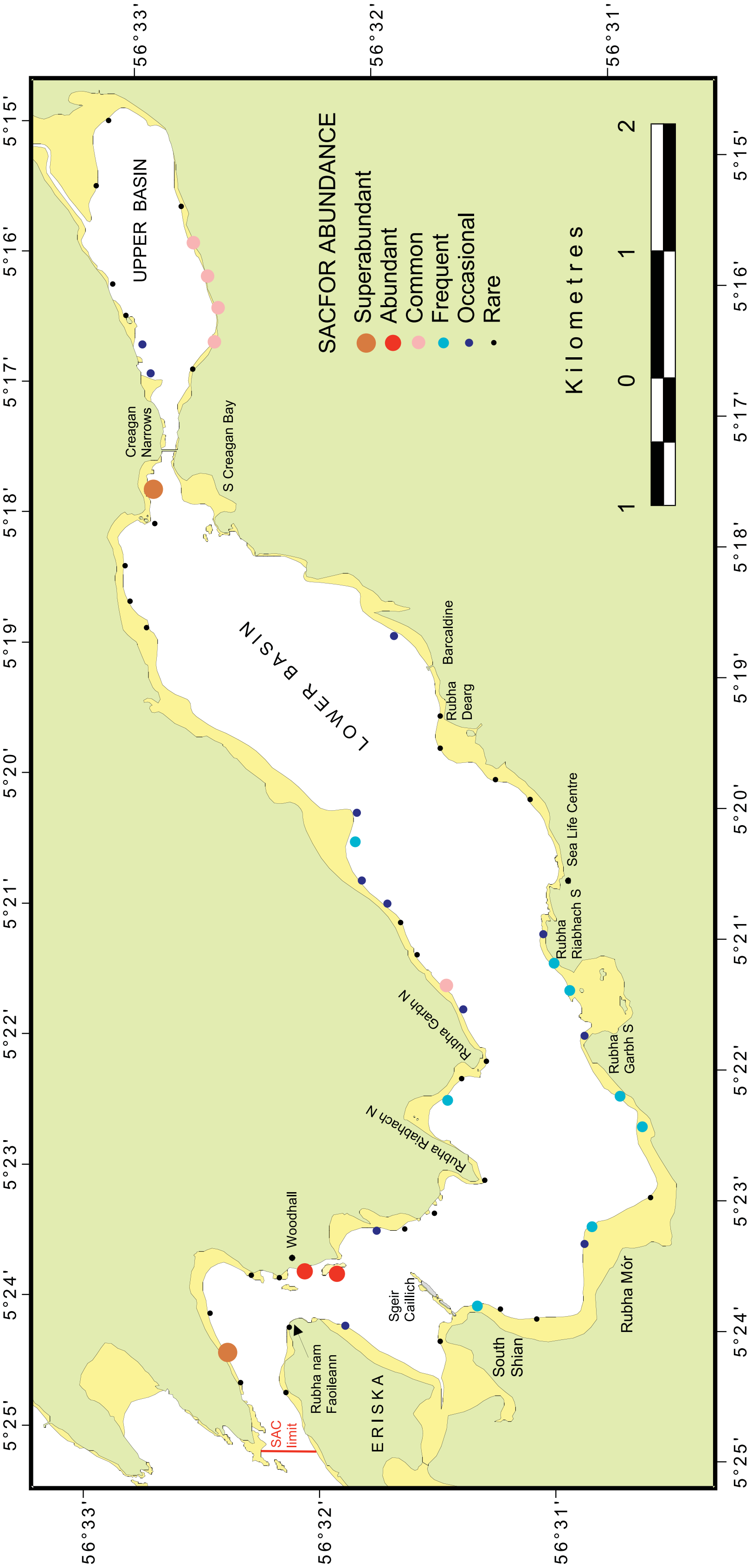


Table 6 Mean percentage cover of the seabed by live *Modiolus modiolus* along four transects in the upper basin (on left) and three transects in the lower basin (on right)

Transect	Station	Depth (m)	% cover
LC05MM01	0	5.5	1.88
LC05MM01	1	8.4	3.75
LC05MM01	2	11.5	10.63
LC05MM01	3	15.5	13.75
LC05MM01	4	20.9	11.25
LC05MM01	5	26.8	3.13
LC05MM02	0	6.5	5.63
LC05MM02	1	11.6	8.13
LC05MM02	2	16.2	7.50
LC05MM02	3	20.1	6.88
LC05MM02	4	23.1	5.00
LC05MM02	5	25.3	2.50
LC05MM02	6	26.9	0.00
LC05MM03	0	4.8	0.00
LC05MM03	1	9.8	4.38
LC05MM03	2	15.3	10.00
LC05MM03	3	21.6	6.88
LC05MM03	4	25	3.75
LC05MM04	0	7.5	0.63
LC05MM04	1	13	7.50
LC05MM04	2	18.5	8.75
LC05MM04	3	26.3	0.63
LC05MM04	4	29	0.00

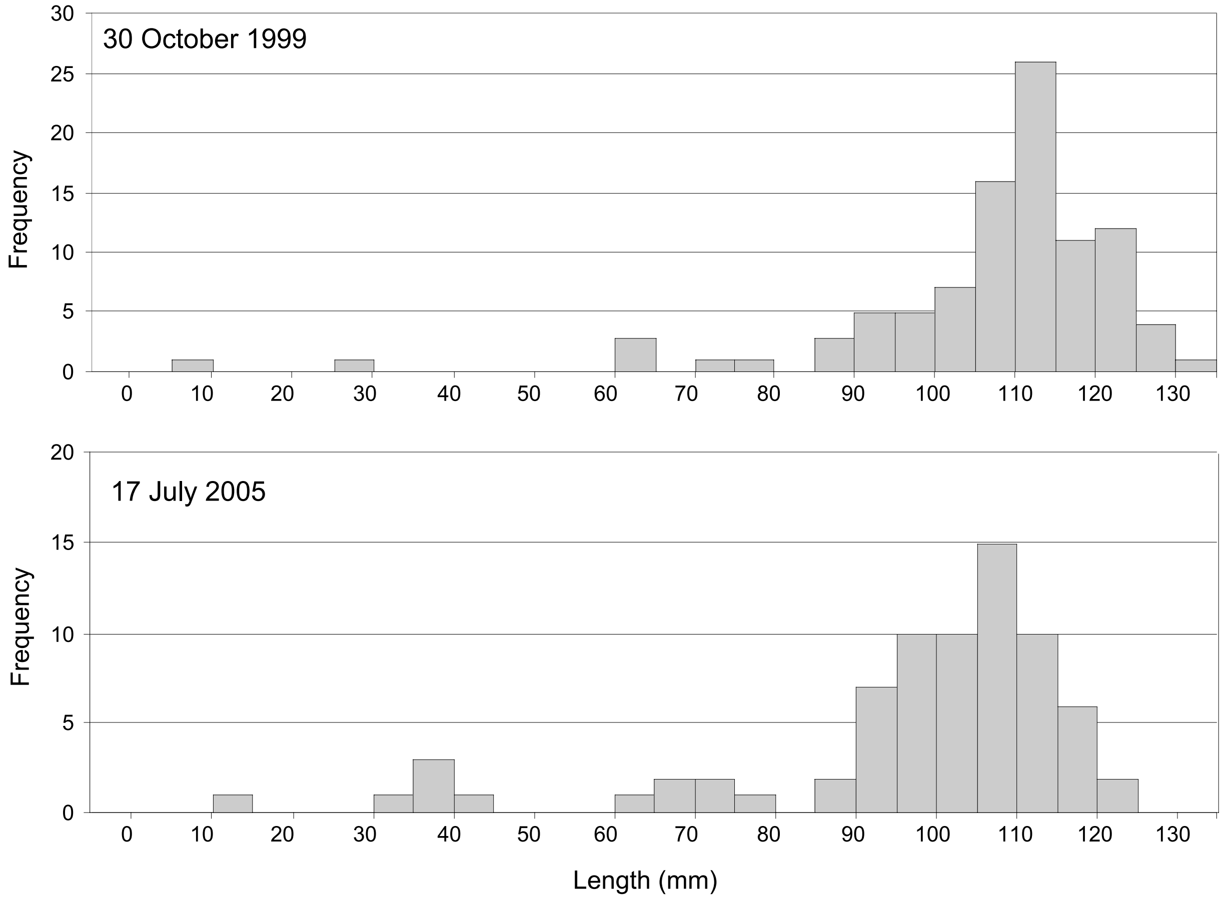
Transect	Station	Depth (m)	% cover
LC05MM05	0	5.2	3.13
LC05MM05	1	7	33.75
LC05MM05	2	8.6	30.63
LC05MM05	3	10.5	26.88
LC05MM06	0	10.1	0.00
LC05MM06	1	11.3	0.00
LC05MM06	2	14.3	17.50
LC05MM06	3	18.4	2.50
LC05MM06	4	21.9	3.75
LC05MM06	5	25.5	4.38
LC05MM07	0	9.5	1.88
LC05MM07	1	12.6	10.00
LC05MM07	2	13.7	1.25
LC05MM07	3	15.9	3.75
LC05MM07	4	17.1	0.63
LC05MM07	5	19.4	0.00
LC05MM07	6	22.8	0.00
LC05MM07	7	22.9	0.00

3.3.2 Detailed studies at major sites

3.3.2.1 Density survey

The density of *Modiolus* was assessed along seven transects as percentage cover based on quadrat string intersection counts and the raw data are presented in Table A8. Table 6 shows the resulting cover estimates. *Modiolus* is widely distributed along the upper basin transects (LC05MM01–4), only being unrecorded from three of the 23 sites. Maximum density is achieved between 10–20m, with transect LC05MM01 near the centre of the bed displaying the highest coverage figures (maximum 14%). However, the highest values for the loch as a whole were obtained in the shallow, current-swept area below Creagan Narrows (LC05MM05), where coverage reached 34%. Here, the mussels were found to be overlain by a dense carpet of brittlestars, *Ophiothrix fragilis*. The two current-swept transects near the mouth of the loch (LC05MM06–7) displayed maximum coverage values similar to those of the upper basin.

Figure 20 Length frequency distribution of *Modiolus* collected from the upper basin of Loch Creran in 1999 (Mair *et al.* 2000) and in 2005 (current study)



3.3.2.2 Population structure

Figure 20 illustrates the length frequency analysis based on a sample of 74 *Modiolus* from station 3 on transect LC05MM01. The population is strongly dominated by large *Modiolus* (85–125mm), probably at least 11 years of age (Mair *et al*. 2000). Recruitment appears to have been very poor for many years, with very small numbers of younger age groups.

3.3.2.3 Biotope community survey

The abundance of taxa recorded during the MNCR phase 2 survey at station 3 on transect LC05MM01 is shown in Table A9. Live *Modiolus* was abundant, particularly in clumps, although dead *Modiolus* shells made up the majority of the hard substrates, which were scattered on muddy sand. The *Modiolus* shells supported a sessile fauna dominated by serpulid tubeworms, barnacles, ascidians and hydroids, which were accompanied by a vagile component including abundant *Asterias rubens* and *Ophiothrix fragilis*. The biotope can be ascribed to SBR.SMus.ModHAs. 58 taxa were recorded.

The species composition of the community associated with four *Modiolus* clumps from the same site is given in Table A10. This laboratory analysis of material retained on a 0.5mm sieve recorded a total of 174 taxa with each clump supporting 88–104 species (Table 9).

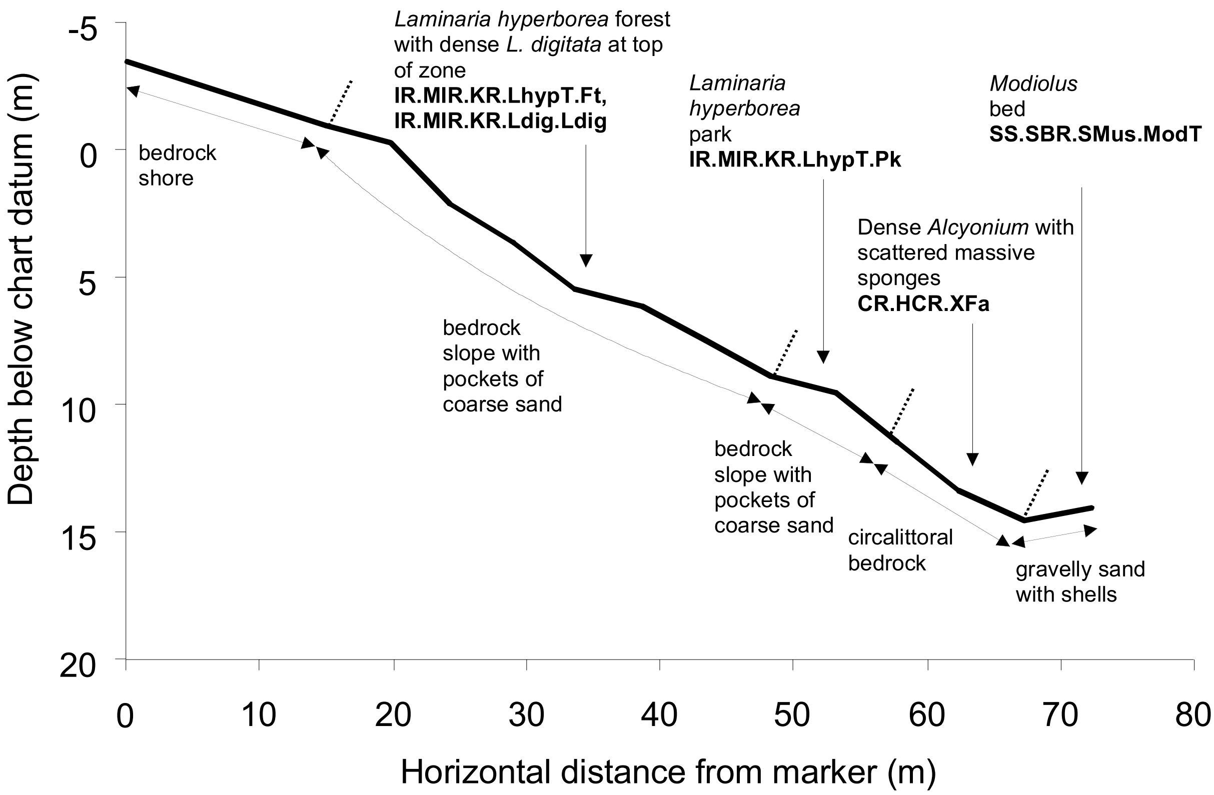
The three lower basin *Modiolus* transects ran through tideswept areas of mixed coarse sediment (gravel, pebbles, cobbles and shell). At Creagan (LC05MM05) the *Modiolus* supported a dense cover of *Ophiothrix fragilis*. At the mouth of the loch (LC05MM06) the associated community included hydroids, *Alcyonium* and *Alcyonidium* and at Woodhall (LC05MM07) hydroids, *Alcyonium*, *Antedon* and ascidians. All three sites can be referred to the tideswept *Modiolus* biotope, SBR.SMus.ModT.

3.4 Rocky reef MNCR phase 2 surveys

3.4.1 Woodhall

The transect was located close to the southern end of a rocky islet swept by strong currents of around 3kt in the entrance channel of Loch Creran and consequently is only available for study during slack water (Figure 2). The physical details and species abundances along the transect are given in Tables A11 and A14 respectively, and summarised in Figure 21.

Figure 21 Woodhall rocky reef transect profile with summary of the substrates, dominant biota and biotopes recorded within the component zones

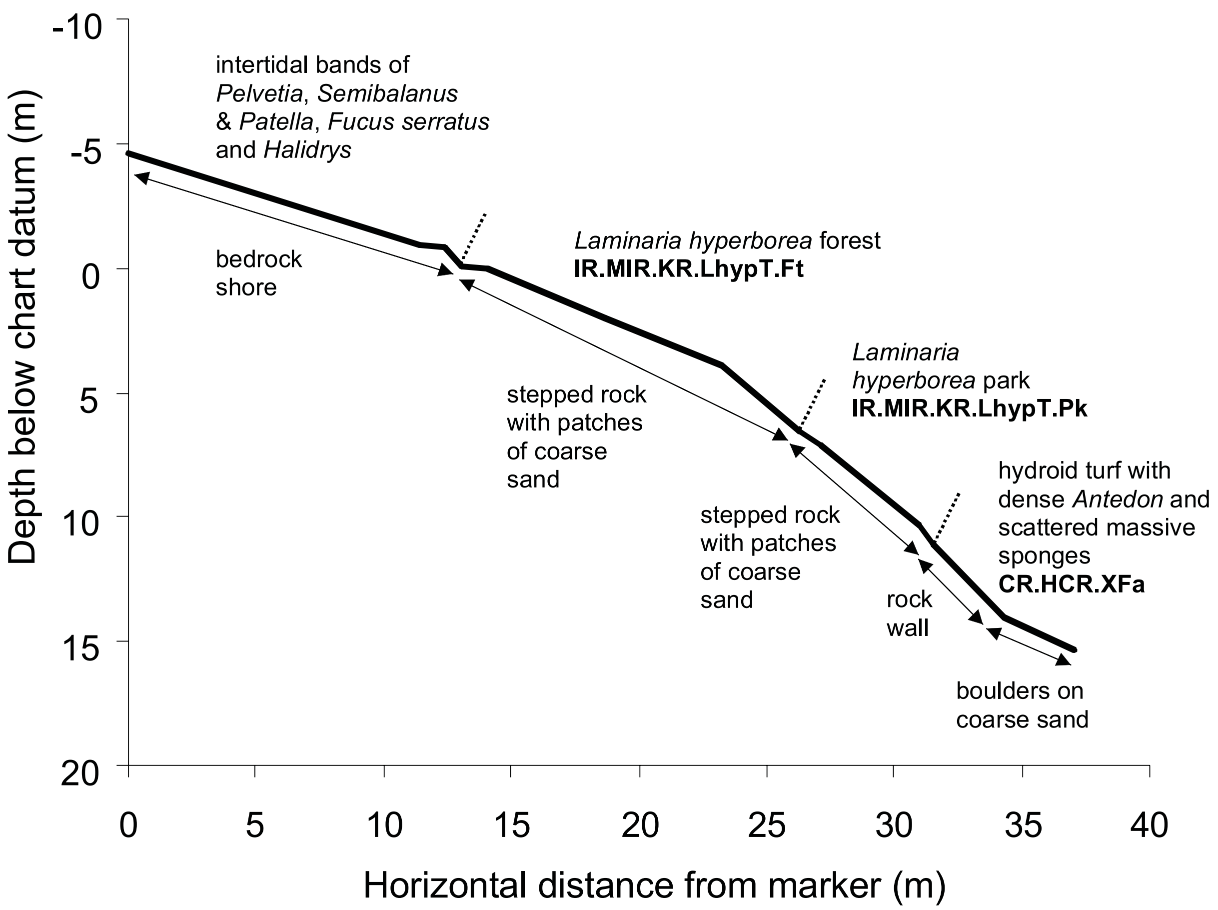


A narrow band of dense *Laminaria digitata* (IR.MIR.KR.Ldig.Ldig) gives way to a forest of *Laminaria hyperborea* on a bedrock slope with pockets of coarse sand (IR.MIR.KR.LhypT.Ft). The kelp stipes support a dense red algal flora, especially *Delesseria sanguinea* and *Membranoptera alata*, and harbour profuse growths of the bryozoan, *Alcyonidium hirsutum*, which reaches 15cm in length. Beneath the forest the rock supports abundant *Ophiocomina nigra* and a red algal turf of around 30% cover, which includes as dominant species, *Cryptopleura ramosa*, *Plocamium catilagineum* and *Phycodrys rubens*. At around 9m the forest thins out to a park with the kelp stipes still supporting dense *A. hirsutum*, a profuse red algal flora, with *D. sanguinea* dominant, and didemnid ascidians (IR.MIR.KR.LhypT.Pk). The underlying red algal turf is reduced to around 15% but *O. nigra* becomes superabundant. Below 11.4m the kelp is lost and the assemblage becomes dominated by animals, especially *Alcyonium digitatum* (superabundant in patches), *O. nigra* and hydroids, particularly *Nemertesia* spp., *Halecium halecinum* and *Abietinaria abietina* (CR.HCR.XFa). This circalittoral zone also supports large growths of the sponges, *Pachymatisma johnstoni* and *Clione celata*, although colonies of the latter were just outwith the transect band. At around 14.5m the rock gives way to a *Modiolus* bed on coarse gravely sand. Although live *Modiolus* is common here, there is a preponderance of dead shells supporting barnacles and a hydroid turf (SS.SBR.SMus.ModT). 76 taxa were recorded along the transect.

3.4.2 Rubha nam Faoileann

This site is only about 250m from the Woodhall reef but lies on the opposite shore at the north-eastern tip of Eriska Island (Figure 2). The physical details and species abundances along the transect are given in Tables A12 and A15 respectively, and summarised in Figure 22.

