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Biotope analysis of archived stills from the SEA7 region of Scotland's seas (2011)

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Contents

1 Introduction: data sources

In 2011, JNCC commissioned SAMS to undertake habitat and taxonomic analysis of seabed photos captured during the following research cruises (Table 1.1) from the broad areas shown in Figure 1.1. More detailed station positions will be given in the corresponding report sections.

Table 1.1. Research crusies on the Hebridean slope

Cruise	Dates	Location
Challenger 26/88	March 1988	Hebridean slope NW of St. Kilda (The "Geikie Bulge")
Charles Darwin 91B	March 1995	NERC *Land-Ocean Interaction Study-Shelf Edge Study* (LOIS-SES) transect, across Hebridean Shelf break and Barra Fan
Charles Darwin 92A	April 1995	LOIS-SES transect
Challenger 121A/B	August 1995	LOIS-SES transect
Challenger 123B	November 1995	LOIS-SES transect
Challenger 125B	February 1996	LOIS-SES transect
Challenger 126B	May 1996	LOIS-SES transect
Challenger 128B	August 1996	LOIS-SES transect
Discovery 230C	February 1998	DTI Tranche 38, 17th Round Licence Block 154/1. Area licenced for hydrocarbon exploration by Enterprise Oil Ltd., NW of Isle of Lewis
Pelagia	May 1998	Areas licenced for hydrocarbon exploration by Statoil (UK) Ltd. and Agip Ltd., NW of Isle of Lewis

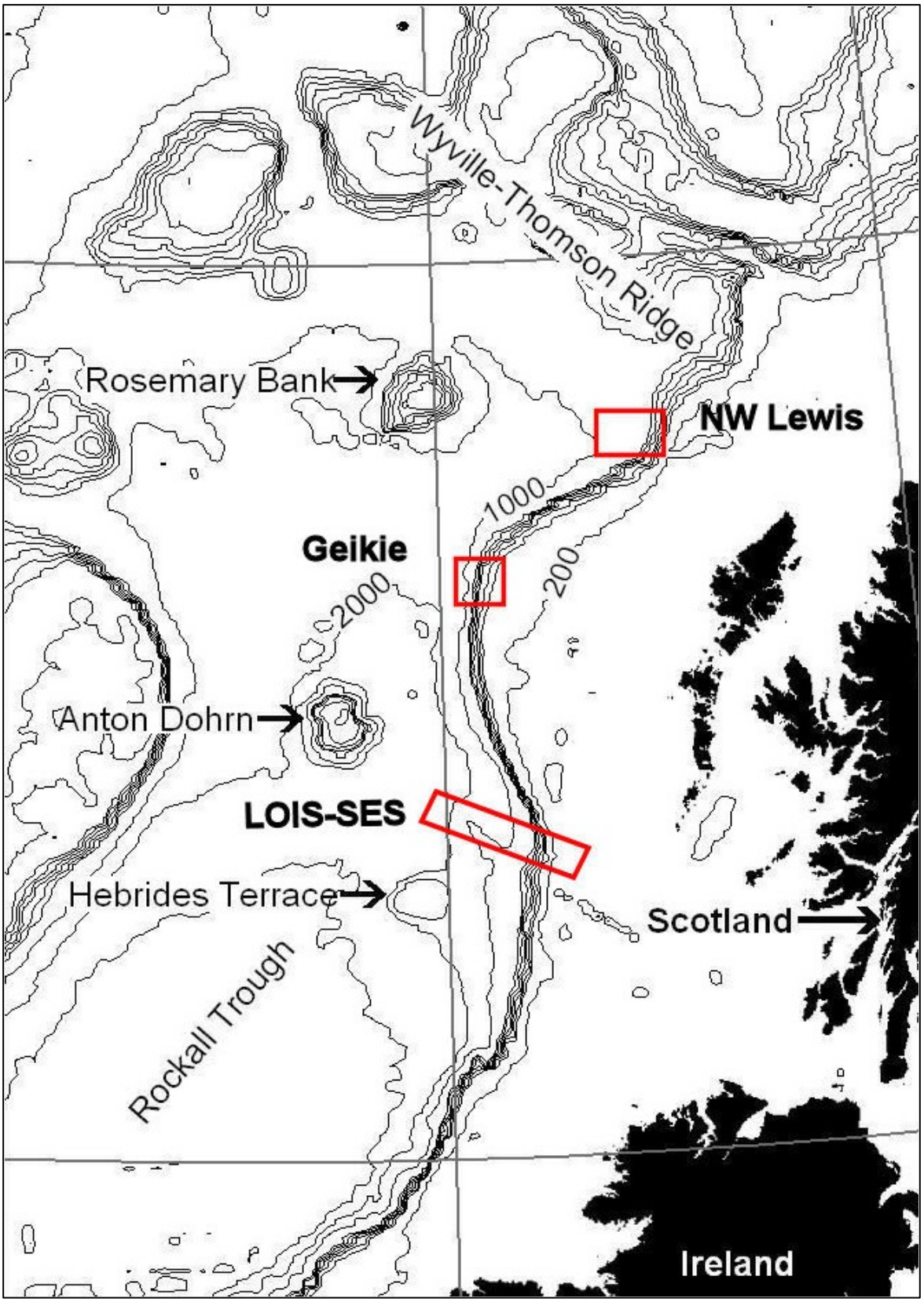

Figure 1.1. Bathymetric chart of the contintental margin west of Scotland, showing the three survey areas discussed in this report.