Figure 22 Rubha nam Faoileann rocky reef transect profile with summary of the substrates, dominant biota and biotopes recorded within the component zones

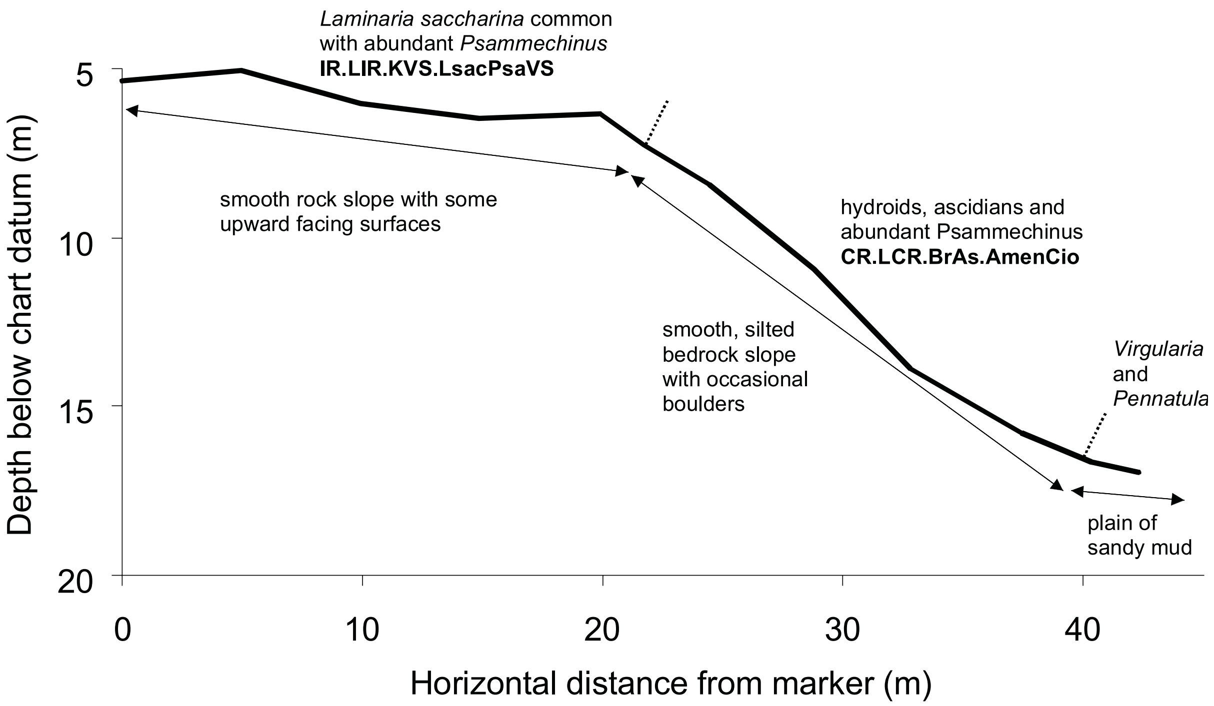


The site probably experiences similar current conditions to Woodhall reef and exhibits a similar range of biotopes, although the profile is significantly steeper. Down to 11.2m the subtidal substrate is largely steep, stepped rock with pockets of coarse sand. Above 6.6m the rock supports a dense forest of *Laminaria hyperborea*, whose stipes are clothed in dense red algae, especially *Delesseria sanguinea*, and didemnids, dominated by *Tridemnum cereum* (IR.MIR.KR.LhypT.Ft). Beneath the forest is a dense red algal turf (70% cover) dominated by *Heterosiphonia plumosa*. Below 6.6m the forest thins to a park, with a 30–40% red algal turf including *D. sanguinea* and *Plocamium catilagineum* (IR.MIR.KR.LhypT.Pk). The dense brittlestars of the Woodhall site are replaced here by several other abundant echinoderms, *Crossaster papposus*, *Asterias rubens* and *Antedon bifida*, which is superabundant in patches. Below 11.2m and extending to about 14m is a steep rock wall, which supports a similar fauna-based community to that present on boulders beneath the wall. A rich hydroid turf is dominated by *Hydrallmania falcata* and *Nemertesia* spp. and is accompanied by a turf of superabundant *A. bifida*. Large colonies of *Pachymatisma johnstoni* are scattered over this zone (CR.HCR.XFa). 70 taxa were recorded along the transect.

3.4.3 Rubha Riabhach S

The transect runs down a bedrock slope at the north-eastern end of an uncharted rock outcrop off Rubha Riabhach S (Figure 2). The physical details and species abundances along the transect are given in Tables A13 and A16 respectively, and summarised in Figure 23.

Figure 23 Rubha Riabhach S rocky reef transect profile with summary of the substrates, dominant biota and biotopes recorded within the component zones



The outcrop is not uncovered at low tide, having a minimum depth of around –3m. Current action will be slight in this area and the communities more typical of subtidal rocky habitats in the loch than the previous two sites. From the start of the transect at –5.4m the predominantly undulatory smooth rock surface extends for a distance of 20m before reaching the top of a smooth rock slope at –6.4m. To a depth of –7.3m *Laminaria saccharina* is common and the fauna is strongly dominated by abundant (locally superabundant) *Psammechinus miliaris*, which may explain the bare appearance of the rock surface (IR.LIR.KVS.LsacPsaVS). Below 7.3m the rock slope continues to a depth of 16.7m and is covered by a dusting of silt. *Echinus esculentus* is common here, *Psammechinus* is still abundant, and the rock retains its generally bare appearance, although there is a scattering of hydroids and ascidians (particularly *Ascidiella aspersa*, *Ascidia mentula* and *Pyura microcosmus*. The zone can be referred to the biotope, CR.LCR.BrAs.AmenCio. At 16.7m the base of the slope meets a plain of sandy mud with scattered seapens, *Virgularia mirabilis* and *Pennatula phosphorea*. 47 taxa were recorded along the transect.

4 DISCUSSION

Where data permits, the condition and indications of temporal change of the biogenic and rocky reef habitats of the loch are discussed below. They are also summarised in a draft Site Attribute Table for the reef feature in Loch Creran (Table A17).

4.1 Serpulid reefs

No previous estimates of the spatial extent of serpulid reefs in Loch Creran are available, although an index measure of extent can be derived from the 1994 survey by Moore *et al*. (1998). Of 50 transects surveyed for reefs around the periphery of the loch, serpulid reefs were present at 34 (68%), a figure close to that for the 2005 survey (66%). However, the 1994 transects were not uniformly spread around the loch and so will not be as representative as the current survey. The transect band width was also narrower in 1994 and so in the absence of major differences in estimates between years, it can only be concluded that the comparison of these surveys provides no evidence for a temporal change in extent between these years. In theory, an estimate of the extent of the habitat could be derived from the AGDS survey of Black *et al*. (2000), but the level of intensity of groundtruthing and possible difficulties in separating the acoustic signatures of other habitat types, such as scattered boulders, invalidates this approach.

Localized loss of extent through anthropogenic activities has certainly taken place in Loch Creran, although it is difficult to quantify. A dredge track off Rubha Mór was first discovered by the first author whilst diving on 6 December 1998 and some preliminary sidescan work by Heriot-Watt University on 3–4 February 2001 revealed their widespread nature. Systematic coverage of the area using the same system (Klein 3000) as in 2005 was carried out on 5–8 July 2004 and this shows the same pattern of tracks as found in 2005. Figure 25 illustrates this for an area where the sidescan followed almost exactly the same route. Figure 24 from 2005 provides wider coverage of the dredge tracks off Rubha Mór. Although the tracks are clearly discernible on the raw images illustrated, the warping process involved in georectification results in considerable loss of detail in the mosaiced image. Knowledge of damage of serpulid reefs from dredging, presumably for scallops, is confined to the Rubha Mór area, although the 2004 sidescan survey revealed what appear to be c.6m wide dredge tracks about 35m from dense reefs at South Shian (Figure 26). Nearby, just south of Sgeir Caillich, an area of dense reefs is interrupted by a linear, c.11m wide denuded channel, possibly resulting from dredge or trawl activity (Figure 28).

The pattern of dredge tracks and the area of serpulid habitat destroyed at Rubha Mor can be assessed by tracing around the dredge track margins within Arcview (Figure 27). This indicates the presence of at least three tracks resulting in a loss in habitat extent of 0.45ha. This represents 10.9% of the reef band outlined in Figure 27.

Although it appears that much, if not all, of the dredging activity off Rubha Mór took place before February 2001, it is not possible to be much more precise regarding the time. Based on unpublished studies on the rate of reef growth, it is estimated that reefs grow in height by approximately 3cm per annum. Thus in 10–15 years it might be expected that there would remain little evidence of dredging. However, much of the debris in the tracks is heavily fouled with epibionts; particularly conspicuous are ascidians and red algae (Figure 29). This may prevent significant recruitment by *Serpula* and thus delay recovery.

Figure 24 Non-georectified sidescan image of apparent dredge tracks through serpulid reefs off Rubha Mór in 2005. The position of the centre of the image is approximately 56.51298°N 5.38225°W. Image width 70m, length 228m

Figure 25 Non-georectified sidescan images of same area of serpulid reef damage surveyed in 2004 and 2005. The position of centre of the image is approximately 56.51301°N 5.38218°W

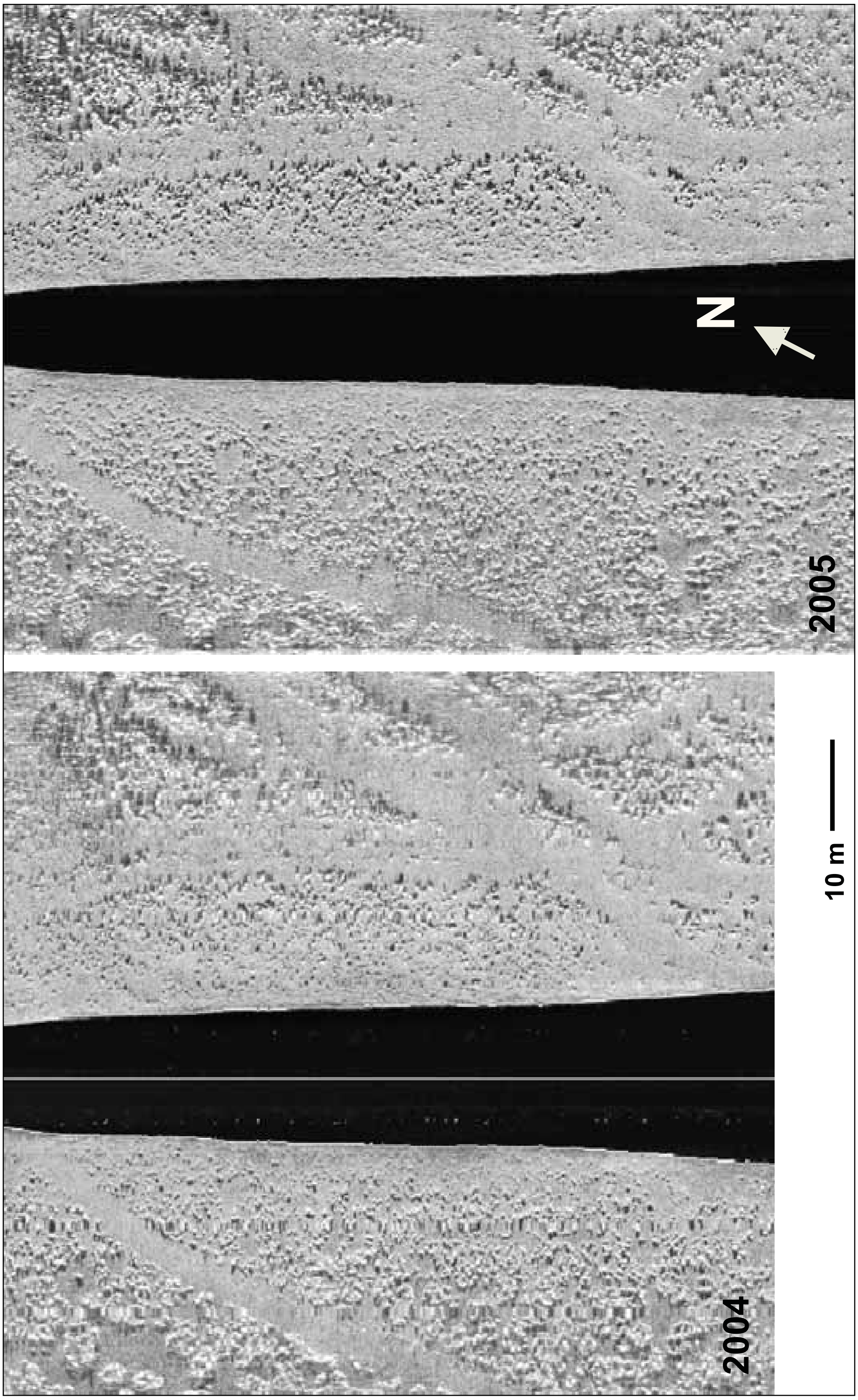


Figure 26 Sidescan sonar image (not georectified) of apparent dredge track (arrowed) off very dense reefs at South Shian. Also note mooring. Scale approximate. Centre of image at 56.52382°N 5.39664°W

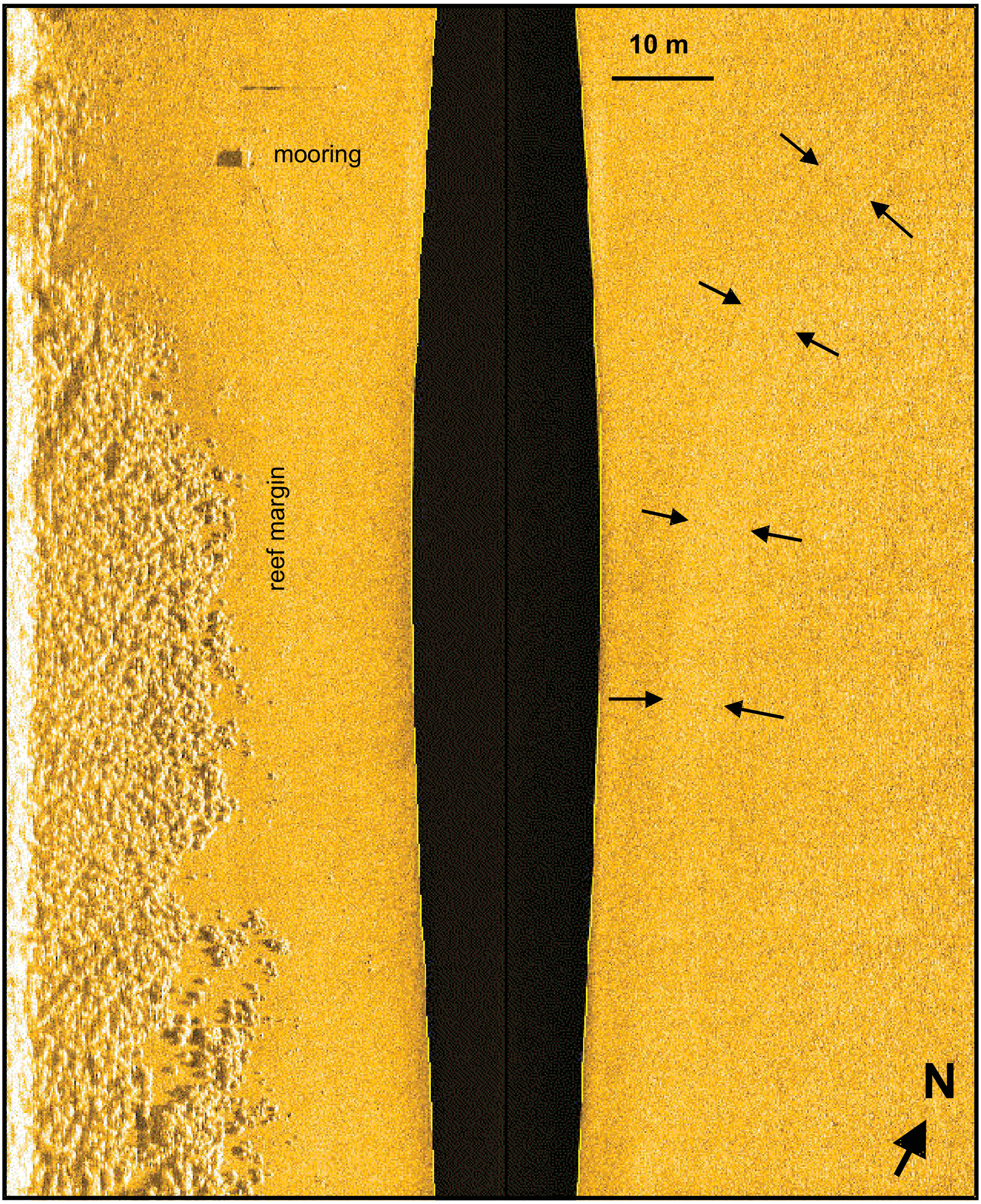


Figure 27 Mosaiced sidescan image of Rubha Mór. Reef band delineated by orange pecked line. Dredge tracks shown by pink lines

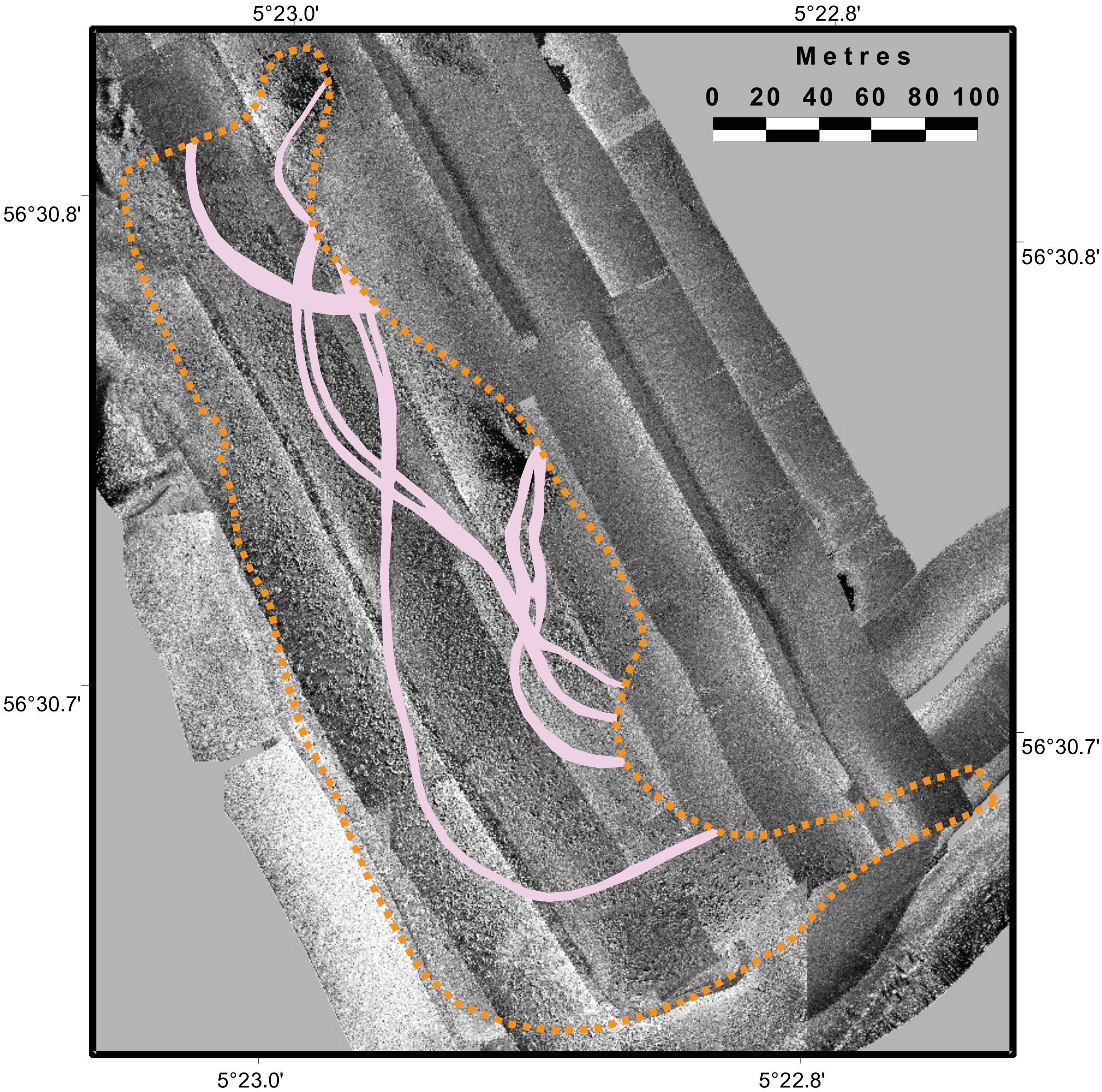


Figure 28 Sidescan sonar image (not georectified) of apparent serpulid reef damage on southern side of Sgeir Caillich. A band of width c.11m on right side of image has apparently been largely cleared of reefs. Scale approximate. Centre of damaged area at approximately 56.52547°N 5.39730°W

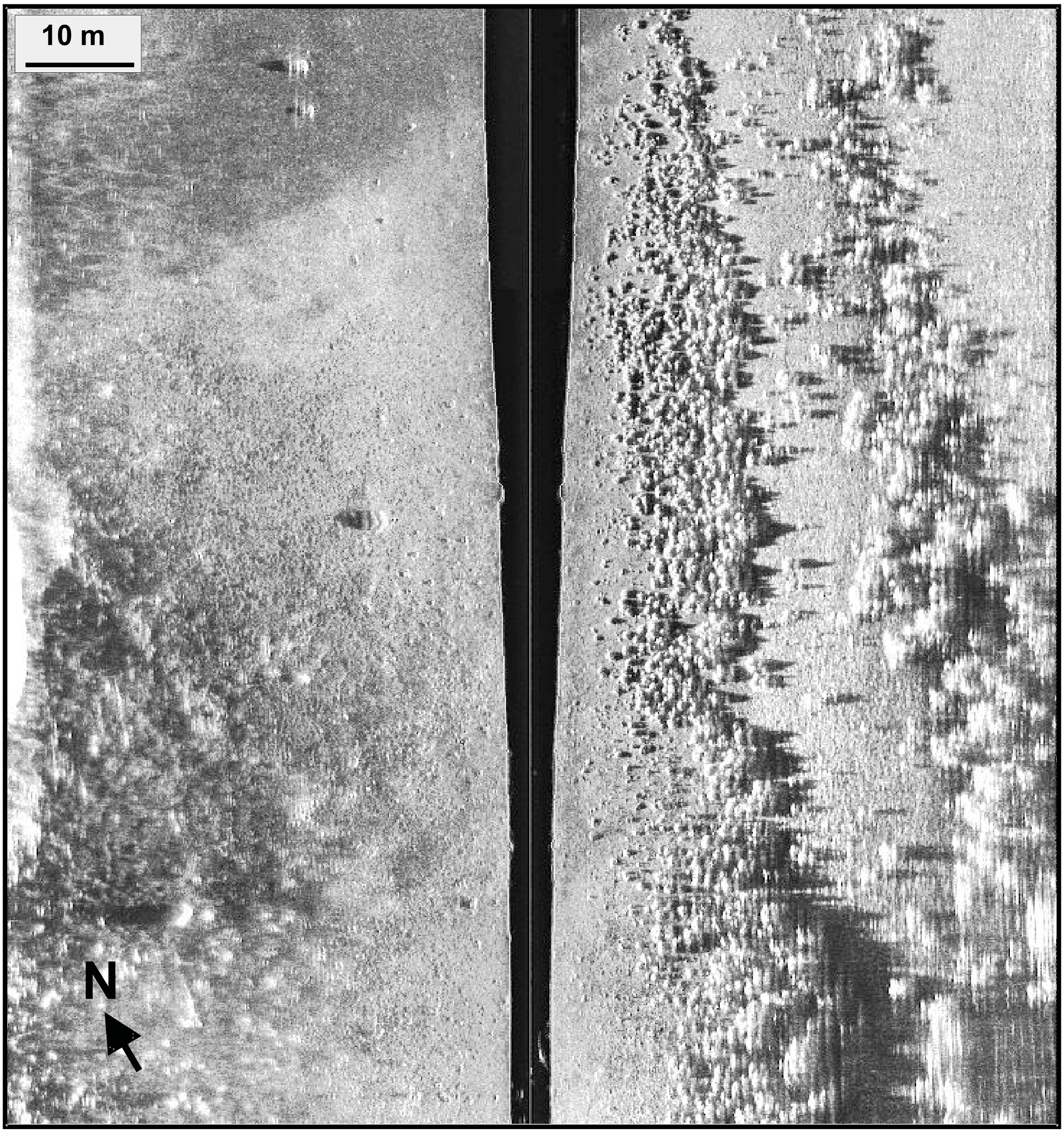


Figure 29 Serpulid reef damage apparently caused by dredging off Rubha Mór. The upper photo shows the reef rubble within the track, the lower photo the track margin with healthy reefs on right and rubble on left

Figure 30 Sidescan sonar image (not georectified) of break in serpulid reef band at the salmon harvesting pontoon site at South Shian. Pecked orange line marks edge of reefs, P = pontoon with associated moorings, M = reef-depleted mooring site, white arrow indicates mooring line. Scale approximate. Centre of image at 56.52102°N 5.39723°W

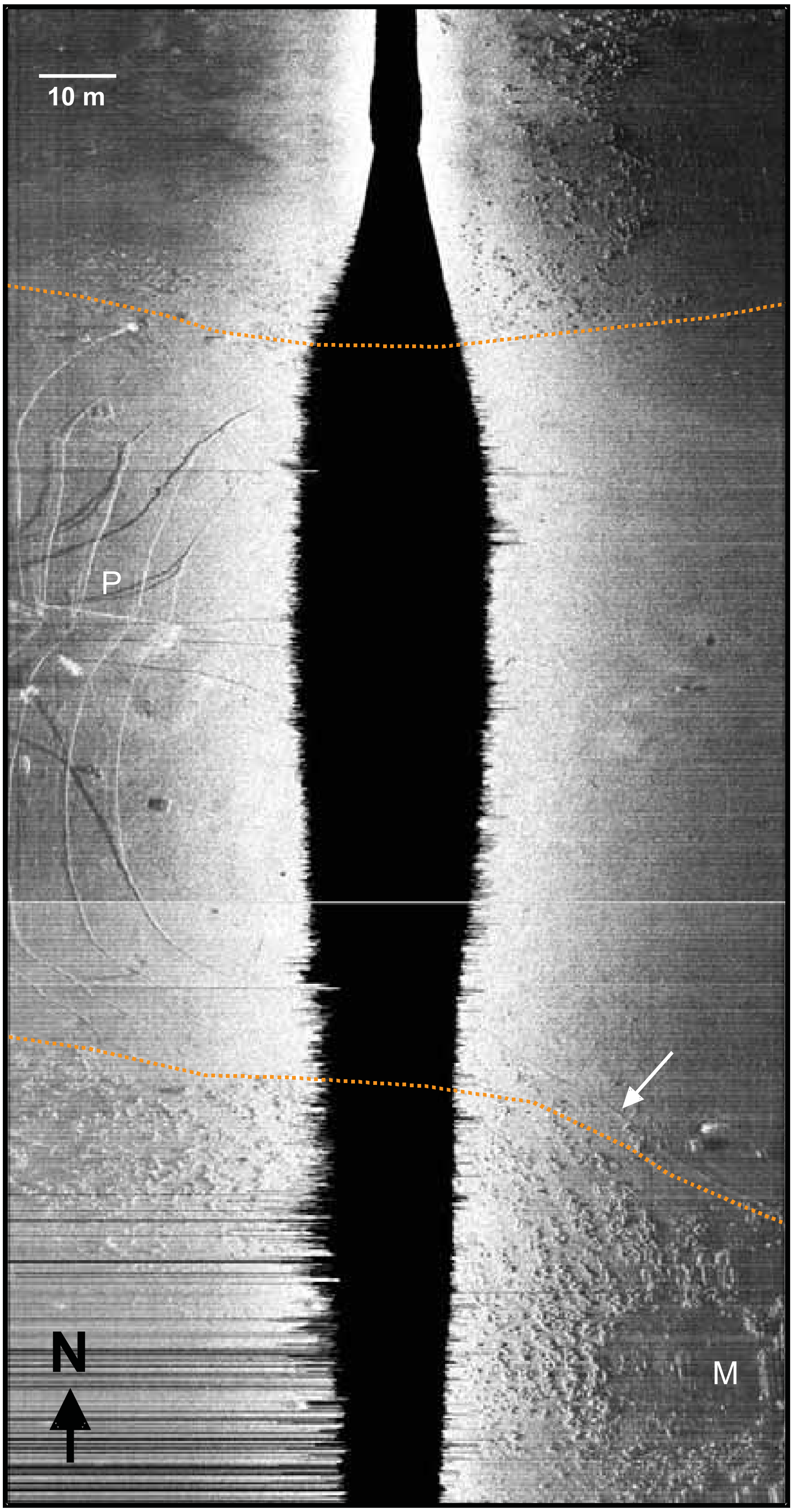


Figure 31 Serpulid reef damage caused by boat moorings at South Shian. The orange pecked line shows the likely original outer margin of the reef band. The two larger green circles indicate the area of scour from mooring chains; mooring weights can be seen at their centres. The smallest green circle may represent an area of damage from a possible third mooring

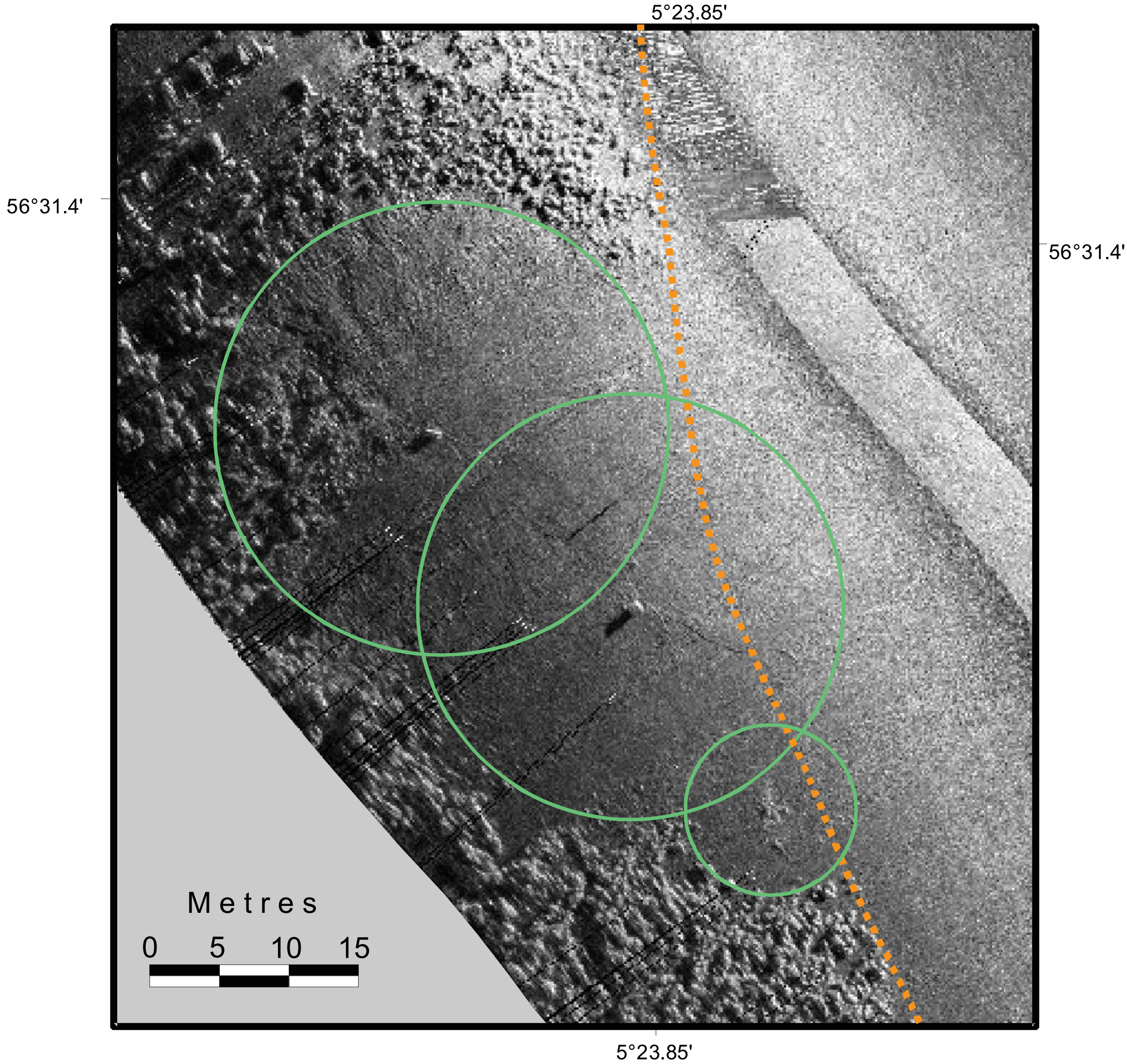


Figure 32 Serpulid reef damage caused by a boat mooring at South Shian. The upper photo shows reef rubble in the vicinity of the mooring weight. The lower photo shows decimation of an area of previously dense, large reefs about 10m from the mooring weight

Reduction in extent has also taken place as a result of salmon farming activities. The major area of impact is South Shian. There is a marked break in the reef band off South Shian (Figure 30), where the salmon harvesting pontoon is currently located. This break was present before the construction of the pontoon (unpublished data, Heriot-Watt University) and is almost certainly a result of farm activities. The region devoid of reefs includes areas of reef rubble, fish farm debris, and a large area where the seabed has 100% cover of dead *Mytilus* shells, presumably resulting from the presence of the previous harvesting facility. To the south of this break there are additional, well-defined areas of reef impoverishment, probably resulting from the presence of cages or related moorings (eg Figure 11).

A second area of reef damage is present in the north-east of Sea Life Centre Bay in the vicinity of transect LC05SV03 (Figure 2). This has been caused by the construction of salmon cages on the adjacent shore which commenced in 2000 but has now ceased. Cages were temporally moored in the bay and dragging of mooring weights and chains has led to areas of fragmented reefs. This damage is not revealed by the sonar images and so the extent of this impact cannot be quantified.

Since the establishment of Loch Creran as a candidate SAC, mussel farming has expanded in the loch along the northern coastline. Evidence of damage caused by this activity was identified in January 2006. A mussel work platform has been recently established over the serpulid reef band opposite Barcaldine. Fragmented reef material is present in the vicinity of the mooring weight and chain and an extensive area of seabed is completely covered with a layer of dead mussel shells. Broken serpulid reef fragments are mixed with the shells (Figure 33). The occasional living specimen of *Serpula vermicularis* amongst the fragmented material reveals the recent nature of this impact.

Figure 33 Serpulid reef fragmentation resulting from mussel farming

Serpulid reef extent has also been reduced by boat moorings. Very localised damage resulting from a mooring chain was observed during the peripheral transect survey just north of Barcaldine Pier but more extensive damage has been caused by moorings off South Shian, just to the south of Sgeir Caillich (Figures 31, 32). Mooring chains have raked a large area of seabed devastating part of a region of very dense reefs. The impact extends to approximately 1500m^2.

The scale and focus of the current investigation has resulted in the most detailed and reliable interpretation of reef distribution in Loch Creran and this must be borne in mind when considering apparent temporal changes. Unless reefs can actually be observed by divers, on video or on sidescan images, the effectiveness of other methods must be questioned. Although the pattern made by larger reefs on sidescan images is characteristic, smaller reefs, particularly when widely scattered, are much more difficult to recognize and hence even sidescan must be accompanied by a high intensity of groundtruthing.

Comparison of the results of the current peripheral transect survey with those of 1994 reveals broad similarity, although with some apparent distributional differences. The gap in the dense serpulid band at Rubha Mór in 2005 (Figure 16) was not identified in 1994. This could be due to the much wider spacing of transects in 1994. In 2005 the existence of this region of impoverishment was supported by three transects, sidescan sonar and associated video groundtruthing. An additional dive in this area in January 2006 revealed the presence of reefs but at very low density. The position of the single transect worked in this area in 1994 indicates that it possibly passed through the isolated patch of reefs identified by sonar in 2005. However, there is limited evidence that reef reduction has occurred in recent years from observations by the first author. During a dive on 4 November 2000 at approximately 56.51755ºN 5.38890ºW (within the gap identified in 2005), the presence of scattered reefs in poor condition was recorded. Most reefs were lying on their side, were populated by few or no living *Serpula vermicularis* and were heavily fouled, especially with red algae.

Distribution in the upper basin appears reduced in 2005. This is probably due to methodological differences. In 1994 reefs were recorded in 20m sections along transects, whereas in 2005, the actual band width, which is generally much narrower than 20m, was determined. Apparent differences in the presence of reefs at certain points around the margin of the upper basin are only evident at sites where reefs were recorded as rare on one date and absent on the other and so there is no convincing evidence for distributional change.

In 1994 no reefs were recorded for a 1km stretch of coastline in the vicinity of the discharge from the alginate factory at Barcaldine, despite high intensity surveying. In 2005, nine years after the closure of the factory, reefs were found along all four transects passing through this area, including moderate numbers of medium and large reefs close to the outfall pipe. Much of the seabed in this area still consists of organically-enriched mud and the reefs were found to be concentrated on boulders and cobbles in shallow water. Recovery seems to be taking place.

In 1994 no reefs were recorded in the outer part of the loch beyond Sgeir Caillich. In 2005 reefs were found growing on a mooring chain on the eastern side of the embayment between Sgeir Caillich and Eriska. From other diving observations in recent years it is clear that reefs are present in very low density at other locations in this bay, although largely restricted to mooring gear. Rather than representing a temporal change, this is likely to be merely a consequence of increased sampling.

The only previous quantitative measure of reef abundance in Loch Creran was carried out at the Rubha Mór site on 12 December 2000 by Moore *et al.* (2003). Using the same video technique, reef coverage of the seabed was measured along 10 replicate 100m transects within the centre of the reef band (7–8m). The mean value of 17% cover is not significantly greater than the value of 14% obtained in 2005 (*t* test), in spite of the 2005 survey spanning a broader depth range (6–9m).

Several previous, unpublished surveys of the associated community of serpulid reefs have been carried out by Heriot-Watt University (Table 7). They all used a similar methodology involving recording the presence or absence of biota on 10 reefs of at least 30cm width. The first two columns of the table present the results of a study of worker variability, with two divers separately recording the biota of the same 10 reefs. There are no significant differences in the recorded species richness between these surveys, nor indeed between any of the surveys carried out at Rubha Mór. Previous surveys have also been performed close to the 2005 survey sites in Sea Life Centre and South Creagan bays. Again, there are no statistically significant temporal differences. Interestingly, as in 2005, the highest diversity has been previously recorded in Sea Life Centre Bay. As might be expected, there are some spatial and temporal differences in species composition between surveys but none that provide any suggestion of anthropogenic disturbance of the reef community.

Table 7 Comparison of unpublished surveys of serpulid reef associated fauna with the current study. All surveys recorded presence/absence of biota on 10 reefs. The final column gives the results of Kruskal-Wallis tests comparing the species richness in 2005 with the results of previous surveys of the same sites

Site	Position	Depth (m)	Date	Mean no. taxa	p
Rubha Mór	56.51378ºN 5.38235ºW	9	11–Feb–01	11.9	
Rubha Mór	56.51378ºN 5.38235ºW	9	11–Feb–01	10.5	
Rubha Mór	56.51278ºN 5.38272ºW	4.0–6.9	2–Dec–01	12.6	
Rubha Garbh N	56.52573ºN 5.35897ºW	4.0–6.9	13–Jan–02	12	
Sea Life Centre	56.52322ºN 5.33263ºW	7.0–9.9	19–Nov–01	16.4	
South Creagan	56.54532ºN 5.29875ºW	4.0–6.9	2–Dec–01	12.1	
Upper Basin	56.54972ºN 5.27617ºW	4.0–6.9	13–Jan–02	10.3	
Rubha Mór	56.51378ºN 5.38290ºW	6.1–7.7	23–Jul–05	11.5	0.264
South Shian	56.51782ºN 5.39768ºW	8.1–9.0	24–Jul–05	12.6	
Sea Life Centre	56.52252ºN 5.33368ºW	6.5–7.6	25–Jul–05	15	0.136
South Creagan	56.54533ºN 5.29932ºW	5.4–5.6	26–Jul–05	10.6	0.215

4.2 *Modiolus* beds

Modiolus modiolus is widely distributed around the margin of Loch Creran but no previous distribution surveys have been carried out, and hence no temporal trends can be examined. For the lower basin, little can also be stated regarding temporal abundance patterns. Comely (1978) studied the abundance and population structure of *Modiolus* at Creagan (close to *Modiolus* transect LC05MM05 and the serpulid reef transect 92) in 1974–6, reporting a mean density of $4m^{-2}$. This is much lower than the density estimates produced in 2005 but Comely's sampling site was significantly shallower.

Table 8 Percentage cover of the seabed by *Modiolus* recorded at stations of similar depth (within 1m) along four transects in the upper basin of Loch Creran in 1999 (Mair *et al*. 2000) and in 2005 (current study)

transect	1999			2005		
	station	depth (m)	% cover	station	depth (m)	% cover
1	0	5.8	0.000	0	5.5	1.875
1	1	9.3	5.000	1	8.4	3.750
1	2	12.3	23.750	2	11.5	10.625
1	3	14.8	18.750	3	15.5	13.750
1	5	20.8	23.750	4	20.9	11.250
2	1	10.9	5.000	1	11.6	8.125
2	2	15.5	7.500	2	16.2	7.500
2	6	25.4	0.000	5	25.3	2.500
3	0	5.3	1.250	0	4.8	0.000
3	3	21.5	10.000	3	21.6	6.875
3	4	25.3	2.500	4	25.0	3.750
4	0	7.0	0.000	0	7.5	0.625
4	4	26.9	0.000	3	26.3	0.625

For the upper basin comparative data are available from the study in 1999 (Mair *et al*. 2000). 23 stations were assessed for *Modiolus* cover along four transects in both years. Measurements of cover were zero for five stations in 1999 and for three stations in 2005. At those stations where zero cover was recorded in one year only, cover was extremely low in the other year or there was a depth discrepancy >1m. These data provide no evidence of any change in distribution or extent.

Probably due to the practical difficulties in precisely repositioning every station along all transects, only 13 stations were at similar depths in both years (within 1m) (Table 8). The mean cover at these stations was 7.5% in 1999 and 5.5% in 2005 but a non-parametric Friedman test revealed no significant difference in *Modiolus* cover between years. A Friedman test also revealed no temporal change in cover along transect 1 alone. There does, however, appear to be a marked reduction in cover at certain stations and a chi-squared test of the number of quadrat string intersections overlying *Modiolus* shows there to be a reduction in cover at 12m and 21m.

Figure 20 compares the size frequency of the population in 1999 and 2005. The size structure appears very similar, except for an apparent reduction in the proportion of the largest size classes (beyond 120mm). The mode is also slightly lower in 2005 (105–110mm) than in 1999 (110–115). In both years the population is strongly dominated by large individuals (>85mm), which are probably at least 11 years old (Mair *et al*. 2000). For the nearby tidal rapids at Creagan, the growth curve produced by Comely (1978) shows an age of 9 at 85mm. Judging by the growth curve for the upper basin population of Mair *et al*. (2000), the 2005 85–125mm size grouping would have been expected to have been represented by a peak between 45–95mm in 1999. Such a peak is not apparent in Figure 20. The most likely explanation is that considerably greater sample sizes are required to adequately characterise the population structure. Unfortunately this has implications for potential damage to the population and the associated community. The data acquired do suggest that recruitment to the population is very slow and, if present trends continue, it is to be expected that population density will decline farther.

Table 9 Diversity of the associated community and volume of 4 clumps of *Modiolus modiolus* collected at site 3 on transect LC05MM01 during the current study and the 1999 study by Mair *et al*. (2000). The Shannon-Wiener (H) and Pielou evenness (J) indices exclude colonial animals and algae and employ $\log_2$. The final column gives the significance of differences in means between years using the *t* test

Year	**2005**					**1999**					**p**
Clump	**1**	**2**	**3**	**4**	**mean**	**1**	**2**	**3**	**4**	**mean**	
No. species	88	94	104	97	95.75	80	81	88	87	84.00	0.024
H	5.144	5.068	5.410	5.297	5.230	4.882	5.009	4.800	5.075	4.942	0.026
J	0.823	0.797	0.838	0.843	0.825	0.791	0.812	0.764	0.812	0.795	0.093
Volume (ml)	1795	1495	1995	1595	1720	1920	1950	2570	2180	2155	

Three *Modiolus* biotopes have been recorded from Loch Creran. The 1989 MNCR survey (Connor 1990) reported the presence of SBR.SMus.ModT at Creagan, which was confirmed as still being present in 2005. The same survey identified the presence of the upper basin southern shore bed, referring it to the biotope, SBR.SMus.ModHAs, as in the current survey. The 1998–9 survey by Black *et al*. (2000) allocated this bed to SBR.SMus.ModCvar but recognised a contiguous bed to the north and west which they referred to SBR.SMus.ModHAs. The 1999 survey by Mair *et al*. (2000) of the upper basin southern shore bed regarded the bed as intermediate in nature between SBR.SMus.ModHAs and SBR.SMus.ModCvar. For practical purposes it is probably best to regard these putative adjacent beds as one (SBR.SMus.ModHAs). In 2005 serpulid reef transect 109 passed through the site of the western bed of Black *et al*. (2000) and confirmed the existence of SBR.SMus.ModHAs here.

Detailed information on the species composition of the upper basin southern shore bed is available from the 1989 MNCR survey (Connor 1990), the 1999 survey by Mair *et al*. (2000) and the current 2005 survey. There appears to be little change in composition between 1989 and 1999, although Mair *et al*. (2000) noted the apparent disappearance of the dominant brittlestar, *Ophiopholis aculeata*. The 1999 and 2005 surveys were conducted by the same recorder using basically the same methodology at the same site. Most differences between the years are due to some of the rarer species being recorded in one year and not the other (Table A9). An exception is the saddle oyster, *Pododesmus patelliformis*, common in 2005 but unrecorded in 1989. However, this is due to this cryptic species being overlooked, as revealed by its high representation in the 1989 clump samples. The MNCR surveys do not indicate a temporal change in diversity, with 62 taxa recorded in 1989, 62 in 1999 and 58 in 2005.

A more quantitative assessment of temporal change in diversity can be obtained by examination of the *Modiolus* clump community (Table 9). There is a significant increase in species richness and Shannon-Wiener diversity, though not evenness, between 1999 and 2005; however, the differences are slight and are possibly due in part to the difference in analysts. Some of the apparent differences in species composition between the years are also probably due to the change in personnel. In summary, temporal changes in the associated community appear slight and are neither indicative of adverse nor anthropogenically-induced temporal patterns.

4.3 Rocky reefs

There is very little previous information on the reef habitats examined in the current study. The tideswept reef communities near the mouth of the loch have not been studied before but represent rich and interesting sites. The rich epibiontic kelp community and the spectacular circalittoral massive sponges (*Pachymatisma johnstoni* and *Clione celata*) are particularly noteworthy. 76 and 70 taxa were recorded at Woodhall and Rubha nam Faoileann reefs compared to 47 on the Rubha Riabhach S reef, which is probably more typical of the sheltered reef habitat in Creran. The Rubha Riabhach S reef was examined during the 1998–9 survey of Loch Creran (Black *et al*. 2000). No detailed information on the community structure was presented in the report but the same biotopes were identified. There is no evidence to suggest that the extent, distribution, diversity and composition of the rocky reef biotopes of Creran have been suffering from anthropogenic impacts over the last six years.