2 Methods

2.1 Seabed photography

All seabed images were taken using the same photographic system, the Proudman Oceanographic Laboratory (POL) "bed-hop" camera. A 35mm film camera, fitted with a semi-wideangle lens is mounted in a pressure housing near the top of a protective steel frame. The camera looks obliquely downwards and forwards. An underwater flashgun in a pressure housing is mounted near the bottom of the frame and is aligned to illuminate the camera's field of view. The low, oblique lighting maximizes shadow-detail of any seabed topographic relief. A bottom-switch is actuated when a lead weight hanging on a steel cable below it touches the seabed, releasing the tension on the suspension cable. The bottom-switch fires the camera and flash, which wind-on and recharge automatically. The frame also holds a downwards- pointing acoustic pinger which signals at 1-second intervals. When the hanging weight touches the seabed, the bottom-switch doubles the ping rate, telling the operator (listening on the ship's acoustic system) that contact has been made and a picture has been taken. A magnetic compass is mounted on an arm at the bottom right-hand corner of the camera's field of view in order to show the orientation of any current-shaped bedforms. The camera system set up and ready for deployment is shown in the photograph below:

Figure 2.1. The "bed-hop" camera system in its supporting grame, just prior to deployment over the side of a research vessel.

The camera system is lowered on the hydrographic wire from the research vessel. Height above the seabed is monitored by the operator on the ship's echo sounder.

In the absence of subsuface currents it is sometimes possible to lower the system almost vertically; but in heavy swell or if currents are running it may be necessary to pay out

considerably more wire than the straight-line distance to the seabed. The system is lowered rapidly until about 50m from the bottom, at which point the wire is paid out much more slowly in order to make a gentle contact with the bed. The operator listens for the ping rate to change, indicating that a bed contact has been made and a picture has been taken. The system is then raised about 5m on the winch and allowed to hang for approximately 1 minute, giving time for the film to wind-on and the flash gun to recharge. In calm conditions the vessel is allowed to drift passively, so that some distance is covered before the camera is lowered again for the next photographic contact. In windier conditions with a surface swell the vessel is made to steam into the wind at a speed of about 0.5 – 1.0 knot to maintain position on station while giving a short distance between successive seabed contacts. After the first contact, the process is repeated until the maximum number of photographs has been taken. The 35mm camera takes standard 36-exposure film casettes but because of the need to leave some slack in the reel (to facilitate extraction) the number of photographic contacts is normally limited to 25 per deployment. The operator normally records the ship's position and water depth at the time of first and last photographic contacts, and in many deployments these data were collected for all photographs in a sequence. At the time of these surveys the standard medium used in the camera was 125 ISO black and white print film, although colour transparency film has since been used in some later studies. Film was normally processed on-board ship during the cruises discussed here.

2.2 Photographic analysis

The field of view shown in these images is trapezoidal, approximately 2m front to back, 1.3m wide at the lower edge and 2.5m wide across the top. Because of the oblique viewpoint, the upper edge of each photograph is normally dark and the foreground bright, but this light gradient can be corrected-for during the development process to give a relatively even illumination.

In the present study, the original 35mm negative strips were scanned and images saved in JPEG format (filesize typically 800KB – 1MB). Each saved image was given a label indicating survey area (Shelf Edge Study – SES; St. Kilda – SK, North-west Lewis – NWL), station number and negative number (to ensure direct correspondence to the original negative strips). The station numbers used in the original cruises were retained to allow ease of reference to the cruise reports written at the time. Where several camera deployments were made at a single station, as was the case for many of the LOIS-SES stations, the month and year of deployment was also included in the filename assigned to each image.

For analysis in this study, and images largely or completely obscured by silt clouds were excluded (these were created by accidentally striking the seabed too hard, usually in conditions of heavy swell). The photographs analyzed and recorded in the accompanying ExcelTM spreadsheet were selected by starting at the first good image, and then using every subsequent third image, so that eight or nine images were provided by a sequence of 25 or 26. In some deployments many of the photographs were obscured by turbidity or unusable due to failure of the flashgun, so that the number of usable images was much lower. In a few cases only one or a few good photographs per station were obtained.

Shipboard record-keeping during the original cruises was patchy. On most of the LOIS-SES cruises and during the May 1998 NW Lewis survey, the position and water depth of each individual seabed contact was recorded. In February 1998 off NW Lewis, and on the 1988 St. Kilda cruise, data for individual photographs were either not recorded or have not been located (the 1988 data were archived at SAMS in the form of hand-written paper notes made at the time). For these deployments only a nominal station position and water depth are known, probably referring to the point at which the camera system was deployed. The level of precision for image locations is therefore high for most of the LOIS-SES stations but lower

for the St. Kilda and February 1998 NW Lewis areas. However, for the present purposes of large-scale benthic biotope analysis this is not considered to be an important deficiency. From experience of using the "bed-hop" camera system, the pictures taken on a typical 25-exposure deployment will usually be taken within a radius of at most a few hundred metres and often much less (there are recorded instances of photographs showing marks made on the seabed by earlier contacts in the same deployment). The camera is designed for use on flat seabeds and is not usually risked over steep or rugged benthic topography. Water depth seldom changes over more than 5m during a typical 25-exposure deployment. In deep-sea settings, in water depths of hundreds or thousands of metres, such small variations will be entirely insignificant. For deployments with only a single station position and depth datum, the images record the seabed within a very small radius of the nominal position and can be taken as replicate samples of the benthic environment at that location.

3 Results

3.1 Benthic environments and biological communities at the photographic stations

The following sections provide short descriptive summaries of the seabed features and biota visible on the photographs analysed at each station. In order to provide the most comprehensive overview possible, the following descriptions are based on all of the available photographs from each station. For each of the three broad survey areas, stations are listed and described in order of increasing water depth, i.e. progressing from the shallowest to the deepest stations.

3.1.1 Land-Ocean Interaction Study - Shelf Edge Study (LOIS-SES) transect

The NERC-funded LOIS-SES programme was an intensive multidisciplinary study of biogeochemical processes occurring across the Hebridean continental slope. Physical, chemical, hydrographic and biological data were collected on a series of 19 cruise legs of the RRS *Challenger* and *Charles Darwin* between March 1995 and September 1996.

Observations were made at a series of stations along two transects (north and south) extending from just short of the Hebridean shelf break (~ 140m depth) and extending down the Barra Fan (north-east of the Hebrides Terrace Seamount) to the floor of the Rockall Trough at ~ 2000m. The positions of the stations along the transect are shown in the chart below (Station N2000 was located outside the bounds of this figure):

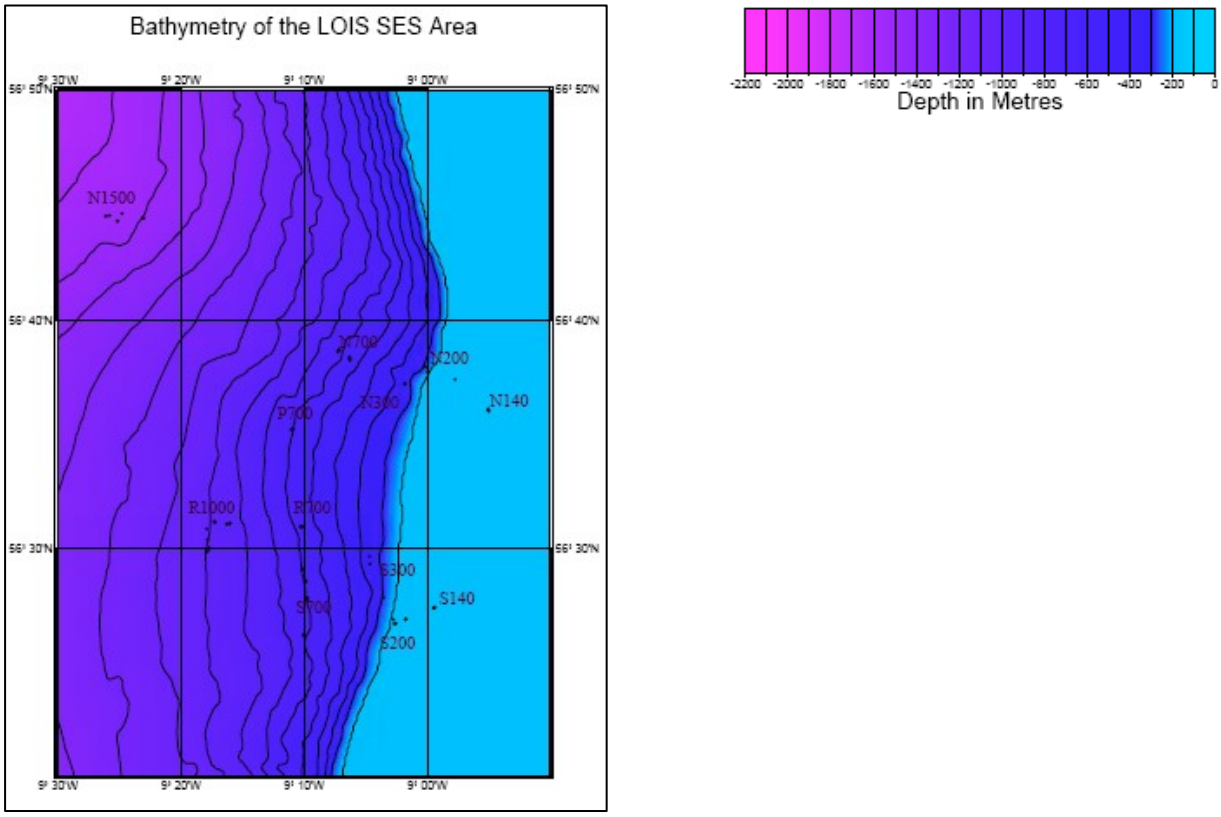

Figure 3.1. Bathymetry of the Hebridean continental slope in the LOIS-SES study area, showing the positions of the photographic stations discussed in this report. Figure reproduced from the LOIS-SES dataset CD-ROM (NERC, 1999).