4.4 Recommendations

No one technique is effective at mapping the serpulid reef habitat under all conditions. Divers can record the presence of reefs within a wide belt of around 8m and can distinguish reefs from other substrates at all levels of reef density and depth. Moreover, the size and health of reefs can be recorded. It is recommended that future monitoring of extent and distribution continues to be based on diver transects, although there are possible improvements that could be made in efficiency and accuracy of position fixing. A diver-based positioning system, such as the Cobra-Tac (RJE International, Irvine, USA) would be worth considering, although the price of such systems is currently prohibitive.

Sidescan sonar provides a valuable supplement to direct observation, enabling delineation of the fringing serpulid reef band at the major reef sites in the loch, where reefs are present at relatively high density over large areas and with few competing sonar reflectors. Combined with an appropriate intensity of groundtruthing, it also provides convincing evidence of reef presence in the form of a visual record, which can be used for temporal comparisons. It was particularly useful in the current survey, and is possibly the only method, for mapping large-scale damage to the habitat. Sidescan should certainly form a component of the monitoring programme. Given the level of anthropogenic damage that has been revealed by sidescan and the level of human activity in the loch, it is suggested that sidescan monitoring should be repeated at no less than 12 year intervals.

During the development of monitoring techniques for the serpulid reefs of the loch, Heriot-Watt University has been able to assess the merits of a number of sidescan systems for the discrimination of serpulid reefs. These include:

- Edgetech 4100 (Edgetech, West Wareham, USA);
- Tritech Seaking (Tritech International Limited, Aberdeen, UK);
- Klein 2000 (Klein Associates Inc., Salem, USA);
- Klein 3000.

Image quality varies considerably between these different systems. The Klein 3000 has been found to offer markedly better resolution of reef structure than the other systems and is the system of choice.

Because of the propensity of *Modiolus* to occur in clumps in the upper basin of the loch and the potential disturbance caused by the clearance of mussels within quadrats, the approach taken in monitoring abundance was to measure percentage cover. To enhance the power of any statistically-based, temporal comparisons, the number of replicate quadrats used for assessing percentage cover was doubled in 2005 to 10 quadrats at each station along the surveyed transect. However, towards the margins of the bed the cover is so low that these stations will contribute little or nothing to the assessment of temporal abundance change. It is suggested that transects continue to be monitored but, except at the more central stations where abundance is high, the stations are only used to determine distribution and extent. For the same effort, this would permit an even higher degree of quadrat replication in the heart of the bed. To minimise the possibility of bogus temporal trends resulting from relocation inaccuracies, consideration should be given to the placement of permanent site markers.

It would appear that considerably larger sample sizes than were taken in the 1999 (Mair *et al*. 2000) and 2005 surveys are necessary to characterise the size structure of the *Modiolus* population (see section 4.2 above). A significant increase in sample size is difficult to justify in view of the habitat disturbance caused. Measured *Modiolus* can be returned to the site but the likely impact of sampling on longevity is unknown. It is recommended that the present level of sampling (c.100 specimens) is continued. This will at least identify the dominant size classes of the population and should reveal evidence of the presence of significant recruitment episodes. This type of information could be useful in distinguishing between the causes of observed population decline (eg due to anthropogenic activities or resulting from lack of recruitment).

References

Anon. (1998). A Statement on Common Standards Monitoring. Peterborough: JNCC.

Black, K. D., Hughes, D. J., Provost, P. G. and Pereira, P. M. F. (2000). Broad scale survey and mapping of seabed biota in Loch Creran, Argyll. Scottish Natural Heritage Commissioned Report F98AA408.

Comely, C.A. (1978). *Modiolus modiolus* (L.) from the Scottish west coast. I. Biology. *Ophelia* 17: 167–193.

Connor, D. (1990). Survey of Lochs Linnhe, Eil, Creran and Aline. Nature Conservancy Council, CSD Report No. 1073.

Connor, D. W., Allen, J. H., Golding, N., Lieberknecht, L. M., Northen, K. O. and Reker, J. B. (2004). The Marine Habitat Classification for Britain and Ireland. Version 04.05. JNCC, Peterborough. Internet version: www.jncc.gov.uk / MarineHabitatClassification.

Inter-Agency Marine Monitoring Group. (2004). Common standards monitoring guidance for littoral rock and inshore sublittoral rock habitats. Peterborough: Joint Nature Conservation Committee.

Mair, J. M., Moore, C. G., Kingston, P. F. and Harries, D. B. (2000). A review of the status, ecology and conservation of horse mussel *Modiolus modiolus* beds in Scotland. Scottish Natural Heritage Commissioned Report F99PA08.

Moore, C. G. (1996). The distribution of serpulid reefs in Loch Creran, Argyll. Scottish Natural Heritage Research, Survey and Monitoring Report, No. 53. SNH, Edinburgh.

Moore, C. G., Harries, D. B., Lyndon, A. R., Saunders, G. R. and Conway, T. R. (2003). Quantification of serpulid biogenic reef coverage of the sea bed (Polychaeta: Serpulidae) using a video transect technique. *Aquatic Conservation: Marine and Freshwater Ecosystems* 13: 137–146.

Moore C. G., Saunders G. R. and Harries D. B. (1998). The status and distributional ecology of reefs of *Serpula vermicularis* L. (Polychaeta: Serpulidae) in Scotland. *Aquatic Conservation: Marine and Freshwater Ecosystems* 8: 645–656.

Appendices

Table A1 Location details for the peripheral transects for assessment of serpulid reef and *Modiolus* presence

Transect no.	Bearing (°M)	Depth in (m)	Depth transect start m)	Depth transect end (m)	Position in latitude	Position in longitude	Position out latitude	Position out longitude	Date
1	333	–0.8	0	8.7	56.54647	–5.29597	56.54722	–5.29628	16–Jul–05
2	330	–0.6	–0.6	14.9	56.54417	–5.29798	56.54628	–5.30133	15–Jul–05
3	245	–1.4	0	12.6	56.54443	–5.30197	56.54422	–5.30290	15–Jul–05
4	316	0	0	10.4	56.54182	–5.30220	56.54230	–5.30302	15–Jul–05
5	280	–0.5	0	11.5	56.53995	–5.30408	56.54010	–5.30547	15–Jul–05
6	310	–0.5	–0.1	11.1	56.53747	–5.30650	56.53792	–5.30708	15–Jul–05
7	284	–1.1	–1	14.7	56.53563	–5.30688	56.53545	–5.30857	15–Jul–05
8	308	–1	–0.6	10	56.53343	–5.31065	56.53388	–5.31120	15–Jul–05
9	313	–0.7	–0.7	12.9	56.53142	–5.31355	56.53248	–5.31495	15–Jul–05
10	324	–0.4	–0.4	9.2	56.52972	–5.31477	56.53070	–5.31658	05–Nov–05
11	350	–0.1	–0.1	12.5	56.52813	–5.31915	56.53067	–5.31977	15–Jul–05
12	338	–0.6	–0.6	14.3	56.52765	–5.32342	56.52967	–5.32535	05–Nov–05
13	320	–0.4	–0.1	13.8	56.52763	–5.32755	56.52787	–5.32832	14–Jul–05
14	300	–0.2	–0.1	13.9	56.52577	–5.33003	56.52633	–5.33153	14–Jul–05
15	317	0	0	14.1	56.52377	–5.33157	56.52530	–5.33322	24–Jul–05
16	325	–0.3	–0.2	13.9	56.52115	–5.33355	56.52335	–5.33700	22–Jul–05
17	330	–0.2	–0.2	12.6	56.51993	–5.33700	56.52147	–5.33877	22–Jul–05
18	6	–0.4	–0.3	12	56.51920	–5.34130	56.52065	–5.34105	22–Jul–05
19	20	–0.5	–0.5	13.3	56.51970	–5.34608	56.52083	–5.34563	22–Jul–05
20	358	–0.4	–0.4	15.3	56.52007	–5.35087	56.52112	–5.35098	24–Jul–05
21	320	–0.1	–0.1	14.1	56.51937	–5.35445	56.52015	–5.35658	11–Jul–05
22	350	0.1	0	14	56.51820	–5.35783	56.51922	–5.35887	24–Jul–05
23	355	0	0	17.4	56.51690	–5.36362	56.51753	–5.36398	24–Jul–05
24	335	–1.1	–1.1	14.7	56.51590	–5.36800	56.51640	–5.36798	12–Jul–05
25	330	–1.2	–1.2	14.4	56.51428	–5.37092	56.51497	–5.37133	12–Jul–05
26	7	–0.8	–0.8	14.5	56.51262	–5.37473	56.51330	–5.37450	12–Jul–05
27	15	–0.8	–0.8	14.6	56.51212	–5.37852	56.51285	–5.37830	12–Jul–05
28	55	–0.7	0	14.4	56.51183	–5.38400	56.51362	–5.38053	12–Jul–05
29	55	–0.2	–0.2	14.8	56.51443	–5.38672	56.51575	–5.38413	12–Jul–05
30	55	0.4	0.4	16.9	56.51602	–5.38772	56.51662	–5.38573	12–Jul–05
31	30	–0.1	–0.1	14.8	56.51653	–5.39015	56.51830	–5.38758	12–Jul–05
32	7	–0.2	–0.2	14.3	56.51638	–5.39422	56.51773	–5.39417	12–Jul–05
33	60	–0.4	–0.4	13	56.51702	–5.39923	56.51817	–5.39572	12–Jul–05
34	87	–0.3	0.1	14.4	56.51953	–5.39997	56.51993	–5.39578	12–Jul–05
35	100	–0.2	–0.2	14	56.52208	–5.39877	56.52233	–5.39617	12–Jul–05
36	75	0	0	14.4	56.52397	–5.39857	56.52405	–5.39695	12–Jul–05
37	140	1	1	17	56.52630	–5.39775	56.52522	–5.39678	12–Jul–05
38	135	–0.1	–0.1	17	56.52787	–5.39522	56.52743	–5.39380	21–Jul–05

Table A1 *(continued)*

Transect no.	Bearing (°M)	Depth in (m)	Depth transect start m)	Depth transect end (m)	Position in latitude	Position in longitude	Position out latitude	Position out longitude	Date
39	320	–0.8	–0.8	12	56.52775	–5.39615	56.52823	–5.39615	13–Jul–05
40	337	–0.7	–0.7	13.9	56.52643	–5.39835	56.52685	–5.39923	13–Jul–05
41	20	–0.8	0.1	14.1	56.52622	–5.40322	56.52698	–5.40250	14–Jul–05
42	120	–0.5	–0.5	11.8	56.52867	–5.40528	56.52832	–5.40233	14–Jul–05
43	124	–1.3	0	8.9	56.52992	–5.40272	56.52948	–5.40120	14–Jul–05
44	115	–0.5	–0.5	10.4	56.53322	–5.40267	56.53312	–5.39948	14–Jul–05
45	70	–0.4	–0.2	7	56.53483	–5.40048	56.53467	–5.39977	14–Jul–05
46	15	–0.9	–0.4	14	56.53695	–5.40203	56.53723	–5.40165	12–Jul–05
47	355	–1.1	–0.8	14.2	56.53727	–5.40668	56.53808	–5.40800	12–Jul–05
48	340	–1.5	0	14.9	56.53693	–5.41035	56.53798	–5.41157	12–Jul–05
49	3	–0.4	0	8.9	56.53577	–5.41502	56.53690	–5.41737	12–Jul–05
50	75	–1.5	0	14.3	56.53913	–5.41312	56.53810	–5.41222	13–Jul–05
51	170	–1	0	14.2	56.54023	–5.40945	56.53937	–5.40910	13–Jul–05
52	170	–0.5	0	14.4	56.54138	–5.40523	56.53992	–5.40547	13–Jul–05
53	170	–0.6	–0.6	8.8	56.54265	–5.40060	56.54092	–5.39960	13–Jul–05
54	240	–0.7	–0.7	5.2	56.54283	–5.39535	56.54220	–5.39773	13–Jul–05
55	320	–1.3	–1.3	5.1	56.53978	–5.39548	56.54168	–5.39975	13–Jul–05
56	248	–1	–0.2	12.3	56.53775	–5.39563	56.53707	–5.39798	14–Jul–05
57	252	–0.5	–0.2	13.1	56.53632	–5.39485	56.53582	–5.39597	14–Jul–05
58	244	–0.5	0	8.3	56.53412	–5.39482	56.53355	–5.39720	14–Jul–05
59	220	–0.7	–0.7	9.5	56.53360	–5.39140	56.53270	–5.39217	14–Jul–05
60	260	–0.8	–0.8	7.5	56.53120	–5.38932	56.53098	–5.39130	14–Jul–05
61	240	0	0	14.7	56.52912	–5.38898	56.52745	–5.39132	21–Jul–05
62	210	1.1	0	14	56.52710	–5.38702	56.52615	–5.38763	21–Jul–05
63	230	–0.4	–0.1	14.9	56.52615	–5.38350	56.52560	–5.38598	14–Jul–05
64	186	–1.1	–0.1	14.3	56.52362	–5.38252	56.52302	–5.38243	14–Jul–05
65	135	–0.6	–0.2	15.7	56.52463	–5.37933	56.52428	–5.37863	14–Jul–05
66	150	–0.5	–0.5	11.4	56.52677	–5.37668	56.52500	–5.37385	14–Jul–05
67	220	–0.3	–0.3	12.1	56.52655	–5.37252	56.52510	–5.37545	14–Jul–05
68	230	–0.6	0	11.4	56.52535	–5.36958	56.52405	–5.37160	14–Jul–05
69	180	–0.8	0	14.6	56.52372	–5.36723	56.52312	–5.36700	14–Jul–05
70	163	–0.7	0	14.3	56.52480	–5.36408	56.52404	–5.36338	13–Jul–05
71	163	0	0	14.6	56.52563	–5.36077	56.52505	–5.36013	13–Jul–05
72	144	–0.2	–0.2	13.7	56.52728	–5.35778	56.52553	–5.35588	13–Jul–05
73	154	0.2	0.1	10.8	56.52895	–5.35392	56.52767	–5.35228	13–Jul–05
74	157	0.1	0.1	11.5	56.53005	–5.35017	56.52780	–5.35030	13–Jul–05
75	150	0	0	12.9	56.53113	–5.34747	56.52897	–5.34540	13–Jul–05
76	186	–0.1	0.1	9.5	56.53308	–5.34465	56.53068	–5.34445	13–Jul–05
77	153	–0.2	0.1	13.6	56.53373	–5.33988	56.53127	–5.33707	13–Jul–05
78	148	–0.7	–0.1	14	56.53358	–5.33622	56.53255	–5.33507	16–Jul–05

Table A1 *(continued)*

Transect no.	Bearing (°M)	Depth in (m)	Depth transect start m)	Depth transect end (m)	Position in latitude	Position in longitude	Position out latitude	Position out longitude	Date
79	113	–0.4	–0.4	12.2	56.53607	–5.33600	56.53573	–5.33435	16–Jul–05
80	133	–0.3	–0.3	14.9	56.53787	–5.33295	56.53748	–5.33207	16–Jul–05
81	138	–0.3	–0.3	13.9	56.53972	–5.33043	56.53922	–5.32965	16–Jul–05
82	130	–0.6	–0.6	12.7	56.54158	–5.32770	56.54102	–5.32708	16–Jul–05
83	127	0.2	0	14.1	56.54347	–5.32645	56.54320	–5.32405	15–Jul–05
84	146	–0.2	0.1	12.8	56.54517	–5.32363	56.54460	–5.32277	15–Jul–05
85	154	–0.2	–0.2	12.9	56.54707	–5.32042	56.54638	–5.31968	15–Jul–05
86	190	–0.3	–0.3	13.1	56.54785	–5.31653	56.54693	–5.31688	15–Jul–05
87	156	–0.2	–0.2	13.4	56.54877	–5.31342	56.54722	–5.31287	15–Jul–05
88	156	–0.4	0.1	11.3	56.55002	–5.31018	56.54872	–5.30943	15–Jul–05
89	180	–0.7	–0.7	12	56.55037	–5.30563	56.54962	–5.30547	15–Jul–05
90	194	–0.8	0	11.2	56.55062	–5.30160	56.54983	–5.30193	15–Jul–05
91	237	15.1	–1.1	14.9	56.54840	–5.30010	56.54818	–5.30072	15–Jul–05
92	172	–0.3	–0.3	9.7	56.54872	–5.29530	56.54777	–5.29552	16–Jul–05
93	140	–1.3	–1.3	14.2	56.54933	–5.28107	56.54857	–5.27878	16–Jul–05
94	164	–0.2	–0.2	12.7	56.54992	–5.27738	56.54875	–5.27610	16–Jul–05
95	150	0	0	13.3	56.55088	–5.27388	56.55027	–5.27282	16–Jul–05
96	154	–0.4	0	14	56.55193	–5.26983	56.55108	–5.26960	16–Jul–05
97	156	–0.2	0	9.7	56.55338	–5.26652	56.55287	–5.26637	16–Jul–05
98	210	0	0	14	56.55400	–5.26170	56.55217	–5.26203	16–Jul–05
99	194	–0.8	0.3	7.2	56.55327	–5.25747	56.55240	–5.25783	25–Jul–05
100	194	–0.8	0.3	6.4	56.55350	–5.25320	56.55287	–5.25328	25–Jul–05
101	219	–0.1	–0.1	8.2	56.55267	–5.24898	56.55177	–5.24947	25–Jul–05
102	278	–0.8	–0.8	9.7	56.54985	–5.24828	56.54972	–5.25033	25–Jul–05
103	342	–1.3	0	7.9	56.54807	–5.25167	56.54848	–5.25202	25–Jul–05
104	2	–0.3	0.1	12.3	56.54770	–5.25603	56.54810	–5.25620	25–Jul–05
105	355	–0.9	–0.9	14.5	56.54707	–5.25962	56.54757	–5.25992	25–Jul–05
106	347	–0.4	–0.1	14.5	56.54650	–5.26388	56.54678	–5.26440	25–Jul–05
107	348	–1.5	–1.5	14.4	56.54534	–5.26807	56.54577	–5.26858	19–Jul–05
108	6	–0.2	0	14.9	56.54462	–5.27212	56.54515	–5.27208	19–Jul–05
109	26	–0.2	0	13.8	56.54478	–5.27673	56.54582	–5.27625	16–Jul–05
110	42	–0.2	–0.2	13.4	56.54603	–5.28020	56.54655	–5.27958	16–Jul–05

Table A2 Serpulid reef depth limits and sizes observed along 110 transects around Loch Creran. The shallow and deep bounds are given for all serpulid reef sizes and for medium and large (M & L) reefs. The presence of individuals of *Serpula* (I) and small (S), medium (M) and large (L) reefs are indicated by 'y'. The maximum abundance of *Modiolus* recorded along the transect is also given using the MNCR SACFOR scale (Superabundant, Abundant, Common, Frequent, Occasional, Rare)

Transect No.	Depth all reefs start (m)	Depth all reefs end (m)	Depth M & L reefs start (m)	Depth M & L reefs end (m)	I	S	M	L	Reef damage	Maximum *Modiolus* SACFOR
1	1.2	4.4	2.6	2.6	y	y	y			
2	2.5	7	3	6	y	y	y	y		
3	7	12			y	y				
4	3.5	5.2			y	y				
5					y					
6	1.7	8.1	2.6	6.1	y	y	y	y		
7	3.6	5	4.5	5	y	y	y			
8	–0.1	1			y	y				
9	1.2	4.4	2.5	4.4	y	y	y			O
10	–0.2	3.8	0.9	3.8	y	y	y	y	mooring chain toppling reefs	
11	–0.1	4.7	0.8	2.9	y	y	y			
12	1.2	6	1.2	4.2	y	y	y	y		R
13	1.7	8.9	1.7	8.9	y	y	y	y		R
14	13	13	13	13	y		y			
15	3	10.3	1.9	9.8	y	y	y	y		R
16	1.4	12.3	2.4	11.7	y	y	y	y		R
17	0	12.4	0.6	12.4	y	y	y	y		
18	0	9.5	1.2	9.5	y	y	y	y		
19	0.1	12.6	1.8	9.6	y	y	y	y		
20	0.6	14	0.7	12.8	y	y	y	y	smashed reefs, cause unclear	O
21	–0.1	13.6	1.9	7.1	y	y	y	y		F
22	0.6	13.7	3.4	13.7	y	y	y	y		F
23	0.3	16.8	0.3	15.2	y	y	y	y		O
24	7.4	8.6	7.4	8.6	y	y	y			
25	3.4	3.4			y	y				F
26	1.5	12.4	1.5	12.2	y	y	y	y		F
27	4.6	10.2	4.6	10.2	y	y	y	y		
28	3.6	11.1	4.6	10.5	y	y	y	y	dredge damage	R
29					y					
30										F
31					y					O
32	3.6	13.6	6.6	13.2	y	y	y	y		
33	6.5	12.3	6.5	12.3	y	y	y	y		
34	4.2	10.9	4.2	10.9	y	y	y	y	smashed reefs, cause unclear	R

Table A2 *(continued)*

Transect No.	Depth all reefs start (m)	Depth all reefs end (m)	Depth M & L reefs start (m)	Depth M & L reefs end (m)	I	S	M	L	Reef damage	Maximum *Modiolus* SACFOR
35	5	6.2	5	6.2	y	y	y	y		R
36	5.5	12.8	5.5	12.8	y	y	y	y	y	F
37	5.3	15.9	5.3	8.2	y	y	y	y	at start	
38										
39										
40	13.8	13.8	13.8	13.8	y	y	y	y		
41					y					R
42										
43										
44										O
45										
46										R
47										
48					y					R
49										
50										
51										R
52					y					S
53										R
54										
55										R
56										R
57					y					A
58										A
59										
60					y					O
61										R
62					y					R
63										
64	3.6	3.6			y	y				R
65	3.7	15.1	12.2	12.2	y	y	y			
66	2.4	11.4	3.4	11.2	y	y	y	y		
67	0.9	11.3	0.9	9.6	y	y	y	y		F
68	2.4	11.4	7.1	11.2	y	y	y	y		R
69	9.2	9.2			y	y				R
70	8.5	12.4			y	y				
71	2.6	9	2.6	9	y		y	y		O
72	3.5	5.3	3.5	5.3	y	y	y	y		C
73	0.8	6.4	1.9	6.4	y	y	y	y		R
74	3.3	8.3	3.3	5.4	y	y	y	y		R