Table 3.1. LOIS-SES transect: summary of benthic habitats and biota observed at each station.

Station	Depth (m)	Habitat(s)	Species identified	Comments
S5	172-175	Fine mud with megafaunal burrows	*Pennatula phosphorea,* possibly *Sagaertiogeton laceratus.* Burrowers probably include *Calocaris macandreae* and *Nephrops norvegicus*	May be assignable to circalittoral biotope SS.SMu.CfiMu.MegMax.
N140	134-140	Rippled sand, with or without embedded cobbles	*Cidaris cidaris*, unidentified encrusting epifauna on cobbles	
S140	146-150	Rippled sand, rippled sand with embedded cobbles, rippled very coarse sand/fine gravel	*Echinus esculentus, Luidia ciliaris,* unidentified small ophiuroids and sea stars, encrusting epifauna on cobbles	
N200	227	Coarse gravel with variable content of larger stones, up to small boulder size	Very little biota visible. *Munida* sp. and small unidentified sea star	
S200	152-185	Rippled sand without larger stones, coarse gravel, dense cobble fields	Encrusting and upright sessile epifauna on cobbles, *Molva molva*, possible small octopus	Varied benthic topography indicating high degree of spatial patchiness. All high-energy environments.
N300	345	Flat or slightly rippled gravelly sand with cobble patches	Very little biota visible. Small unidentified sea star.	
S300	279-348	Flat or rippled gravelly sand with scattered pebbles and cobbles	*Ophiura* sp., *Aequipecten* sp., *Munida* sp., *Eledone cirrhosa, Molva molva*, unidentified Sabellidae, unidentified small sea star	
N700	686-732	Fine sand or muddy sand with occasional burrows and many epifaunal trails	*Ophiocten gracilis* (abundant), *Spatangus raschi, Cidaris cidaris*, *Gracilechinus* sp., *Stichopus tremulus, Troschelia berniciensis,* unidentified hermit crabs, *Synaphobranchus kaupi.* Cerianthid anemones abundant in August 1996, not observed in March 1995	Contrast in cerianthid abundance may indicate patchy distribution and/or seasonal emergence.
P700	704-707	Fine sand or muddy sand with epifaunal trails	*Ophiocten gracilis* (abundant), cerianthids (abundant), *Spatangus raschi, Gracilechinus* sp., *Munida* sp., *Synaphobranchus*	As at N700, cerianthids visible in August 1996.
R700	659-671	Fine sand or muddy sand with epifaunal trails	*Ophiocten gracilis* (abundant), cerianthids (abundant), *Spatangus raschi, Gracilechinus* sp., *Synaphobranchus kaupi.*	As at N700 and R700, cerianthids visible in August 1996.

Station	Depth (m)	Habitat(s)	Species identified	Comments
S700	698-707	Fine sand or muddy sand with many epifaunal trails and occasional burrow openings	*Ophiocten gracilis* (abundant), *Spatangus raschi, Gracilechinus* sp., *Luidia sarsi, Stichopus tremulus, Troschelia berniciensis, Synaphobranchus kaupi.* Cerianthids abundant in December 1995, April 1996, July 1996. Not observed in April 1995, August 1995.	Lack of consistent pattern in cerianthid presence suggests spatial patchiness rather than seasonal emergence.
R1000	982-1004	<u>April 1995:</u> Current-smoothed muddy sand with scattered fine gravel, occasional larger stones	Very few visible fauna: *Gracilechinus* sp., unidentified ophiuroid, unidentified arachnactid anemone	A few trawl marks
		<u>December 1995, August 1996:</u> Rippled fine sand or muddy sand with scattered pebbles/cobbles	*Ophiocten gracilis* (abundant), *Spatangus raschi, Gracilechinus* sp., arachnactid anemone, *Synaphobranchus kaupi, Lepidion eques, Coryphaenoides rupestris*	Extensive trawl damage in December 1995. Relict marks in August 1996
		<u>May 1996:</u> Slightly rippled muddy sand, many epifaunal trails	*Ophiocten gracilis* (rare), echinothuriid urchin, xenophyophores, arachnactid anemone	A few trawl marks (See text for additional comments on this station)
S1000	1021-1026	Sandy mud or muddy sand with scattered surface gravel. Many epifaunal trails.	*Ophiocten gracilis* (rare), unidentified larger ophiuroid, *Phelliactis* sp., unidentified arachnactid anemone, *Synaphobranchus kaupi*	
N1500	1495-1595	Fine mud with megafaunal burrows	Very few visible fauna: *Pseudostichopus villosus, Synaphobranchus kaupi, Coryphaenoides guentheri,* possible *Antonogadus macrophthalmus.*	Predominant burrows are large, clustered holes probably made by *Munida tenuimana*. “Spoke burrows” of echiuran worms also common.
N2000	2056-2070	Fine mud with megafaunal burrows	Visible fauna more abundant than N1500: *Ophiomusium lymani, Acanella arbuscula, Gracilechinus affinis, Umbellula* sp., unidentified macrourid	Predominant burrow types differ from N1500. Fewer hole clusters, more conical mounds.