Table A2 *(continued)*

Transect No.	Depth all reefs start (m)	Depth all reefs end (m)	Depth M & L reefs start (m)	Depth M & L reefs end (m)	I	S	M	L	Reef damage	Maximum *Modiolus* SACFOR
75	4.7	10.9	4.7	6.7	y	y	y	y	localized damage	O
76	0.4	8.4	1.5	7.2	y	y	y	y	y	O
77	2.7	9.5	2.7	8.4	y	y	y	y		F
78	3.9	10	3.9	10	y	y				O
79	7.8	11.1	7.8	7.8	y	y	y			
80	0	4.6	4.6	4.6	y	y	y			
81	7.2	8.1	5.2	5.2		y	y			
82	–0.1	9.1	2.9	9.1	y	y	y	y		
83	6.9	6.9				y				
84	0.5	8.4	2.7	7	y	y	y	y		
85	0.1	4	0.4	4	y	y	y	y		
86	4.9	4.9				y				
87	1.2	1.5			y	y				R
88	1.9	9.5	4.8	4.8	y	y	y	y		R
89					y					R
90										
91					y					R
92					y					S
93	1	9.3			y	y				O
94	6.1	6.2	6.1	6.2	y	y	y	y		O
95	9.2	9.2			y	y				R
96	1.4	6.4			y	y				R
97	1.3	7.6	3.9	3.9	y	y	y			
98										
99	2.4	5.2	4.4	4.4	y	y	y			R
100	3.3	3.3			y	y				
101										R
102	3.9	3.9			y	y				
103										
104					y					
105					y					R
106	2.2	5.9	3.7	4.9	y	y	y			C
107	2	5.4	5.3	5.4	y	y	y	y		C
108	3.3	3.5			y	y				C
109	4	7.1	4.5	5.7	y	y	y	y		C
110	2.9	2.9			y	y				R

Table A3 Abundance of biota along transects at four serpulid reef sites within Loch Creran SAC. Abundance given is on the SACFOR scale (Superabundant, Abundant, Common, Frequent, Occasional, Rare, Present) and only includes the sedimentary area to within 0.5m of reefs

Taxa	Rubha Mór	South Shian	Sea Life Centre	South Creagan
Esperiopsis fucorum	R		R	
Cliona celata	R			
Kirchenpaueria pinnata	R			R
Virgularia mirabilis		F		
Cerianthus lloydii	R	O		R
Tubulanus annulatus?			R	
Melinna palmata	F	O	F	F
Lanice conchilega				R
Eupolymnia nebulosa	R		R	R
Terebellidae indet.		O	R	F
Myxicola infundibulum			R	R
Bispira volutacornis		R	R	R
Sabellidae indet.	R	O	R	O
Protula tubularia	R			
Palaemonidae indet.	R	R	R	
Crangon crangon				R
Pagurus bernhardus	F	O	O	R
Inachus dorsettensis	R			
Inachus sp.			R	
Macropodia sp.	O		R	
Carcinus maenas	O	O	O	O
Liocarcinus depurator	O	O	O	O
Tectura virginea	R			
Aporrhais pespelecani	O	R		
Gibbula magus	R	R	R	
Gibbula tumida	R			
Turritella communis		O	O	F
Buccinum undatum	R		O	R
Neptunea antiqua			R	
Mya truncata	R			
Aequipecten opercularis	O	O	O	O
Pecten maximus				O
Modiolus modiolus			O	O
Chlamys distorta			R	
Arctica islandica				R
Philine aperta				O
Asterias rubens	O	O	O	O

Table A3 *(continued)*

Taxa	Rubha Mór	South Shian	Sea Life Centre	South Creagan
Henricia sanguinolenta				R
Crossaster papposus		R		
Amphiura filiformis				C
Echinus esculentus			R	
Psammechinus miliaris	O		O	R
Echinocardium cordatum		P		
Thyone raphanus				O
Ascidia mentula			R	
Dendrodoa grossularia			R	
Pyura microcosmus	F		C	O
Callionymus sp.	R	R	R	R
Pomatoschistus sp.	F	F	F	O
Taurulus bubalis	R			
Pleuronectiformes juv. indet.	R	R		
Brown diatomaceous film	A	A	A	A
Ectocarpaceae indet.		R		
Laminaria saccharina			R	
Corallinaceae indet.	R		R	
Foliose red algae indet.	R		R	R
Phycodrys rubens	R			

Table A4 Presence of taxa on 10 serpulid reefs at Rubha Mór, 23 July 2005

	Reefs									
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Esperiopsis fucorum		1		1						1
Haliclona cinerea										
Kirchenpaueria pinnata			1	1	1		1			
Obelia dichotoma	1	1	1		1	1	1		1	
Eupolymnia nebulosa	1		1	1	1	1	1	1	1	1
Pomatoceros spp.		1								
Protula tubularia										
Caridea indet.										
Pagurus bernhardus	1									
Galathea spp.		1				1			1	
Munida rugosa					1					
Porcellanidae indet.										
Hyas araneus										
Inachus sp.										
Macropodia		1						1		1
Liocarcinus depurator	1					1				
Necora puber										1
Gibbula cineraria										
Calliostoma zizyphinum										
Buccinum undatum										
Chlamys varia	1	1		1		1	1	1		1
Arctica islandica										
Antedon bifida										
Henricia sanguinolenta										
Asterias rubens		1	1	1			1			1
Ophiothrix fragilis	1	1	1	1	1	1	1	1	1	1
Psammechinus miliaris		1		1	1		1		1	1
Clavelina lepadiformis				1						
Diplosoma listerianum										
Ciona intestinalis	1			1					1	1
Corella parallelogramma										
Ascidiella aspersa										
Ascidia mentula	1	1	1		1	1	1			1
Ascidia virginea			1			1			1	1
Pyura microcosmus	1	1	1	1	1	1	1	1	1	1
Gobiesocidae sp.										
Syngnathus acus										
Pholis gunnellus									1	

Table A4 *(continued)*

	Reefs									
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Pomatoschistus minutus	1									
Pomatoschistus pictus	1				1				1	
Rhodophyceae indet. (filamentous)	1	1	1	1		1	1	1	1	1
Ceramium sp.										
Phycodrys rubens	1	1	1	1	1	1	1	1	1	1
Ectocarpaceae indet.										
Desmarestia aculeata		1								
Laminaria saccharina									1	
No. taxa	13	14	10	12	10	11	11	7	13	14
Depth (m)	7.7	7.3	7.4	7.3	7.6	7.4	7.1	6.6	6.1	6.7

Table A5 Presence of taxa on 10 serpulid reefs at South Shian, 24 July 2005

	Reefs									
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Esperiopsis fucorum								1		
Haliclona cinerea				1						
Kirchenpaueria pinnata			1	1	1	1	1		1	1
Obelia dichotoma	1	1	1	1	1	1	1	1	1	1
Eupolymnia nebulosa	1	1	1	1	1	1	1	1	1	1
Pomatoceros spp.										
Protula tubularia										
Caridea indet.					1					
Pagurus bernhardus										
Galathea spp.			1			1				
Munida rugosa			1			1				
Porcellanidae indet.										
Hyas araneus										
Inachus sp.										
Macropodia						1				
Liocarcinus depurator	1		1			1		1	1	
Necora puber										
Gibbula cineraria						1				
Calliostoma zizyphinum				1						
Buccinum undatum				1						
Chlamys varia	1		1	1	1	1	1	1		1
Arctica islandica		1								
Antedon bifida										
Henricia sanguinolenta		1		1						
Asterias rubens						1	1		1	
Ophiothrix fragilis	1	1	1	1	1	1	1	1	1	1
Psammechinus miliaris		1	1	1	1	1	1	1	1	1
Clavelina lepadiformis										
Diplosoma listerianum										1
Ciona intestinalis									1	1
Corella parallelogramma										
Ascidiella aspersa										
Ascidia mentula	1	1	1	1	1	1	1	1	1	1
Ascidia virginea			1		1	1			1	1
Pyura microcosmus	1	1	1	1	1	1	1	1	1	1
Gobiesocidae sp.	1									
Syngnathus acus										
Pholis gunnellus										

Table A5 *(continued)*

	Reefs									
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Pomatoschistus minutus				1			1			
Pomatoschistus pictus										
Rhodophyceae indet. (filamentous)		1			1	1	1	1	1	1
Ceramium sp.										
Phycodrys rubens				1						1
Ectocarpaceae indet.	1	1	1	1	1	1	1		1	1
Desmarestia aculeata										
Laminaria saccharina								1		
No. taxa	9	10	13	15	12	17	12	11	13	14
Depth (m)	8.1	8.6	8.6	8.7	8.5	8.8	8.5	8.8	9.0	9.0

Table A6 Presence of taxa on 10 serpulid reefs in Sea Life Centre Bay, 25 July 2005

	Reefs									
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Esperiopsis fucorum						1	1	1	1	1
Haliclona cinerea										
Kirchenpaueria pinnata	1	1	1	1	1	1	1	1	1	1
Obelia dichotoma	1	1	1	1	1	1	1	1	1	1
Eupolymnia nebulosa	1	1	1	1	1	1	1	1	1	1
Pomatoceros spp.								1		
Protula tubularia			1	1				1		1
Caridea indet.										
Pagurus bernhardus	1						1		1	1
Galathea spp.			1							
Munida rugosa										
Porcellanidae indet.		1								
Hyas araneus		1			1					
Inachus sp.							1	1		1
Macropodia	1			1						
Liocarcinus depurator								1		1
Necora puber		1								
Gibbula cineraria										
Calliostoma zizyphinum										
Buccinum undatum										1
Chlamys varia	1		1	1		1		1	1	1
Arctica islandica										
Antedon bifida										
Henricia sanguinolenta										
Asterias rubens		1	1			1				1
Ophiothrix fragilis	1	1	1	1	1	1	1	1	1	1
Psammechinus miliaris	1	1	1	1	1	1	1	1	1	1
Clavelina lepadiformis										
Diplosoma listerianum	1	1		1	1	1	1	1	1	1
Ciona intestinalis	1		1		1					1
Corella parallelogramma	1									
Ascidiella aspersa				1						
Ascidia mentula	1	1	1	1	1	1	1	1	1	1
Ascidia virginea	1	1				1	1		1	1
Pyura microcosmus	1	1	1	1	1	1	1	1	1	1
Gobiesocidae sp.										
Syngnathus acus			1							
Pholis gunnellus										

Table A6 *(continued)*

	Reefs									
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Pomatoschistus minutus	1	1					1			
Pomatoschistus pictus							1	1	1	1
Rhodophyceae indet. (filamentous)	1	1	1	1	1	1		1	1	1
Ceramium sp.										1
Phycodrys rubens					1	1			1	
Ectocarpaceae indet.										
Desmarestia aculeata										
Laminaria saccharina										
No. taxa	16	15	14	13	12	14	14	16	15	21
Depth (m)	6.7	6.7	6.5	6.9	6.8	7.1	7.2	7.2	7.5	7.6

Table A7 Presence of taxa on 10 serpulid reefs at South Creagan, 26 July 2005

	Reefs									
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Esperiopsis fucorum										
Haliclona cinerea										
Kirchenpaueria pinnata		1						1		
Obelia dichotoma	1	1	1	1	1	1		1	1	1
Eupolymnia nebulosa	1	1	1	1	1	1	1	1	1	1
Pomatoceros spp.				1		1				1
Protula tubularia				1	1					1
Caridea indet.										
Pagurus bernhardus				1			1	1	1	
Galathea spp.										
Munida rugosa										
Porcellanidae indet.										
Hyas araneus										
Inachus sp.										
Macropodia										
Liocarcinus depurator										
Necora puber					1					
Gibbula cineraria										
Calliostoma zizyphinum										
Buccinum undatum										
Chlamys varia	1	1	1	1	1	1	1	1	1	1
Arctica islandica										
Antedon bifida						1			1	
Henricia sanguinolenta										
Asterias rubens	1	1							1	
Ophiothrix fragilis	1	1	1	1	1	1	1	1	1	1
Psammechinus miliaris	1	1	1	1		1	1	1	1	1
Clavelina lepadiformis										
Diplosoma listerianum							1			
Ciona intestinalis	1			1				1	1	
Corella parallelogramma		1		1				1		1
Ascidiella aspersa				1						
Ascidia mentula		1	1		1	1		1		
Ascidia virginea							1		1	1
Pyura microcosmus	1	1	1	1	1	1	1	1	1	1
Gobiesocidae sp.										
Syngnathus acus										
Pholis gunnellus										

Table A7 *(continued)*

	Reefs									
Taxa	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Pomatoschistus minutus										
Pomatoschistus pictus										
Rhodophyceae indet. (filamentous)	1	1	1	1			1	1		
Ceramium sp.										
Phycodrys rubens							1		1	1
Ectocarpaceae indet.										
Desmarestia aculeata										
Laminaria saccharina			1		1		1			
No. taxa	9	11	9	13	9	9	11	12	12	11
Depth (m)	5.6	5.5	5.5	5.6	5.6	5.4	5.4	5.5	5.5	5.6

Table A8 Abundance of *Modiolus* along seven transects in Loch Creran. Abundance is given in terms of the number of string intersections of 10 replicate 0.25m^2 quadrats directly overlying living mussels. Each quadrat has 16 intersections

Transect	Station	Depth (m)	Replicate cross string counts									
LC05MM01	0	5.5	0	0	1	0	1	0	0	0	1	0
LC05MM01	1	8.4	0	1	1	0	1	0	0	1	1	1
LC05MM01	2	11.5	1	1	2	0	2	2	1	3	1	4
LC05MM01	3	15.5	3	2	2	4	0	0	3	4	3	1
LC05MM01	4	20.9	2	0	3	1	0	1	5	3	2	1
LC05MM01	5	26.8	0	0	0	3	0	0	1	0	1	0
LC05MM02	0	6.5	1	2	0	2	0	2	0	2	0	0
LC05MM02	1	11.6	1	1	2	3	1	2	1	1	1	0
LC05MM02	2	16.2	2	1	0	0	5	2	0	1	1	0
LC05MM02	3	20.1	1	0	0	3	2	4	0	0	1	0
LC05MM02	4	23.1	2	0	0	0	0	1	2	1	1	1
LC05MM02	5	25.3	0	0	0	1	0	1	0	1	1	0
LC05MM02	6	26.9	0	0	0	0	0	0	0	0	0	0
LC05MM03	0	4.8	0	0	0	0	0	0	0	0	0	0
LC05MM03	1	9.8	0	0	1	0	2	0	1	1	1	1
LC05MM03	2	15.3	1	3	1	2	1	2	3	1	2	0
LC05MM03	3	21.6	0	1	2	0	2	0	1	1	2	2
LC05MM03	4	25	0	1	0	1	0	1	0	1	0	2
LC05MM04	0	7.5	0	0	0	0	0	1	0	0	0	0
LC05MM04	1	13	1	1	1	0	3	2	1	0	1	2
LC05MM04	2	18.5	2	0	2	4	3	0	1	1	0	1
LC05MM04	3	26.3	0	1	0	0	0	0	0	0	0	0
LC05MM04	4	29	0	0	0	0	0	0	0	0	0	0
LC05MM05	0	5.2	0	2	1	0	2	0	0	0	0	0
LC05MM05	1	7	3	6	3	11	2	6	8	6	5	4
LC05MM05	2	8.6	4	6	5	6	4	5	6	3	4	6
LC05MM05	3	10.5	5	3	5	5	8	5	3	5	1	3
LC05MM06	0	10.1	0	0	0	0	0	0	0	0	0	0
LC05MM06	1	11.3	0	0	0	0	0	0	0	0	0	0
LC05MM06	2	14.3	2	4	3	4	5	1	1	1	3	4
LC05MM06	3	18.4	1	3	0	0	0	0	0	0	0	0
LC05MM06	4	21.9	0	2	0	0	1	0	3	0	0	0
LC05MM06	5	25.5	0	2	3	1	0	0	1	0	0	0
LC05MM07	0	9.5	0	0	0	0	0	1	0	0	0	2
LC05MM07	1	12.6	1	2	1	4	2	1	0	2	1	2
LC05MM07	2	13.7	0	0	0	0	0	0	1	0	1	0
LC05MM07	3	15.9	1	0	0	0	1	2	1	1	0	0
LC05MM07	4	17.1	0	0	0	0	0	1	0	0	0	0
LC05MM07	5	19.4	0	0	0	0	0	0	0	0	0	0
LC05MM07	6	22.8	0	0	0	0	0	0	0	0	0	0
LC05MM07	7	22.9	0	0	0	0	0	0	0	0	0	0

Table A9 Abundance of taxa recorded during MNCR phase 2 surveys at site 3 along the *Modiolus* bed transect LC05MM01 in 1999 (Mair *et al.* 2000) and during the current study. Abundance given is on the MNCR SACFOR scale (Superabundant, Abundant, Common, Frequent, Occasional, Rare, Present)

Taxa	1999	2005
Suberites carnosus?	R	R
Halichondria bowerbankia?	R	R
Haliclona urceolus		R
Mycale sp.	O	R
Esperiopsis fucorum	F	R
Myxilla incrustans	R	R
Bougainvillia ramosa	O	
Bougainvillia / Eudendrium sp.		F
Halecium halecinum	F	
Halecium beanii		R
Kirchenpaueria pinnata	O	C
Hydrallmania falcata	R	
Obelia sp.	O	
Sarsia tubulosa	R	
Alcyonium digitatum	O	O
Cerianthus lloydii		R
Pachycerianthus multiplicatus	R	
Sargartiogeton laceratus	R	O
Calliactis parasitica	R	
Eupolymnia nebulosa	F	F
Myxicola infundibulum	O	F
Pomatoceros triqueter	C	C
Serpula vermicularis	C	C
Verruca stroemia	F	C
Balanus balanus	F	C
Balanus crenatus	F	F
Crangon crangon	R	R
Pagurus bernhardus		C
Pagurus spp.	C	
Munida rugosa	F	F
Hyas araneus	P	
Inachus dorsettensis	R	F
Macropodia sp.	R	
Carcinus maenas		R
Liocarcinus depurator	C	F
Pododesmus patelliformis		C
Buccinum undatum	O	F

Table A9 *(continued)*

Taxa	1999	2005
Modiolus modiolus	A	A
Chlamys distorta	P	P
Chlamys varia	C	F
Aequipecten opercularis	F	O
Mya truncata	R	P
Hiatella arctica	O	O
Disporella hispida	C	C
Antedon bifida	C	F
Crossaster papposus	R	R
Solaster endeca		R
Henricia sp.	O	R
Asterias rubens	C	A
Ophiothrix fragilis	C	A
Amphipholis squamata	O	
Psammechinus miliaris	O	C
Echinus esculentus	O	R
Thyone fusus	R	
Diplosoma listerianum	F	R
Ciona intestinalis	O	F
Corella parallelogramma	O	F
Asidiella aspersa	C	F
Ascidia mentula	F	F
Ascidia virginea	R	F
Dendrodoa grossularia	F	C
Botryllus schlosseri	R	
Boltenia echinata	O	R
Pyura microcosmus	C	F
Polycarpa pomaria		R
Clavelina lepadiformis		R
Gobiesocidae sp.		F
Syngnathus acus	R	R
Pomatoschistus pictus	P	F
Pomatoschistus minutus?	P	
Pholis gunnellus		R
Corallinaceae indet.	O	R
Lithothamnion glaciale	O	
Laminaria saccharina	R	
Number of taxa recorded	62	58

Table A10 Composition of the community associated with four clumps of *Modiolus modiolus* from station 3 on transect LC05MM01. For non-colonial animals the number of individuals is given. The presence of algae and non-colonial animals is indicated by 'P'

Taxa	**Clump**			
	1	**2**	**3**	**4**
Porifera sp. A	P	P	P	P
Porifera sp. B	P	P	P	
Porifera sp. C		P	P	P
Suberites domuncula			P	P
Leucosolenia sp.	P	P	P	P
Cliona celata	P		P	P
Scypha ciliata		P	P	P
Hymedesmia sp.				P
Dysidea fragilis?	P			
Cnidaria sp. juv.		P		
Alcyonium digitatum	P	P	P	P
Halecium beanii				P
Kirchenpaueria pinnata				P
Clytia hemisphaerica			P	P
Obelia sp.				P
Platyhelminthes sp.			1	
Tubulanus polymorphus				1
Cerebratulidae spp.	1	1	1	
Loxosomella sp.			P	
Pedicellina cernua				P
Adyte pellucida			1	
Alentia gelatinosa		1		1
Gattyana cirrosa	1			
Harmothoe spp. juv. / indet.	8	12	7	7
Harmothoe extenuata		1		
Lepidonotus squamatus	14	14	7	19
Pholoe inornata	10	7	3	4
Pholoe baltica	3	6	1	7
Sthenelais boa	1			1
Eteone longa	1			
Eulalia bilineata		1		
Eumida sp. juv. / indet.				1
Eumida bahusiensis			1	4
Eumida sanguinea	2	2	1	1
Nereiphylla sp. juv.		1		
Pirakia punctifera	1			

Table A10 *(continued)*

Taxa	**Clump**			
	1	**2**	**3**	**4**
Glycera alba		1		2
Goniada maculata				1
Amphidurus fuscescens	4	3	2	3
Kefersteinia cirrata	2	4	5	3
Nereimyra punctata	18	24	27	33
Podarke pallida	12	6	4	4
Syllidia armata	1			
Typosyllis armillaris	1	1	2	3
Typosyllis hyalina	1	4	2	2
Amblyosyllis formosa	1			
Autolytus spp.	2	4	10	2
Nephtys kersivalensis	1	1	1	
Spinther oniscoides	1		2	
Nematonereis unicornis			1	
Lumbrineris gracilis	2	2		3
Ophryotrocha sp.	1	1		
Parougia eliasoni				1
Protodorvillea kefersteini	1	3	3	
Paradoneis lyra	1			1
Aonides oxycephala	1			
Minuspio cirrifera		1	1	1
Polydora caeca	1	6	7	13
Polydora caulleryi	1	1		1
Polydora flava	1		1	
Polydora ?saintjosephi	1			
Prionospio fallax	2	1		3
Cirratulidae spp. indet.		1		
Caulleriella alata		2	1	
Tharyx killariensis			1	
Caulleriella zetlandica		1		1
Cirriformia tentaculata				1
Dodecaceria sp.			2	
Flabelligera affinis	4	6	3	5
Pherusa flabellata			2	
Pherusa plumosa	1	1	2	2
Mediomastus fragilis	17	13	18	6
Notomastus latericeus			1	
Scalibregma inflatum		1	2	