Station S5: nominal position 55^0 56.60' N, 08^0 00.30' W, depth ~ 175m

This station was not part of either of the main SES transects but was visited in May 1996 (16 usable images) and July 1996 (24 images). The station was located in a deep basin on the Malin Shelf, at slightly more than half the distance from the Inner Hebrides (Islay, Jura and Colonsay) to the shelf edge. The images show a seabed of fine mud indicating a low-energy depositional environment. The May 1996 images are relatively clear despite the particles of "marine snow" in the near-bed water column. The seabed surface in May has a granular texture and appears to be covered with a layer of settled phytodetritus. The July 1996 images have a much more "hazy" appearance owing to high turbidity in the water column. The seabed has a smoother texture than was observed in May. At both periods the muddy seabed shows signs of intense bioturbation by burrowing megafauna, in the form of numerous mounds, pits and burrow openings. The identity of the burrowers is not usually clear, but negatives 22 and 23 taken in July show large clusters of holes suggestive of the thalassinidean mud-shrimp *Calocaris macandreae*. Negative 24 taken in May shows a stellate feeding trace likely to have been made by the echiuran worm *Maxmuelleria lankesteri*. The large conical or domed mounds visible on several images are also suggestive of this species. Very few epifauna are visible, although there are many surface traces made by sea stars. One specimen of the seapen *Pennatula phosphorea* is visible on image 22 from the May series. Occasional anemones, possibly *Sagartiogeton laceratus*, are present. Image 25 taken in May shows a small fish that appears to be one of the rocklings (Family Gadidae), but species identity is unclear.

No specimens of the tall seapen *Funiculina quadrangularis* or the fireworks anemone *Pachycerianthus multiplicatus* can be seen, although both species might be expected in a deep mud environment of this type. Overall, this station can be considered to represent one of the circalittoral mud biotopes in the JNCC marine habitat classification. The apparent rarity of seapens and obvious abundance of burrowing megafauna suggests a provisional assignment to the biotope "Burrowing megafauna and *Maxmuelleria lankesteri* in circalittoral mud" (SS.SMu.CfiMu.MegMax).

In one image (May 1996, negative 20) the camera is looking along two shallow, parallel linear tracks on the sediment surface, spaced about 1m apart. These are presumably anthopogenic, perhaps the filled-in remnants of old trawl marks.

Station N140: nominal position 56^0 36.52' N, 08^0 56.20' W, depth ~ 135m

This station on the outer Hebridean shelf was visited in March 1995 (only one usable image) and August 1996 (24 images). Two seabed types were observed, both indicating a hydrodynamically-active benthic environment. Ten of the 25 photos show a plain of sand sculpted into conspicious linguoid ripples by bottom currents. The remainder show a field of cobbles embedded in rippled sand, with signs of current activity in the form of moats and depositional tails on opposite sides of the stones. Small encrusting epifauna is visible on the cobble surfaces but at the available level of resolution it is difficult to identify this further. Encrusting and nodular bryozoan colonies and small serpulid polychates would be likely candidates for this type of environment. The long-spined urchin *Cidaris cidaris* is the most conspicuous mobile animal visible and appears to be quite common, present on nine photos (sometimes two or three individuals per photo). One individual of a small unidentified sea star is the only other mobile animal seen. There is no evidence of anthropogenic disturbance.

At a water depth of ~135m, this station is located above the upper depth limit (200m) of Howell's (2010) benthic classification system. However, given its geographic position close to the shelf edge it is probably most useful to include it within Howell's system and regard it as an extension of her Upper Slope (200-750m) depth division. The conspicuous presence

of *Cidaris cidaris* allows provisional assignment to her "*Cidaris cidaris – Stichopus tremulus* assemblage", although *S. tremulus* is not seen on the images reviewed here.

Station S140: nominal position 56^0 27.70' N, 08^0 57.75' W, depth ~ 148m

Located further south on the outer shelf at a slightly greater depth, this station shows a more varied benthic topography than N140. Twenty-five seabed images were obtained in February 1996. The seabed ranges from strongly-rippled sand without larger stones, to rippled sand with embedded cobbles (as seen at N140), to megarippled very coarse sand or fine gravel. Seven photos show a dense, almost continuous field of cobbles embedded in coarse sand. The variety of seabed types visible in only 25 images is indicative of a patchy benthic environment, all subject to strong current action. Small encrusting sessile epifauna is present on the rock surfaces of the dense cobble field. Mobile epifauna are uncommon, and the urchin *Cidaris cidaris*, the most conspicuous species seen at N140, is not seen here. A single specimen of the coastal urchin *Echinus esculentus* is present on image 14A. Image 17A shows two sea stars, a small 5-armed specimen which could be either *Asterias rubens* or *Luidia sarsi*, and a larger, probably 7-armed specimen of *Luidia ciliaris*. There is no evidence of anthropogenic disturbance.

In relation to Howell's (2010) system, the seabed types visible at S140 would be classed as Upper Slope Sand, Mixed or Coarse Substratum, but the available images from S140 show too few animals to allow assignment to any of the biotopes defined in her paper.

Station N200: nominal position 56^0 37.44' N, 08^0 59.74' W, depth ~ 227m

Station N200, at the Hebridean shelf break, was visited in March 1995 (24 usable images obtained). The seabed here is predominantly coarse gravel, with a mixture of larger pebbles and cobbles, grading up to small boulders in some images (e.g. photo 12). Five photos show a flat, uniform gravel plain without any larger stones. The images from N200 are almost devoid of visible life. The rock surfaces appear to carry little or no encrusting epifauna and the only mobile animals seen are small squat lobsters (*Munida* sp.) on images 9 and 18, and one very small unidentifed sea star. All seabed types here would be classed as Upper Slope Coarse Substratum under Howell's system, but the sparse biological community does not allow assignment to a biotope. No evidence of anthropogenic disturbance is seen at this station.

Station S200: nominal position 56^0 27.20' N, 09^0 02.87' W, depth ~ 152-185m

This station was visited in March 1995 (25 images) and August 1995 (29 images). For reasons not recorded, the photographic stations were at slightly different locations, giving a water depth of ~152m in March and 176-185m in August. Seabed topography at the March station was very variable but all indicative of a high-energy environment. Substrata ranged from rippled sand without larger stones, to flat coarse gravel, megarippled sand with gravel in the intervening furrows, to dense fields of cobbles embedded in coarse sand. The cobble fields supported twig-like and nodular sessile epifauna, probably bryozoan colonies, but no details are visible at the level of resolution of the images. A single individual of the holothurian *Stichopus tremulus* can be seen on image 15.

The deeper August station showed a similar patchy seabed, including rippled sand with embedded cobbles, flat coarse sand with scattered surface gravel, and dense cobble fields. A slightly wider variety of organisms was recorded. A ling (*Molva molva*) is present on image 15, an unidentified brittlestar on image 16, and possibly a small octopus on image 27. Encrusting and twig-like sessile fauna is present on the larger cobbles. A few photos show small, cup-shaped sessile organisms (best seen on image 23) which may be either sponges

or erect bryozoan colonies. No evidence of anthropogenic disturbance is visible at either station.

Overall, station S200 shows a patchwork of high-energy benthic environments with substratum types falling within Howell's Upper Slope Sand, Coarse and Mixed Substratum categories. The scarcity of identifiable fauna precludes assignment to any of her defined biotopes.

Station N300: nominal position 56^0 37.50' N. 09^0 01.20' W, depth ~ 345m

Only eight photos were obtained here on a visit in March 1995. The seabed consists either of featureless flat gravelly sand, slightly rippled sand with fine gravel exposed in the furrows, or patches of angular cobbles embedded in gravelly sand. With the exception of one very small unidentified sea star, no animals at all are visible. The rocks in the cobble patches appear to be devoid of encrusting fauna. Seabed types can be classed as Upper Slope Sand or Mixed Sediment, but it is not possible to identify a correspondence to any of the biotopes defined by Howell (2010). There is no evidence of athropogenic disturbance.

Station S300: nominal position 56^0 27.50' N, 09^0 03.73' W, depth ~ 280-340m

This station was visited in March 1995 (25 images obtained) and August 1995 (23 images). There was a difference in depth between the two photographic sites (March ~348m, August ~280m) but benthic environments are similar at both. Images from the March station show an approximately equal mix of flat coarse sandy gravel with occasional pebbles or cobbles, and a slightly rippled sand with scattered cobbles. Benthic animals are not numerous but are present in greater variety than at the stations discussed so far. Very small sea stars (species unidentified) are visible on several photos and solitary large brittlestars (probably *Ophiura* sp.) can be seen on images 14A and 28A. The tails of large fish, possibly ling (*Molva molva*) extend into the field of view on photos 9A, 25A and 27A. Small scallops (*Aequipecten* sp.) are present on four photos (1-3 individuals per photo). A small comatulid crinoid appears on photo 27A. The penultimate photo in the series (29A) shows an area of rippled sand with relatively low gravel content, with the tentacle crowns of small sabellid polychaetes (~ 10m-2) extending from tubes at the sediment surface.

The shallower August station has a substratum of rippled sand with a variable, but usually high, content of gravel and small pebbles. Occasional larger stones, up to the size of small boulders, are also seen. Benthic fauna is very sparse, consisting of occasional small sea stars, and on one photo (image 13) a brittlestar (*Ophiura* sp.) and a small octopus, probably *Eledone cirrhosa*. There is no evidence of anthropogenic disturbance at either station.

Substratum types at S300 would be classified as Upper Slope Sand, Mixed or Coarse Substrata according to Howell's (2010) system, but the sparse fauna observed cannot be assigned to any of the biotopes defined under these headings.