Table A10 *(continued)*

Taxa	**Clump**			
	1	**2**	**3**	**4**
Owenia fusiformis				1
Lagis koreni		1	1	
Melinna sp. juv. / indet.	1			
Amphicteis sp. juv.		2		
Terebellides stroemi	2	5	1	3
Trichobranchus glacialis	5	1	2	7
Amphitritinae spp. juv. / indet.	3	3	1	
Amphitrite cirrata	1	1	1	
Eupolymnia nebulosa	1	3	2	5
Pista cristata			1	1
Polycirrus spp.	6	12	7	8
Polycirrus aurantiacus	1			1
Polycirrus norvegicus				3
Thelepus cincinnatus			1	
Branchiomma bombyx	2	2	3	1
Chone filicaudata		1		
Pseudopotamilla reniformis	2		4	
Hydroides norvegica		1	1	1
Serpula / Hydroides spp			2	1
Pomatoceros triqueter	33	30	47	52
Serpula vermicularis	7	1	1	4
Tubificidae spp.	1	3		1
Copepoda sp. (parasitic)		1		
Balanus balanus	19	9	27	17
Balanus crenatus	1	2	5	4
Ostracoda spp.	1		2	3
Verruca stroemia	41	76	14	40
Anchialina agilis	1			
Heteromysis formosa		6	2	2
Gammaridea spp.indet			2	
Apherusa bispinosa			3	
Harpinia crenulata	1	2		1
Parametaphoxus fultoni				1
Lysianassa ceratina			1	
Orchomene humilis	1			2
Perrierella audouiniana	2		14	
Iphimedia minuta	1			
Liljeborgia kinahani			1	2

Table A10 *(continued)*

Taxa	**Clump**			
	1	**2**	**3**	**4**
Liljeborgia pallida	1	1	4	2
Tritaeta gibbosa	3		4	
Ampelisca tenuicornis			1	
Cheirocratus sp. ♀		1		
Ericthonius sp. ♀				1
Lembos websteri				4
Corophium bonnellii	2	3	24	6
Phtisica marina	4	14	5	30
Pseudoprotella phasma				22
Anthura gracilis	1		3	
Janira maculosa			1	11
Tanaopsis graciloides			2	1
Vauntompsonia cristata		2	1	
Eudorella truncatula		1		
Pisidia longicornis	8	8	7	15
Leptochiton asellus	1	2	4	5
Ischnochiton albus	5	1	3	4
Buccinum undatum juv.		2		1
Nudibranchia sp. indet.		1	1	
Tritonia ?plebeia			1	1
Nucula nucleus		1		
Mytilidae spat	2	1		2
Mytilus edulis	2	5	4	11
Modiolus modiolus	12	8	11	7
Palliolum striatum		1		
Chlamys distorta			1	
Chlamys varia var. *nivea*		1	2	4
Anomiidae spp. juv.				5
Pododesmus patelliformis	15	35	39	11
Heteranomia squamula				4
Thyasira flexuosa	1			
Mysella bidentata		3	5	1
Abra alba		1	3	1
Abra nitida		1		
Timoclea ovata		1		
Mya truncata	1	5		
Corbula gibba		1	1	
Hiatella arctica	2	7	4	5

Table A10 *(continued)*

Taxa	**Clump**			
	1	**2**	**3**	**4**
Thracia spp. juv.		1		
Disporella hispida	P	P	P	P
Bowerbankia sp.	P			
Tubulipora sp.				P
Fenestrulina malusii	P	P	P	P
Callopora dumerilii	P	P	P	P
Scrupocellaria scruposa	P		P	P
Antedon bifida		1	4	1
Antedon sp. juv.				2
Asterias rubens			1	
Ophiuroidea spp. juv.		1		
Ophiothrix fragilis	6		21	6
Psammechinus miliaris			2	1
Ciona intestinalis		1	1	
Corella parallelogramma	1		3	
Ascidiella sp. juv.		1		
Ascidiella aspersa	2	1		1
Ascidia mentula	1	2	1	1
Ascidia virginea	1		1	
Dendrodoa grossularia	29	32	20	19
Boltenia echinata	2		1	
Pyura microcosmus	14	6	12	8
Diplosoma listerianum		P	P	
Corallinaceae indet.	P	P	P	P

Table A11 Profile data, substrates, dominant biota and biotopes recorded in zones along the rocky reef transect at Woodhall

Feature	Tape distance (m)	Depth below CD (m)	Substrate	Biogenic features of zone	Biotopes
base of mooring ring	0.00	–3.47	bedrock		
			bedrock	*Verrucaria maura* and *Prasiola*	
	1.00				
			bedrock	*Semibalanus balanoides*	
	1.50				
			bedrock	mixed fucoids and *Semibalanus*	
	8.00				
			bedrock	*Fucus serratus*	
zone 4 upper limit	15.00	–0.97			
zone 4			bedrock slope with pockets of coarse sand	forest of *Laminaria hyperborea* with dense *L. digitata* at top of zone	IR.MIR.KR.LhypT.Ft, IR.MIR.KR.Ldig.Ldig
	20.00	–0.30			
	25.00	2.10			
	30.00	3.60			
	35.00	5.40			
	40.00	6.10			
	45.00	7.40			
zone 3/4 boundary	50.00	8.80			
zone 3			bedrock slope with pockets of coarse sand	park of *L. hyperborea*	IR.MIR.KR.LhypT.Pk
	55.00	9.50			
zone 2/3 boundary	60.00	11.40			
zone 2			circalittoral bedrock	dense *Alcyonium* with scattered massive sponges	CR.HCR.XFa
	65.00	13.30			
zone 1/2 boundary	70.00	14.50			
zone 1			gravelly sand with dense cover of shells	tide-swept *Modiolus* bed with shells supporting barnacles and hydroid turf	SS.SBR.SMus.ModT
	75.00	14.00			

Table A12 Profile data, substrates, dominant biota and biotopes recorded in zones along the rocky reef transect at Rubha nam Faoileann

Feature	Tape distance (m)	Depth below CD (m)	Substrate	Biogenic features of zone	Biotopes
concrete base of navigation light	0.00	–4.59	concrete		
intertidal			bedrock slope	bands of *Pelvetia, Semibalanus & Patella, Fucus serratus*	
	12.00	–0.90			
	13.00	–0.85			
intertidal			bedrock	band of *Halidrys siliquosa*	
zone 3 / Halidrys boundary	14.00	–0.10			
zone 3			stepped rock with patches of coarse sand	forest of *L. hyperborea*	IR.MIR.KR.LhypT.Ft
	15.00	0.05			
	20.00	2.05			
	25.00	3.95			
zone 2 / 3 boundary	29.00	6.55			
zone 2			stepped rock with patches of coarse sand	park of *L. hyperborea*	IR.MIR.KR.LhypT.Pk
	30.00	7.15			
	35.00	10.35			
zone 1 / 2 boundary	36.00	11.15			
zone 1			rock wall, with boulders on coarse sand below	hydroid turf with dense *Antedon*	CR.HCR.XFa
	40.00	14.05	base of rock wall		
	43.00	15.35			

Table A13 Profile data, substrates, dominant biota and biotopes recorded in zones along the rocky reef transect at Rubha Riabhach S

Feature	Tape distance (m)	Depth below CD (m)	Substrate	Biogenic features of zone	Biotopes
marker	0.00	5.35	2 metal pitons in rock crevice		
zone 2			smooth undulating rock, then rock slope	*L. saccharina* common with abundant *Psammechinus*	IR.LIR.KVS.LsacPsaVS
	5.00	5.05			
	10.00	6.05			
	15.00	6.45			
	20.00	6.35			
zone 1 / 2 boundary	22.00	7.25			
zone 1			smooth silted bedrock slope with occasional boulders	hydroids, ascidians and abundant *Psammechinus*	CR.LCR.BrAs.AmenCio
	25.00	8.45			
	30.00	10.95			
	35.00	13.85			
	40.00	15.75			
base of rock slope	43.00	16.65			
	45.00	16.95	sandy mud plain	*Virgularia* and *Pennatula*	

Table A14 Abundance of biota within zones along rocky reef transect at Woodhall. Abundance given (#) is on the MNCR SACFOR scale (Superabundant, Abundant, Common, Frequent, Occasional, Rare, Present)

Zone and taxa	**#**	**comments**
Zone 1		
Hydrozoa indet.	C	
Alcyonium digitatum	O	
Balanus spp.	C	
Pagurus berhardus	O	
Liocarcinus sp.	R	
Necora puber	P	
Modiolus modiolus	C	
Asterias rubens	O	
Echinus esculentus	F	
Rhodophyceae indet. foliose	R	
Zone 2		
Pachymatisma johnstonia	R	large colony present
Haliclona cinerea?	P	
Halecium halecinum	F	
Abietinaria abietina	O	
Nemertesia antennina	C	
Nemertesia ramosa	P	
Alcyonium digitatum	C	locally S
Sagartia elegans	P	
Balanus crenatus	O	
Caprellidae indet.	P	on *Nemertesia antennina*
Cancer pagurus	F	
Necora puber	F	
Antedon bifida	R	
Antedon petasus	R	
Solaster endeca	O	
Crossaster papposus	F	
Asterias rubens	A	
Ophiocomina nigra	A	locally S
Echinus esculentus	A	
Clavelina lepadiformis	C	
Myoxocephalus scorpius	R	
Pomatoschistus pictus	O	
Bonnemaisonia hamifera	R	*Trailliella* phase
Corallinaceae indet. pink crust	F	

Table A14 *(continued)*

Zone and taxa	#	comments
Zone 2		
Plocamium cartilagineum	O	
Aglaothamnion hookeri	R	
Cryptopleura ramosa	R	
Delesseria sanguinea	O	the dominant red alga
Phycodrys rubens	O	
Boergeseniella thuyoides	O	
Asperococcus sp.	R	
Zone 3		
Leucosolenia sp.	P	on *Delesseria* on kelp stipes
Halichondria panicea	P	O on kelp stipes
Sarsia eximia	P	C on kelp stipes
Amphisbetia operculata	P	O on kelp stipes
Alcyonium digitatum	F	R on kelp stipes
Urticina felina	F	
Necora puber	F	
Calliostoma zizyphinum	P	
Heteranomia squamula	P	O on kelp stipes
Alcyonidium hirsutum	P	C on kelp stipes
Electra pilosa	P	on red algae on kelp stipes
Crossaster papposus	F	
Henricia sp.	R	
Ophiocomina nigra	S	
Echinus esculentus	A	
Trididemnum cereum	P	F on red algae on kelp stipes
Didemnum maculosum	P	O on red algae on kelp stipes
Ciona intestinalis	P	
Botrylloides leachi	P	O on kelp stipes
Erythrotrichia carnea	R	and R on kelp stipes
Audouinella daviesii	R	and R on kelp stipes
Plocamium cartilagineum	O	
Heterosiphonia plumosa	O	
Cryptopleura ramosa	R	O on kelp stipes
Delesseria sanguinea	C	A on kelp stipes
Membranoptera alata	P	R on kelp stipes
Ectocarpus siliculosus	P	R on kelp stipes
Laminaria hyperborea	C	
Enteromorpha compressa	P	R on kelp stipes

Table A14 *(continued)*

Zone and taxa	#	comments
Zone 4		
Halichondria panicea	P	O on stipes
Abietinaria abietina	O	
Sertularella polyzonias	O	
Obelia geniculata	P	A on kelp fronds and P on stipes
Alcyonium digitatum	F	
Urticina felina	F	
Sagartia elegans	P	
Necora puber	F	
Mytilus edulis	P	O on stipes
Bryozoa sp.	P	O on kelp stipes
Crisia eburnea	R	
Alcyonidium hirsutum	P	on stipes where profuse and long (15cm)
Membranipora membranacea	P	F on kelp fronds
Electra pilosa	P	on red algae, especially *Phycodrys*, on stipes
Bicellariella ciliata	R	
Asterias rubens	A	
Ophiocomina nigra	A	
Echinus esculentus	C	
Clavelina lepadiformis	O	
Erythrotrichia carnea	R	on kelp stipes
Audouinella daviesii	R	on kelp stipes
Bonnemaisonia hamifera	O	*Trailliella* phase
Palmaria palmata	P	C on kelp stipes
Callophyllis laciniata	R	
Plocamium cartilagineum	F	
Aglaothamnion hookeri	R	
Ceramium nodulosum	R	
Halurus flosculosus	R	on kelp stipes
Ptilota gunneri	R	on kelp stipes
Cryptopleura ramosa	C	
Delesseria sanguinea	O	C on kelp stipes
Membranoptera alata	P	C on kelp stipes
Phycodrys rubens	F	
Boergeseniella thuyoides	O	
Polysiphonia stricta	P	C on kelp stipes
Pterosiphonia parasitica	O	
Ectocarpus fasciculatus	R	on kelp stipes
Chorda filum	O	
Laminaria digitata	R	but S in 1–2m band at top of zone
Laminaria hyperborea	A	
Ulva lactuca	R	O on kelp stipes

Table A15 Abundance of biota within zones along rocky reef transect at Rubha nam Faoileann. Abundance given (#) is on the MNCR SACFOR scale (Superabundant, Abundant, Common, Frequent, Occasional, Rare, Present)

Zone and taxa	#	comments
Zone 1		
Pachymatisma johnstonia	R	several large colonies
Halecium halecinum	F	
Abietinaria abietina	O	
Hydrallmania falcata	A	
Nemertesia antennina	C	
Nemertesia ramosa	C	
Alcyonium digitatum	F	
Urticina felina	F	
Pomatoceros spp.	C	
Cancer pagurus	F	
Necora puber	C	
Crisia eburnea	O	
Alcyonidium diaphanum	R	
Antedon bifida	S	patchily distributed
Crossaster papposus	C	
Asterias rubens	A	
Echinus esculentus	C	
Clavelina lepadiformis	R	
Ascidia mentula	C	
Botryllus schlosseri	R	
Crenilabrus melops	O	
Ctenolabrus rupestris	O	
Pholis gunnellus	R	
Audouinella daviesii	R	
Bonnemaisonia hamifera	R	*Trailliella phase*
Plocamium cartilagineum	O	
Aglaothamnion hookeri	R	
Heterosiphonia plumosa	R	
Delesseria sanguinea	R	
Haraldiophyllum bonnemaisonii	R	
Phycodrys rubens	R	
Boergeseniella thuyoides	O	
Pterosiphonia parasitica	R	
Zone 2		
Halecium halecinum	R	
Nemertesia ramosa	R	

Table A15 *(continued)*

Zone and taxa	#	comments
Zone 2		
Alcyonium digitatum	R	
Sagartia elegans	R	
Antedon bifida	A	locally S
Crossaster papposus	A	
Asterias rubens	A	
Clavelina lepadiformis	R	
Trididemnum cereum	R	
Ascidiella aspersa	C	
Botryllus schlosseri	R	
Erythrotrichia carnea	R	
Audouinella daviesii	R	
Bonnemaisonia hamifera	R	*Trailliella* phase
Callophyllis laciniata	R	
Plocamium cartilagineum	F	
Ceramium nodulosum	R	
Delesseria sanguinea	C	
Phycodrys rubens	O	
Boergeseniella thuyoides	R	
Polysiphonia stricta	R	
Pterosiphonia parasitica	R	
Ectocarpus fasciculatus	R	
Dictyota dichotoma	R	
Chorda filum	P	
Laminaria hyperborea	C	
Enteromorpha compressa	R	
Zone 3		
Leucosolenia sp.	P	on red algae on kelp stipes
Halichondria panicea	P	dense on some kelp stipes
Myxilla rosacea	R	
Obelia geniculata	P	locally S on kelp fronds
Urticina felina	C	
Sagartia elegans	F	
Balanus crenatus	P	on *Gibbula cineraria*
Gibbula cineraria	P	
Calliostoma zizyphinum	P	on kelp stipes
Alcyonidium hirsutum	R	
Eucratea loricata	P	C on kelp stipes

Table A15 *(continued)*

Zone and taxa	**#**	**comments**
Zone 2		
Membranipora membranacea	P	locally C on kelp fronds and on stipes
Electra pilosa	P	on red algae on kelp stipes
Antedon bifida	A	
Asterias rubens	A	
Echinus esculentus	C	
Clavelina lepadiformis	C	
Trididemnum cereum	P	on red algae; profuse on *Delesseria* on kelp stipes
Trididemnum cereum	P	profuse on red algae on kelp stipes
Didemnum maculosum	P	on red algae on kelp stipes
Ascidiella scabra	R	
Erythrotrichia carnea	P	R on kelp stipes
Audouinella daviesii	P	R on kelp stipes
Bonnemaisonia hamifera	R	
Corallinaceae indet. pink crust	O	
Plocamium cartilagineum	R	
Halurus flosculosus	P	O on kelp stipes
Ptilota gunneri	P	O on kelp stipes
Heterosiphonia plumosa	S	
Cryptopleura ramosa	R	O on kelp stipes
Delesseria sanguinea	R	but A on kelp stipes
Membranoptera alata	P	F on kelp stipes
Phycodrys rubens	R	
Boergeseniella thuyoides	R	
Odonthalia dentata	O	
Pterosiphonia parasitica	R	
Ectocarpus sp.	R	
Leptonematella fasciculata	R	
Scytosiphon lomentaria	R	
Dictyota dichotoma	R	
Desmarestia aculeata	R	
Laminaria hyperborea	A	
Laminaria saccharina	R	
Ulva lactuca	R	

Table A16 Abundance of biota within zones along rocky reef transect at Rubha Riabhach S. Abundance given (#) is on the MNCR SACFOR scale (Superabundant, Abundant, Common, Frequent, Occasional, Rare, Present)

Zone and taxa	#	comments
Zone 1		
Suberites domuncula	P	
Esperiopsis fucorum	R	
Myxilla incrustans	R	
Halecium halecinum	O	
Halopteris catharina	R	
Kirchenpaueria pinnata	R	
Nemertesia antennina	R	
Alcyonium digitatum	R	
Pomatoceros spp.	F	
Serpula vermicularis	C	
Pagurus bernhardus	F	
Munida rugosa	F	
Inachus phalangium	R	
Liocarcinus depurator	F	
Necora puber	O	
Carcinus maenas	O	
Trivia monacha	O	
Modiolus modiolus	F	
Aequipecten opercularis	C	
Chlamys varia	R	
Crossaster papposus	O	
Asterias rubens	A	
Ophiothrix fragilis	P	
Psammechinus miliaris	A	
Echinus esculentus	C	
Diplosoma listerianum	R	
Ascidiella aspersa	F	
Ascidia mentula	F	
Pyura microcosmus	F	
Pomatoschistus minutus	F	
Brown diatom film	A	
Corallinaceae indet. pink crust	O	

Table A16 *(continued)*

Zone and taxa	#	comments
Zone 2		
Hydractinia echinata	R	on *Pagurus bernhardus* shell
Halecium halecinum	R	
Obelia dichotoma	R	
Obelia geniculata	P	locally O on kelp fronds
Alcyonium digitatum	R	
Serpula vermicularis	O	
Caridea indet.	R	
Pagurus bernhardus	F	
Hyas araneus	R	
Liocarcinus depurator	F	
Necora puber	F	
Carcinus maenas	O	
Polyplacophora indet.	R	
Gibbula cineraria	P	locally C on kelp
Modiolus modiolus	O	in isolated clumps
Membranipora membranacea	P	locally R on kelp fronds
Solaster endeca	O	
Crossaster papposus	F	
Asterias rubens	C	
Ophiothrix fragilis	R	
Psammechinus miliaris	A	locally S
Diplosoma listerianum	R	especially on serpulid tubes
Ascidia mentula	R	
Pyura microcosmus	O	
Pomatoschistus minutus	F	
Pomatoschistus pictus	F	
Corallinaceae indet. pink crust	O	
Phycodrys rubens	R	
Boergeseniella thuyoides	R	
Polysiphonia elongata	R	
Polysiphonia stricta	R	
Laminaria saccharina	C	

Table A17 Draft Site Attribute Table for the reef habitats of Loch Creran

Attribute	Target	Prescription	Result of Monitoring
Extent	No change in extent of inshore sublittoral rock allowing for natural succession or known cyclic change	At six year intervals review activities and events with the potential to reduce extent of feature such as land reclamation and shoreline development	No relevant activities seen or previously reported
	No change in extent of inshore sublittoral rock allowing for natural succession or known cyclic change	At six year intervals assess the extent of the inshore sublittoral rock feature by diver survey	Baseline established along diver transects in 2005
	No change in extent of *Serpula vermicularis* reefs allowing for natural succession or known cyclic change	At six year intervals review activities and events with the potential to reduce extent of feature such as land reclamation and shoreline development, fishing and recreational activity	Reef extent known to be reduced locally by bottom gear, presumed to be scallop dredges, in 1998 and dredge tracks confirmed as widespread from sidescan sonar surveys in 2001, 2004 and 2005. Extent has also been reduced by fishfarm activities at South Shian and Sea Life Centre Bay and boat moorings at South Shian. Strings of whelk pots were deployed in reef areas in 2004 and probably caused damage. Additional areas of damage identified in 2004 and 2005 but causes unknown. Some recovery of reefs appears to be taking place at Barcaldine, where reefs were once absent in the vicinity of an alginate factory discharge.
	No change in extent of *Serpula vermicularis* reefs allowing for natural succession or known cyclic change	At six year intervals assess the extent of *Serpula vermicularis* reefs by diver survey	Extent of *Serpula vermicularis* reefs established in 2005 as 108ha. No previous data for temporal comparison.
	No change in extent of *Serpula vermicularis* reefs allowing for natural succession or known cyclic change	At 12 year intervals confirm the results of the diver survey and assess reef damage at the following sites using sidescan sonar: Rubha Mór, South Shian, Sea Life Centre Bay, South Creagan.	Baseline established in 2005
	No change in extent of *Modiolus modiolus* (horse mussel) beds allowing for natural succession or known cyclic change	At six year intervals review activities and events with the potential to reduce extent of feature such as land reclamation and shoreline development, fishing and recreational activity	No relevant activities seen or previously reported
	No change in extent of *Modiolus modiolus* beds allowing for natural succession or known cyclic change	At six year intervals assess the extent of *Modiolus modiolus* beds by point station video or diver survey	2005 survey of upper basin bed revealed no change in extent since the 1999 survey by Mair *et al.* (2000). Baseline set for three other beds in 2005.