Station N700: nominal position 56^0 38.60' N, 09^0 07.00' W, depth ~ 686-730m

Photographs were taken on visits in March 1995 (27 images) and August 1996 (24 images). The August 1996 station was slightly deeper (714-732m) than the station visited visited in March 1995 (~ 686m). A uniform benthic environment is seen across all photos from both stations. A substratum of fine sand or muddy sand may show slight evidence of current-induced rippling in some photos, but overwhelmingly the sediment surface is modified by biological activity. There are only occasional small holes and mounds, plus a single large oblique burrow opening on image 14 from March 1995, indicating that burrowing megafauna are not abundant here. However, conspicuous linear epifaunal trails are seen on almost every image. These are created by the epifaunal heart urchin

Spatangus raschi, which is visible on seven photos each from March 1995 and August 1996, sometimes with two or three individuals visible. The most abundant animal is the small brittlestar *Ophiocten gracilis*, which is present on every photograph. Densities are variable, but in some photos reach ~ 50 individuals m^{-2}. Sea star traces are also visible on most images, and the animals themselves are occasionally seen. A large sea star visible on image 7 from March 1995 may be *Luidia sarsi.* The long-spined urchin *Cidaris cidaris* is also present in the March 1995 series (on six photos) but is not seen at the August 1996 station. A third urchin species of the genus *Gracilechinus* (either *G. acutus* or *G. elegans*, both formerly placed in the genus *Echinus*) is present on two photos from August 1996. Other less common epifauna include unidentified hermit crabs, the holothurian *Stichopus tremulus* and a neogastropod, possibly *Troschelia berniciensis.* Three fish species are seen, isolated individuals of halibut (*Hippoglossus hippoglossus*) and an unidentified small macrourid, and the cut-throat eel *Synaphobranchus kaupi*, which is frequently visible swimming in mid-water at both stations (on seven photos from March 1995, four from August 1996).

The two N700 stations shared the same common species, namely *Ophiocten gracilis, Spatangus raschi* and *Synaphobranchus kaupi.* The most obvious difference between the stations (apart from the sporadic rare taxa) was the abundance of tube-dwelling cerianthid anemones at the August 1996 station. These anemones are seen on every photo in this series but are not present in the March 1995 images. The cerianthids are seen extending from their tubes with tentacle crowns expanded, and uniformly leaning towards the north-west, possibly indicating some bottom-current flow at this time. Densities are variable, but range up to ~ 50 individuals m^{-2}. Since these anemones can retract fully into their buried tubes it is not possible to be sure whether they were genuinely absent from the March 1995 station, or simply retracted below the surface at this time.

There are no trawl marks or other signs of anthropogenic disturbance visible in either series of images.

The depth, substratum and biological community visible at N700 show a degree of correspondence to the Upper Bathyal Mud "*Echinus acutus norvegicus* assemblage" defined by Howell (2010). *Ophiocten gracilis, Spatangus raschi* and *Gracilechinus acutus* are all listed by Howell as present in this assemblage. However, at N700 *Gracilechinus* sp. is only seen in small numbers, and in abundance terms *O. gracilis* dominates the visible community. Howell (2010) does not mention cerianthids as a characterizing member of this assemblage.

Station P700: nominal position 56^0 35.22' N, 09^0 10.95' W, depth ~ 705m

Only ten images were obtained here in August 1996. Benthic environment and biota are essentially the same as those observed at N700 at that time. A seabed of rippled fine sand or muddy sand with urchin trails supports abundant *Ophiocten gracilis* and cerianthid anemones. As at N700, the expanded cerianthids show a uniform orientation towards the north-west. *Spatangus raschi, Gracilechinus* sp. and *Synaphobranchus kaupi* are also present. A small squat lobster (*Munida* sp.) can be seen in a pit or burrow opening on image 10.

Station R700: nominal position 56^0 30.94' N, 09^0 10.22' W, depth ~ 665m

Station R700 was also visited in August 1996, providing 25 images. Observations match those at N700 and P700, showing a community dominated numerically by *Ophiocten gracilis* and cerianthids, with *Spatangus raschi, Gracilechinus* sp. and *Synaphobranchus kaupi* also present. This seabed at this station shows occasional small mounds and burrow

openings created by large infauna. Two very large pits or burrow openings are visible on image 17A. There are no signs of anthropogenic disturbance at either R700 or P700.

Station S700: nominal position 56^0 27.75' N, 09^0 09.75' W, depth ~ 700m

This station was visited in April 1995 (23 images), August 1995 (25 images), December 1995 (25 images), April 1996 (25 images) and Ju.ly 1996 (24 images). All observations show an environment and community matching those at N700, P700 and R700. The fine sand or muddy sand substratum is slightly rippled in some images and is always heavily marked by urchin trails and numerous sea star traces. There is occasional evidence of infaunal bioturbation in the form of small mounds and burrow openings. A cluster of very large holes or pits is seen on image 7 from April 1996. *Ophiocten gracilis* is always visible, at varying densities but often abundant. Cerianthid anemones are not seen at all in April and August 1995, but are visible in the other three series of photos. *Spatangus raschi, Gracilechinus* sp. and *Synaphobranchus kaupi* are the most commonly seen species after the two numerical dominants. Rare species sporadically visible are small sea stars, hermit crabs, the holothurian *Stichopus tremulus* and a large neogastropod (possibly *Troschelia berniciensis*). A large sea star, possibly *Luidia sarsi*, is visible on image 28A from December 1995. There is no evidence of anthropogenic disturbance at any time.

The observations from all the ~ 700m stations are consistent, and in Howell's (2010) classification show the closest match to the Upper Bathyal Mud "*Echinus acutus norvegicus* assemblage". The most obvious point of difference is that *Ophiocten gracilis* and cerianthid anemones are by far the most abundant taxa at the LOIS-SES stations. *Gracilechinus* sp., while consistently present, is relatively uncommon.

Station R1000: nominal position 56^0 30.00' N, 09^0 18.00' W, depth ~ 990m

This station was visited four times, in April 1995 (25 images), December 1995 (25 images), May 1996 (26 images) and August 1996 (24 images). Several rather different benthic environments are recorded. Images from April 1995 show a flat seabed of fine sediment, possibly muddy sand, which has clearly been smoothed by near-bed currents. There is a fine surface scatter of gravel or small pebbles in many images, and occasional larger stones. A cuboidal boulder rests on the sediment surface in photo 28A. Photo 22A shows what appears to be a localized patch of denser gravel on the surface. The most obvious explanation for these features is that they are iceberg dropstones dating from the last glaciation. There is very little evidence of infaunal bioturbation and few if any epifaunal trails (near-bed current flow would presumably erase any such features rapidly). There is very little visible biota. Unidentified brittlestars much larger than the abundant *Ophiocten gracilis* at the 700m stations are present at low density on four images (one or two individuals per image). A single *Gracilechinus* sp. is seen on photo 26A, and there are occasional small *Synaphobranchus kaupi* swimming near the seabed. An expanded ceriantharian anemone is clearly visible on photo 15A. This individual is much larger than the cerianthids present in abundance at some of the 700m stations and has quite a different appearance, with the tentacle crown expanded in a horizontal plane rather than facing laterally. The pale tentacles are thick, curved at their tips and relatively few in number (possibly 26, although the resolution of the image makes an accurate count difficult). In general appearance this anemone closely resembles *Arachnanthus sarsi* (Family Arachnactidae). The continental slope setting of station R1000 would represent a very considerable extension to the known depth range of *A. sarsi,* and it is possible that the individual in photo 15A belongs to a different, bathyal arachnactid species. Two images (23A and 26A) from the April 1995 series show clear linear striations on the sediment surface which are likely to be anthropogenic, presumably trawl marks.

The R1000 images from December 1995 show a quite different environment and biota to the April 1995 series. The fine sand or muddy sand seabed is conspicuously rippled, indicating strong bottom current activity. Several photos show scattered pebbles or cobbles on the seabed and there is also evidence of infaunal bioturbation in the form of occasional burrow openings and sediment mounds. In contrast to the very sparse benthic fauna recorded at the April locality, the December 1995 series shows a dense population of the brittlestar *Ophiocten gracilis*, visible on all photos at abundances similar to, or greater than, those seen at the 700m stations. Several other taxa are sporadically present. Irregular urchins, probably *Spatangus raschi*, appear on photos 6 and 17, and there is a single *Gracilechinus* sp. on image 14. Macrourid fish, probably *Coryphaenoides rupestris*, are seen on photos 11 and 14. Several distinct anemone species are present, none matching the *Arachnanthus*-like specimen recorded in the April series. An unidentified anemone with dark, thick tentacles is seen on photo 19, and a similar, but pale-coloured individual on photo 24. Five large cerianthids can be seen extending from tubes on the side of an elevated ridge of sediment on photo 20. These have a quite appearance to the small cerianthids present in abundance at 700m. A small comatulid crinoid is also present on photo 24.

The December 1995 series is notable for the high frequency of trawling impact on the seabed. Disturbed sediment, linear striations or deep furrows with exposed cobbles or small boulders are visible on nine out of the 25 images in this series. The clearest example is photo 27, which shows a deep furrow with sediment thrown up to the sides. The furrow has a distinct curvature, presumably made as the vessel changed course while trawling. Burrow openings and other infaunal traces are visible within the furrow, indicating recolonization of the disturbed sediment and the passage of some time between trawling and seabed photography.

The 26 images taken in May 1996 show a muddy sand seabed, perhaps slightly rippled, but to nothing like the degree evident in December 1995. The sediment surface is extensively marked by sea star traces and also shows occasional burrow openings made by large infauna. *Ophiocten gracilis* is present at low density but is far less abundant than in the December 1995 series. An echinothuriid urchin, likely to be either *Phormosoma placenta* or *Calveriosoma hystrix,* is seen on image 18. Large, thick-tentacled burrowing halcampid anemones are present on photos 21, 25 and 26. Photo 26 is notable in showing, in addition to the anemone, two giant protists (xenophyophores), possibly *Syringammina fragilissima,* and a cluster of large, oblique burrow openings, one of which is occupied by an unidentified decapod crustacean. A pale-coloured anemone which may be the same species as the *Arachnanthus*-like form noted in the April 1995 series is visible in the background of image 32. Evidence of trawl damage in this series is less frequent than in the December 1995 photos and appears to be less recent. Broad, shallow linear furrows or striations are seen on photos 14, 23 and 34 (three out of 26). None are as deep or disruptive to the seabed as some of the examples noted in December 1995.

The photos taken in August 1996 show a benthic environment similar to that observed in December 1995, with conspicuous rippling of the substratum caused by strong near-bed currents. Scattered stones, occasionally up to the size of small boulders (photo 16A) are present at the surface. As in the December 1995 series, *Ophiocten gracilis* is abundant and seen on every image. Fauna sporadically visible are the large halcampid anemone (photo 8A), small squat lobsters (*Munida* sp., photos 8