Table A17 *(continued)*

Attribute	Target	Prescription	Result of Monitoring
Biotope composition of the inshore sublittoral rock	Maintain the variety of biotopes identified for the site, allowing for natural succession or known cyclic change. The following biotopes must be found within the SAC: SS.SBR.PoR.Ser, SS.SBR.SMus.ModHAs, SS.SBR.SMus.ModT, IR.MIR.KR.LhypT.Ft, IR.MIR.KR.LhypT.Pk, IR.LIR.KVS.LsacPsaVS, CR.LCR.BrAs.AmenCio, CR.HCR.XFa	At six year intervals assess the continued existence of reef biotopes recorded along the fixed transects	All biotopes confirmed as present in 2005
Distribution of biotopes. Spatial arrangement of biotopes at specified locations	Maintain the distribution and spatial arrangement of biotopes, allowing for natural succession or known cyclic change	At six year intervals confirm the geographic distribution of reef biotopes along the relocatable transects	Baselines established in 2005
Extent of representative or notable biotope	No change in extent of the biotopes identified for the site allowing for natural succession or known cyclic change. No change in the extent (range along transect and depth range) of selected biotopes along the fixed transects in which they were found during the baseline survey	Every six years assess the extent of specified biotopes along established fixed relocatable transects	Baselines established in 2005
Species composition of representative or notable biotopes	No decline in biotope quality due to change in species composition or loss of notable species allowing for natural succession or known cyclic change. No change in species composition and diversity (allowing for natural succession or known cyclic change) in the following biotopes at the transects where they were recorded in the baseline survey: SS.SBR.PoR.Ser, SS.SBR.SMus.ModHAs, SS.SBR.SMus.ModT, IR.MIR.KR.LhypT.Ft, CR.HCR.XFa	Every six years assess species composition and diversity by means of MNCR Phase 2 surveying and presence / absence survey of biota on serpulid reefs	No change in diversity of biota on serpulid reefs at 3 sites between 2001 and 2005. No change in diversity of *Modiolus* bed community in upper basin SS.SBR.SMus.ModHAs biotope between 1999 and 2005. Slight temporal differences observed at the serpulid reef and *Modiolus* bed sites can be considered as natural succession
	No decline in biotope quality due to change in species composition or loss of notable species allowing for natural succession or known cyclic change. No change in associated community composition and diversity (allowing for natural succession or known cyclic change) of the biotope SS.SBR.SMus.ModHAs	Every six years collect four replicate clumps of *Modiolus* from station 3 on transect 1 in the upper basin and assess species composition and diversity of associated biota	Slight changes in diversity and composition between 1999 and 2005 considered as natural succession

Table A17 *(continued)*

Attribute	Target	Prescription	Result of Monitoring
	Presence and abundance of specified species	Maintain presence and abundance of specified species. No reduction in the abundance of live *Modiolus* and serpulid reefs at specified survey locations	No change in overall abundance of *Modiolus* (as measured by percentage cover of the seabed) along the relocatable transects through the upper basin *Modiolus* bed between 1999 and 2005. A reduction observed at two stations in 2005 could be considered due to natural temporal variation and may have been caused by the low recruitment observed for this bed. No reduction was observed in the abundance of serpulid reefs (as measured by percentage cover of the seabed) between surveys at the same site (Rubha Mór) in 2000 and 2005

LOCH CRERAN SAC SITE CONDITION MONITORING 2005

FIELD LOG

Compiled by:

Colin G. Moore
School of Life Sciences
Heriot–Watt University
Riccarton
Edinburgh EH14 4AS

Staff involved:

Colin Moore (CM)	Heriot-Watt University
Graham Saunders (GS)	Scottish Natural Heritage
Hamish Mair (HM)	Heriot-Watt University
Alastair Lyndon (AL)	Heriot-Watt University
Dan Harries (DH)	Heriot-Watt University
Dan Edwards (DE)	Heriot-Watt University
Nick Moore (NM)	Heriot-Watt University
Stuart Brown (SB)	Heriot-Watt University
Andy Mogg (AM)	Heriot-Watt University
Jane Hawkridge (JH)	Joint Nature Conservation Committee
Richard Bates (RB)	St Andrews University

6 November 2005

Sunday 10 July

10.30 CM, AL, DH, DE, SB depart from Riccarton campus. In pm workup dives for CM and DE. In evening meet GS for discussions on methodology.

Monday 11 July

08.00 meet and depart in Serpula at 09.15. Delay of about 1 hour due to gear problems. Start peripheral diving transect survey of serpulid reef extent. Worked 9 transects. Finished diving at 16.30.

Tuesday 12 July

08.00 meet and depart in Serpula at 08.55. Worked 18 peripheral transects. Finished at 18.00. Joined in evening by Jane Hawkridge, JNCC.

Wednesday 13 July

08.00 meet and depart in Serpula at 09.15. Worked 16 peripheral transects. Fixed position of mooring used by mussel farm workboats, apparently overlying serpulid reefs. Also fixed position of line of mussel ropes in the central region of the lower basin, which may also be overlying reefs. Finished 18.00.

Thursday 14 July

08.00 meet and depart in Serpula at 09.00. Worked 19 peripheral transects. Finished at 18.00.

Friday 15 July

08.00 meet and depart in Serpula at 09.00. Worked 20 peripheral transects. Finished at 18.00.

Saturday 16 July

Depart in Serpula at 09.15. Worked 15 peripheral transects in lower and upper basins.

Sunday 17 July

08.00 discussion of day's work and preparation of gear. 10.15 depart in Serpula for work along *Modiolus* transect 1. Relocated inner end of transect by GPS fix and confirmed by reference to local features. Dropped shot at position. Laid 200m calibrated groundline with anchor attached at inshore end. DH recorded depths at stations at 20m intervals (by diving) and left buoyed shot at station 3. CM did MNCR phase 2 at station 3, GS still photography at station 3 and HM video along whole transect. DE and SB estimated % cover mussels using 10 0.25m^2 cross–strung quadrats at each station. 4 mussel clumps collected by DH at station 3, 20m to the east of the station marker. AL cleared 5 0.25m^2 quadrats of *Modiolus*. Returned to Creran Moorings 16.00 and measured length of *Modiolus*, with adults being returned to sea. 18.00 HM and DE depart for Edinburgh.

Monday 18 July

Rest day. AM arrived 19.00. AL departed 11.30.

Tuesday 19 July

HM returned. Team now consists of HM, GS, CM, DH, AM. 08.30 depart for upper basin. % cover quadrat surveys along *Modiolus* transect 2 (GS, DH), transect 3 (CM, AM) and transect 4 (HM), then video at station 3 along transect 1 (GS), then 2 peripheral reef transects in upper basin (DH,CM+AM). 17.00 return Creran Moorings. Evening – review video.

Wednesday 20 July

08.30 planning and collection of gear. Attempted to resolve outboard engine problem. 10.20 depart for rocky reef survey at Woodhall. DH recced and found suitable transect position and laid groundline, profiled transect and split into zones. CM did MNCR phase 2, HM video and GS stills. DH retrieved line. 1430 returned Creran Moorings. Outboard taken to Oban for repair. Collected material bottled and preserved. MNCR written up.

Thursday 21 July

10.00 depart for rocky reef survey at Eriska Point. AM checked out site for suitability, then DH laid line, split into biotopes and profiled transect. CM did MNCR phase 2, with GS doing stills and HM video. Then did 3 peripheral serpulid reef transects. Relocated to Rubha Mór where all divers were calibrated for fin kicks against a tape measure. Using reefs at this site, CM produced checklist of associated reef biota for subsequent monitoring work. 18.00 returned to base. Evening – processing samples and data entry.

Friday 22 July

08.00 meet to discuss plans and organise gear. 09.15 depart for Columba seamount (rocky reef site, aka Rubha Riabhach S). DH recced area and laid line at NE end and profiled transect. CM did MNCR phase 2, GS stills and HM video. AM laid concrete block at base of rock slope for marker. Tested out serpulid reef video quantification technique at Rubha Mór. Redid some of the peripheral transects done on day 1, as GPS originally supplied some suspect positions.

Saturday 23 July

Late start due to change in domestic arrangements and gear preparation for video survey of serpulid reefs. 10.30 depart for Rubha Mór. GS and AM started video transects but experienced significant compass deviation problems. Resolved by having lead diver with compass and following diver videoing. CM and DH did 8 transects and GS 2. Then did MNCR phase 2 survey (DH), presence / absence of reef biota on 10 reefs (CM), video and stills (GS). 19.00 returned to base. Evening – write-up and data collation.

Sunday 24 July

09.15 depart for South Shian. Did 10 video transects (HM, AM), MNCR phase 2 survey (DH), presence / absence of reef biota (CM), stills and video (GS). Redid 4 peripheral reef transects done on first day. Took GPS position and photographed workboat anchored in reef area at Rubha Mór.

Monday 25 July

08.30 depart for 8 peripheral reef transects in upper basin. Followed by 10 serpulid video transects in Sea Life Centre Bay (HM, AM). DH did MNCR phase 2, CM presence / absence survey, GS stills and video survey. Finally did *Modiolus* % cover transect at Creagan (HM, AM).

Tuesday 26 July

a.m. GS departs for Edinburgh. 08.30 depart base for Creran mouth. Worked *Modiolus* % cover transects at two sites (HM+AM and CM+DH). Then 10 serpulid video transects at Butterchurn Bay (HM,AM), followed by MNCR phase 2 (DH), presence / absence survey (CM), still photography (CM) and video (HM). 17.00 returned to base. 18.30 HM. DH and AM depart for Edinburgh.

Monday 5 September

Staff: CM, RB, NM, HM

09.15 set up Submetrix bathymetric system on *Serpula* and surveyed upper basin and NE part of lower basin on south side. 20.00 returned to base.

Tuesday 6 September

08.18 depart base. Bathymetric survey of south coast of lower basin and western part of lower basin. Sidescan sonar survey of Rubha Mór and start survey of South Shian. 19.17 return to base.

Wednesday 7 September

08.05 depart base. Bathymetric survey of eastern half of lower basin. Sidescan sonar survey of Sea Life Centre Bay. 18.24 return to base.

Thursday 8 September

07.52 depart base. Sidescan sonar survey of Butterchurn Bay (aka South Creagan) and finish survey of South Shian. 12.05 return to base. Unload equipment and demob.

Friday 9 September

Sidescan returned to Aberdeen by van.

Tuesday 1 November

CM and NM mobilised to Creran for drop-down video groundtruthing of sidescan.

Wednesday 2 November

08.00 setup video system on *Serpula*. Performed video drifts along transects at Rubha Mór and South Shian. Also across dense trawl track area off Sea Life Centre Bay. 15.45 return to base as light too low.

Thursday 3 November

08.45 depart Creran Moorings on *Serpula* for video transects at Butterchurn Bay and Sea Life Centre Bay. Also recorded fishfinder readings at several contours at both sites to check accuracy of bathymetric sidescan bathymetry. Redid video in trawl track area but still too little light to discern tracks. 13.30 returned base. NM returned to Edinburgh.

Friday 4 November

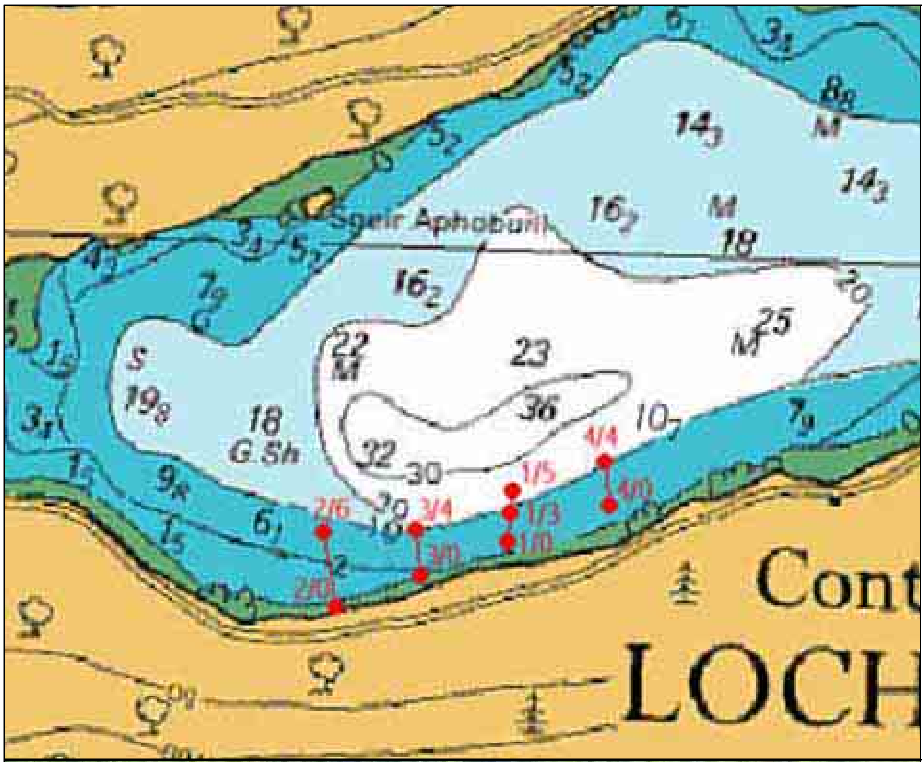
Joined by dive team (CM, AL, DH, AM, SB). 10.30 depart Creran Moorings in Serpula. Still photography of dredge damage at Rubha Mór (CM) and of mooring damage off South Shian (CM). To check / adjust georectification of sidescan mosaic off Rubha Mór, GPS positions taken when diver located conspicuous features on the sidescan image and at various points along one of the dredge tracks (DH). 16.45 returned to base.

Saturday 5 November

09.30 depart Creran Moorings in *Serpula*. Repeated diver transects of peripheral serpulid reef band at sites 12 (DH) and 10 (CM). Groundtruthed apparent dense trawl track area off Sea Life Centre Bay by diver inspection (CM). 15.00 returned to base. Demobbed to Edinburgh.

TRANSECT RELOCATION FORM – LOCH CRERAN SCM 2005

Transect name	Upper Basin 1	**Type**	*Modiolus* reef
Full site code	LC05MM01		
INNER END position (WGS84):	56.54548ºN 5.26897ºW	**Depth (m):**	5.5
OUTER END position (WGS84):	56.54625ºN 5.26890ºW	**Depth (m):**	26.8
Transect bearing (ºT)	0	**Transect length (m)**	100



Location of all upper basin transects.

1/0 = station 0 along transect 1 etc.

1/3 = site of MNCR phase 2 survey

Photo no. dsc04643.jpg

View of inner transect buoy.

GPS (WGS84): 56.54577ºN 5.26840ºW

Bearing 221ºT

Tidal rise 2.6m

Photo no. dsc04644.jpeg

View of inner transect buoy.

GPS (WGS84): 56.54552ºN 5.26925ºW

Bearing 79ºT

Tidal rise 2.6m

Photo no. dsc04646.jpeg

View of buoys marking (with increasing distance) outer end, station 3 and inner end of transect.

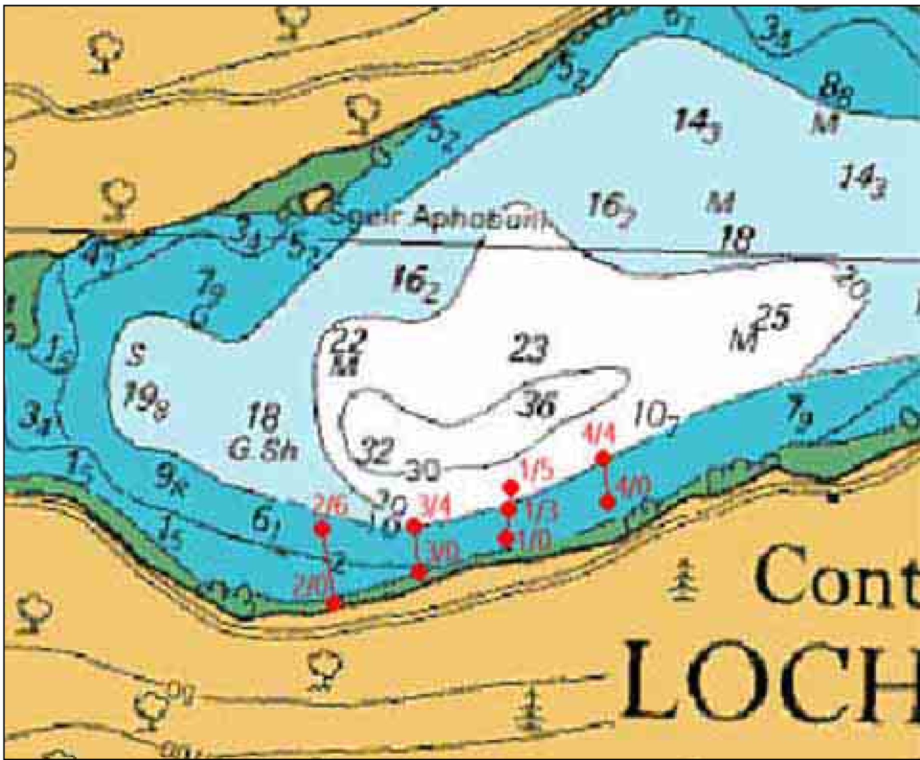
GPS (WGS84): 56.54668ºN 5.26870ºW

Bearing 186ºT

Tidal rise 2.6m

TRANSECT RELOCATION FORM – LOCH CRERAN SCM 2005

Transect name	Upper Basin 2	**Type**	*Modiolus* reef
Full site code	LC05MM02		
INNER END position (WGS84):	56.54445ºN 5.27348ºW	**Depth (m):**	6.5
OUTER END position (WGS84):	56.54553ºN 5.27390ºW	**Depth (m):**	26.9
Transect bearing (ºT)	344	**Transect length (m)**	120



Location of all upper basin transects.

2/0 = station 0 along transect 2 etc.

Photo no. dscf2510.jpg

View of inner transect buoy (on left).

GPS (WGS84): 56.54468ºN 5.27395ºW

Bearing 129ºT

Tidal rise 1.0m

Photo no. dscf2511.jpeg

View of inner transect buoy (on left).

GPS (WGS84):
56.54467ºN
5.27327ºW

Bearing 204ºT

Tidal rise 1.0m

Photo no. dscf2513.jpeg

View inshore along transect (inner buoy arrowed).

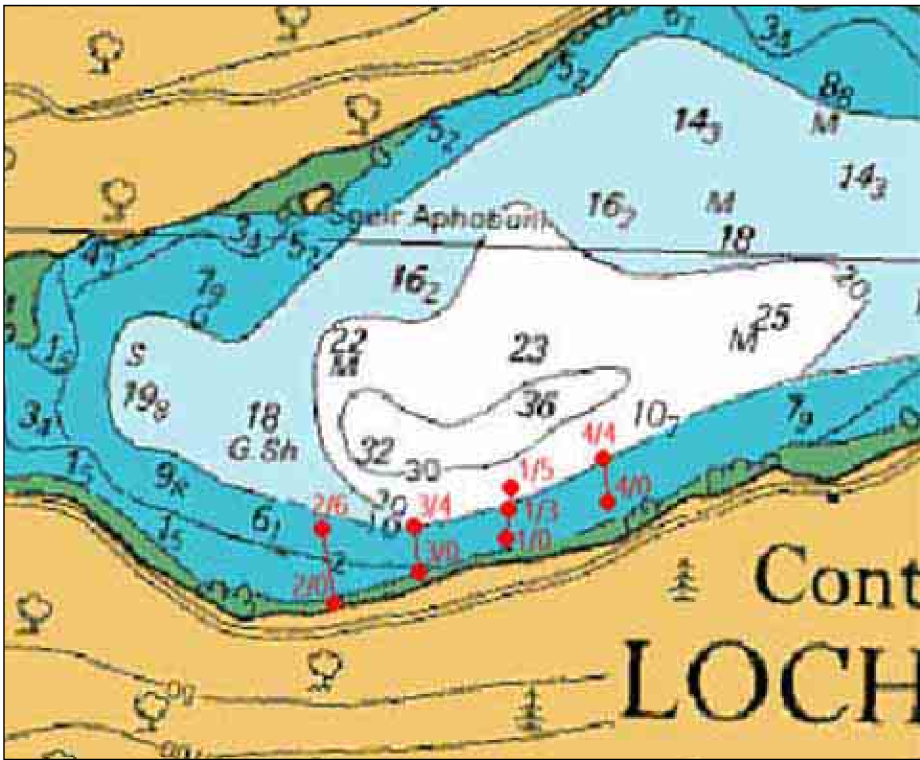
GPS (WGS84):
56.54590ºN
5.27433ºW

Bearing 164ºT

Tidal rise 1.0m

TRANSECT RELOCATION FORM – LOCH CRERAN SCM 2005

Transect name	Upper Basin 3	**Type**	*Modiolus* reef
Full site code	LC05MM02		
INNER END position (WGS84):	56.54495ºN 5.27127ºW	**Depth (m):**	4.8
OUTER END position (WGS84):	56.54562ºN 5.27147ºW	**Depth (m):**	25.0
Transect bearing (ºT)	349	**Transect length (m)**	80



Location of all upper basin transects.

3 / 0 = station 0 along transect 3 etc.

Photo no. dscf2514.jpg

View of inner transect buoy (buoy on left in centre of view).

GPS (WGS84): 56.54543ºN 5.27087ºW

Bearing 194ºT

Tidal rise 1.1m

Photo no.
dscf2515.jpg

View of inner transect buoy (buoy on left).

GPS (WGS84):
56.54523ºN
5.27158ºW

Bearing 134ºT

Tidal rise 1.1m

Photo no.
dscf2516.jpg

View inshore along transect (inshore buoy arrowed).

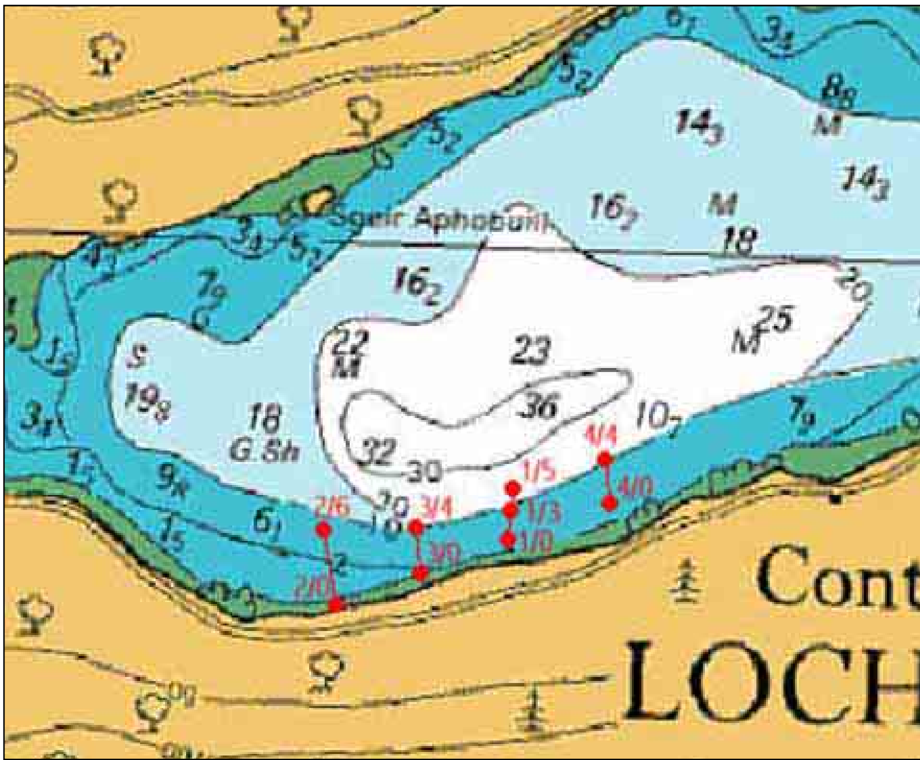
GPS (WGS84):
56.54617ºN
5.27145ºW

Bearing 169ºT

Tidal rise 1.2m

TRANSECT RELOCATION FORM – LOCH CRERAN SCM 2005

Transect name	Upper Basin 4	**Type**	*Modiolus* reef
Full site code	LC05MM04		
INNER END position (WGS84):	56.54608ºN 5.26632ºW	**Depth (m):**	7.5
OUTER END position (WGS84):	56.54673ºN 5.26647ºW	**Depth (m):**	29.0
Transect bearing (ºT)	344	**Transect length (m)**	80



Location of all upper basin transects.

4 / 0 = station 0 along transect 4 etc.

Photo no. dscf2524.jpg

View of inner transect buoy (buoy on right).

GPS (WGS84): 56.54625ºN 5.26618ºW

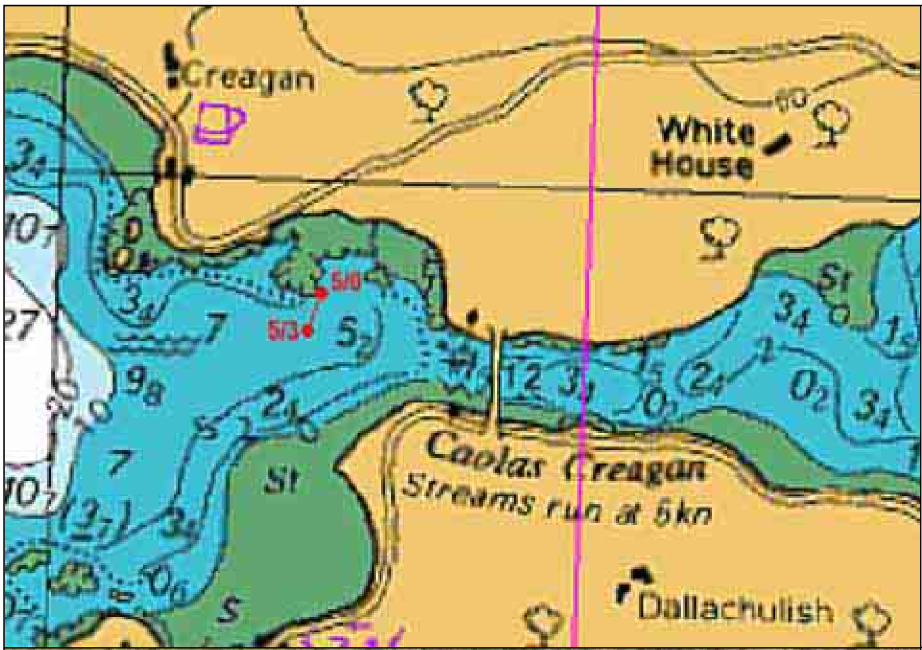
Bearing 204ºT

Tidal rise 1.7 m

	Photo no. dscf2525.jpg View of inner transect buoy (buoy on left). GPS (WGS84): 56.54625ºN 5.26692ºW Bearing 129ºT Tidal rise 1.7m
	Photo no. dscf2526.jpg View inshore along transect (inshore buoy arrowed). GPS (WGS84): 56.54717ºN 5.26677ºW Bearing 164ºT Tidal rise 1.7m

TRANSECT RELOCATION FORM – LOCH CRERAN SCM 2005

Transect name	Creagan	**Type**	*Modiolus* reef
Full site code	LC05MM05		
INNER END position (WGS84):	56.54832ºN 5.29488ºW	**Depth (m):**	5.2
OUTER END position (WGS84):	56.54782ºN 5.29520ºW	**Depth (m):**	10.5
Transect bearing (ºT)	200	**Transect length (m)**	60



Location of transect

5 / 0 = station 0 and
5 / 3 = station 3

Photo no. dscf2623.jpg

View inshore along transect (inshore buoy just behind inflatable).

GPS (WGS84): 56.54770ºN 5.29527ºW

Bearing 12ºT

Tidal rise 0.6m

Photo no. dscf2625.jpg

View of inner transect buoy.

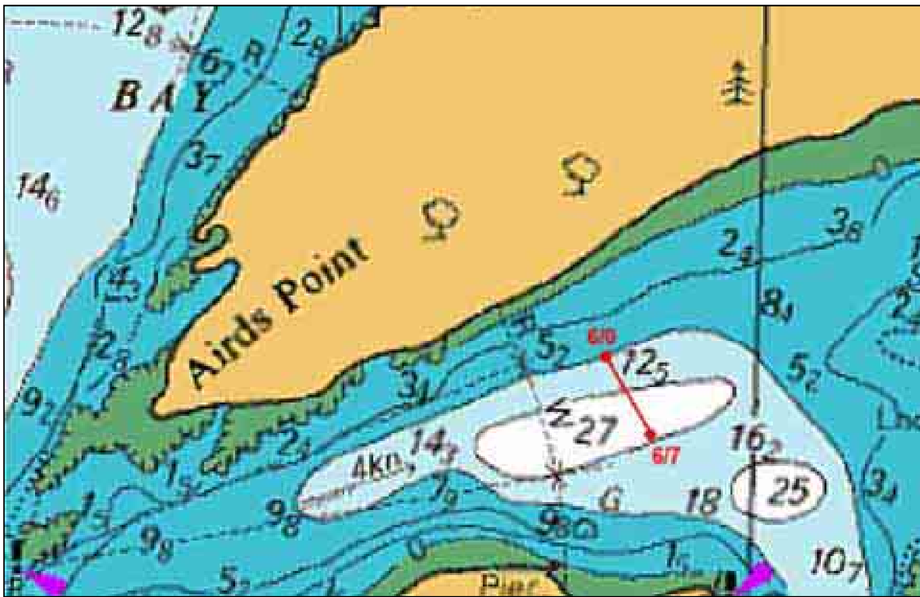
GPS (WGS84): 56.54818ºN 5.29452ºW

Bearing 331ºT

Tidal rise 0.6m

TRANSECT RELOCATION FORM – LOCH CRERAN SCM 2005

Transect name	Creagan Mouth	**Type**	*Modiolus* reef
Full site code	LC05MM05		
INNER END position (WGS84):	56.54010ºN 5.40537ºW	**Depth (m):**	10.1
OUTER END position (WGS84):	56.53900ºN 5.40413ºW	**Depth (m):**	28.4
Transect bearing (ºT)	329	**Transect length (m)**	140



Location of transect

6 / 0 = station 0 and
6 / 7 = station 7

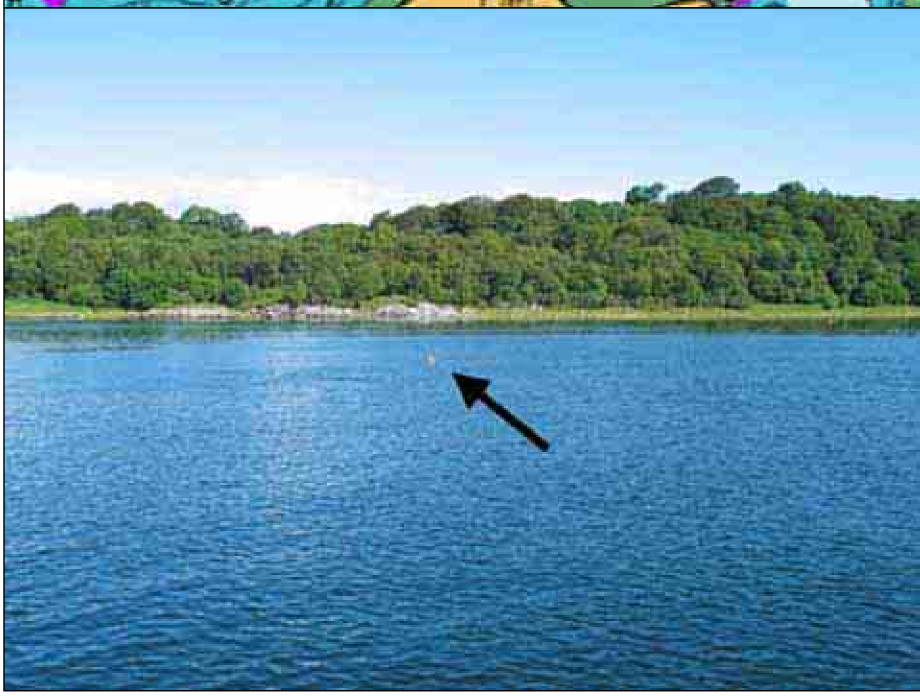


Photo no. creran2_0001.jpg

View of inshore buoy (arrowed).

GPS (WGS84): 56.5393ºN 5.4050ºW

Bearing 345ºT

Tidal rise 3.4m

Photo no.
creran2_0002.jpg

View of inner transect buoy (arrowed).

GPS (WGS84):
56.5393ºN 5.4057ºW

Bearing 14ºT

Tidal rise 3.4m

Photo no.
creran2_0003.jpg

View of outer transect buoy (arrowed).

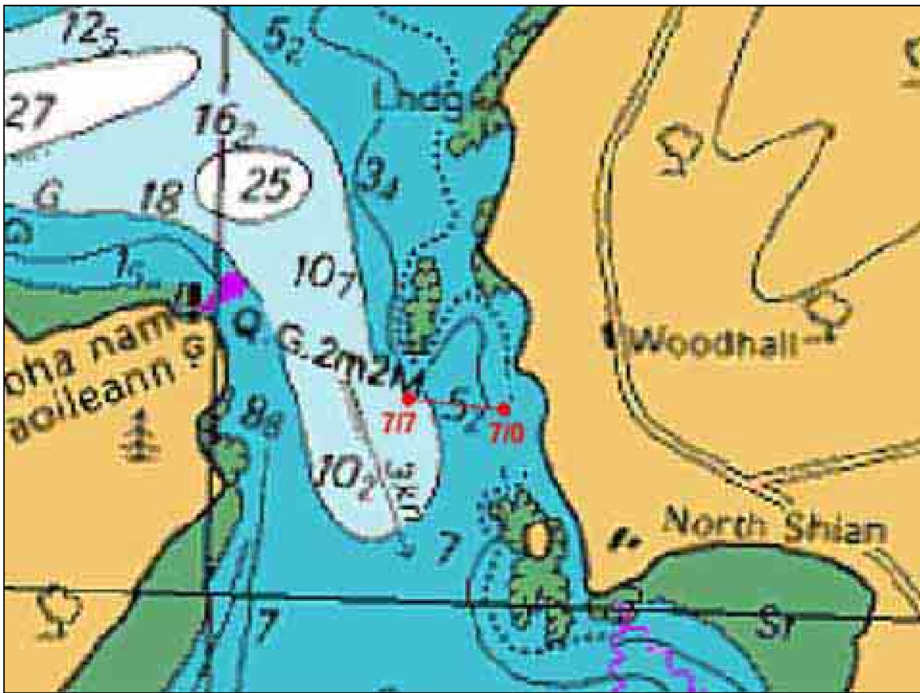
GPS (WGS84):
56.5387ºN 5.4035ºW

Bearing 327ºT

Tidal rise 3.4m

TRANSECT RELOCATION FORM – LOCH CRERAN SCM 2005

Transect name	North Shian	**Type**	*Modiolus* reef	
Full site code	LC05MM07			
INNER END position (WGS84):	56.53573ºN 5.39528ºW	**Depth (m):**		9.5
OUTER END position (WGS84):	56.53580ºN 5.39730ºW	**Depth (m):**		22.9
Transect bearing (ºT)	264	**Transect length (m)**		140



Location of transect

7 / 0 = station 0 and
7 / 7 = station 7

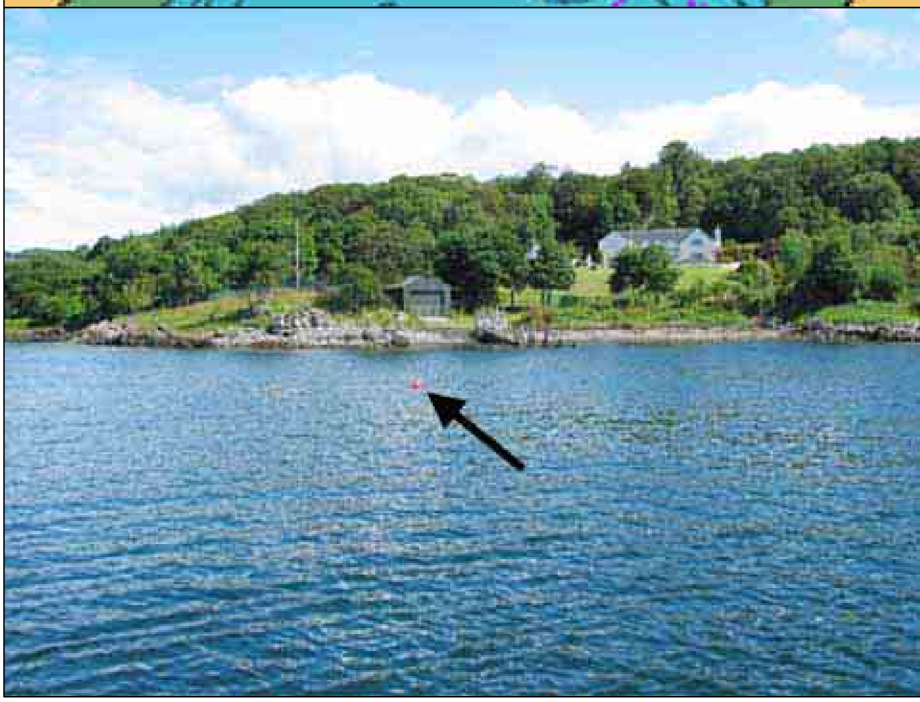


Photo no.
creran2_0005.jpg

View of inshore buoy (arrowed)

GPS (WGS84):
56.53553ºN
5.3955ºW

Bearing 34ºT

Tidal rise 3.0m

Photo no. creran2_0006.jpg

View of inner transect buoy (arrowed).

GPS (WGS84): 56.53573ºN 5.39577ºW

Bearing 89ºT

Tidal rise 3.0m

Photo no. creran2_0007.jpg

View inshore along transect (outer buoy arrowed).

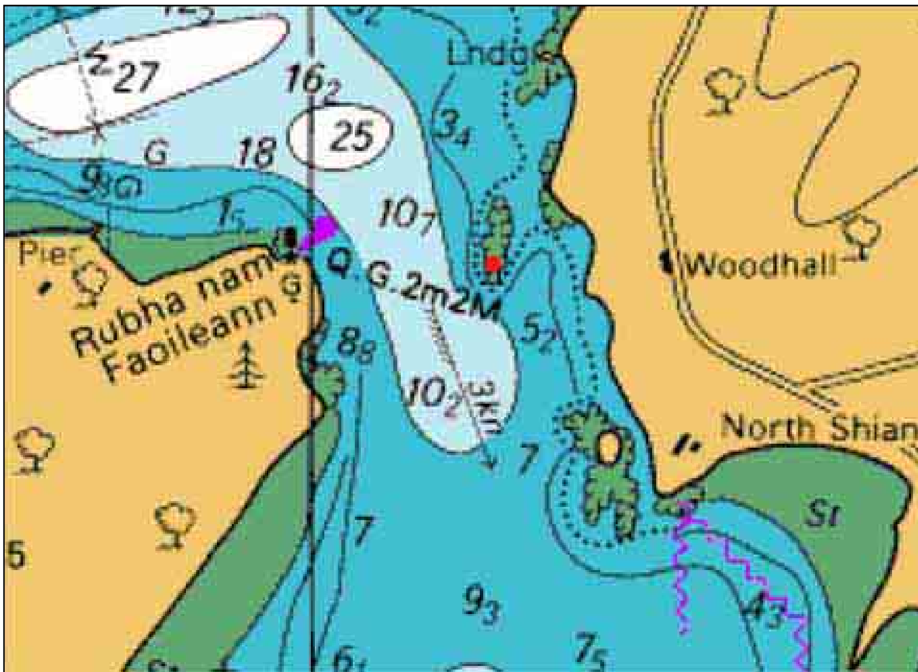
GPS (WGS84): 56.53573ºN 5.39770ºW

Bearing 84ºT

Tidal rise 3.0m

TRANSECT RELOCATION FORM – LOCH CRERAN SCM 2005

Transect name	Woodhall	**Type**	Rock reef
Full site code	LC05SR01		
Marker position (WGS84):	56.53663°N 5.39695°W	**Depth (m):**	–3.5
Transect end position (WGS84):		**Depth (m):**	14.0
Transect bearing (°T)	257	**Transect length (m)**	75



Marker is base of iron mooring ring (red circle) on upper shore

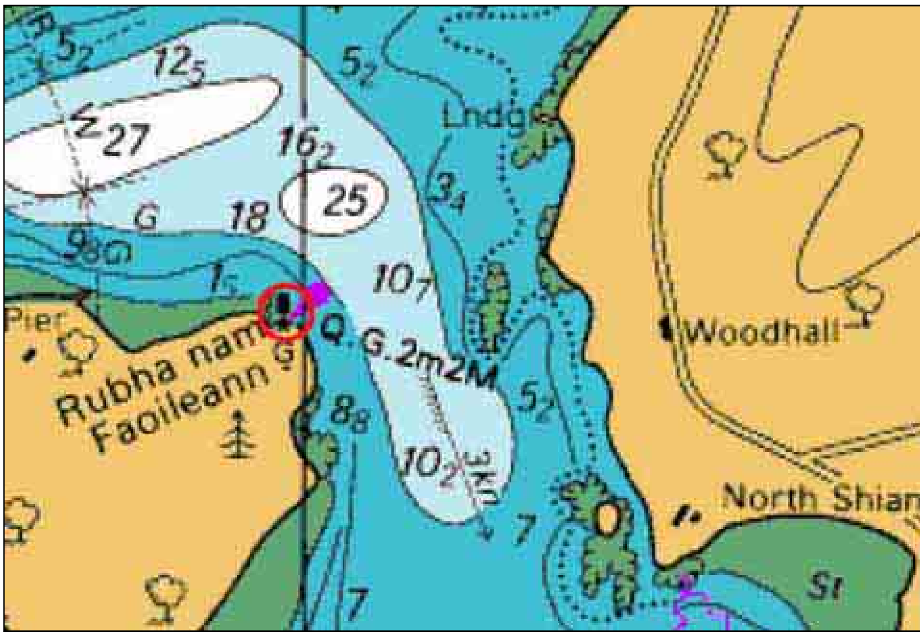
Photo no. DSC04705.jpg

Iron mooring ring (transect marker).

	Photo no. DSC04710.jpg View along line of transect from above mooring ring marker. Tidal rise 1.6m
	Photo no. DSCF2532.jpg View up transect line (arrowed) from offshore. Tidal rise 1.2m

TRANSECT RELOCATION FORM – LOCH CRERAN SCM 2005

Transect name	Rubha nam Faoileann	**Type**	Rock reef
Full site code	LC05SR02		
Marker position (WGS84):	56.53683ºN 5.40148ºW	**Depth (m):**	–4.6
Transect end position (WGS84):		**Depth (m):**	15.4
Transect bearing (°T)	24	**Transect length (m)**	43



Transect marker is base of pole of navigational light at Rubha nam Faoileann (ringed).

N.B. The chart depth contours are grossly inaccurate off this point, the slope being far steeper than charted.

Photo no. creran_0007.jpg

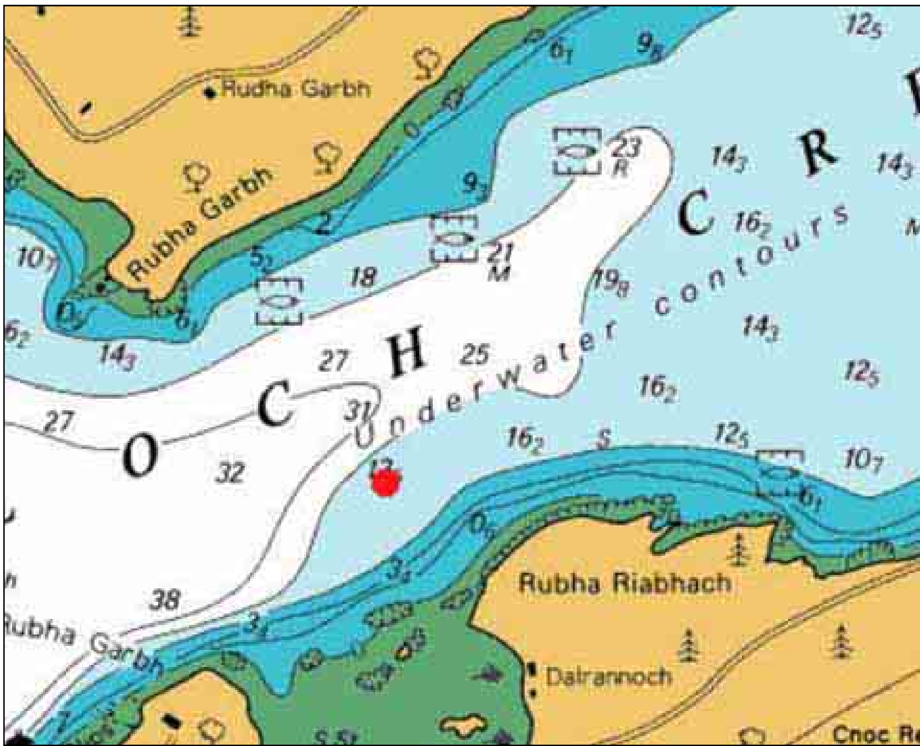
View of transect marker. Tape attached to base of pole.

Tidal rise 1.0m

	Photo no. creran_0004.jpg View from offshore along line of transect. Pillar buoy marks deep end of transect. Bearing 211ºT Tidal rise 2.0m
	Photo no. creran_0006.jpg View down transect line towards target (brown house – arrowed – on opposite side of loch. Bearing 31ºT Tidal rise 1.1m

TRANSECT RELOCATION FORM – LOCH CRERAN SCM 2005

Transect name	Rubha Riabhach S	**Type**	Rock reef
Full site code	LC05SR03		
Marker position (WGS84):	56.52037ºN 5.35858ºW	**Depth (m):**	5.4
Transect end position (WGS84):	56.52073ºN 5.35838ºW	**Depth (m):**	17.0
Transect bearing (°T)	14	**Transect length (m)**	45



Transect marker (red circle) consists of 2 metal pitons in rock crevice at shallow end.

Deep end of transect marked by concrete block at rock / sediment plain junction at depth of 16.7m, 43m along tape.

Photo no. creran_0012.jpg

View along line of transect from shallow end buoy (pillar) to deep buoy (arrowed).

Salmon farm with yellow navigational buoy in background.

GPS (WGS84): 56.5195ºN 5.3590ºW

Bearing 13ºT

Tidal rise 1.6m

Photo no.
creran_0009.jpg

View along line of transect from deep to shallow buoy.

GPS (WGS84):
56.5210ºN 5.3585ºW

Bearing 184ºT

Tidal rise 1.6m

Photo no.
creran_0014.jpg

Type of concrete block marking deep end of transect.

www.snh.gov.uk

Policy and Advice Directorate, Great Glen House,
Leachkin Road, Inverness IV3 8NW
T: 01463 725000

You can download a copy of this publication from the SNH website.

recycle

Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad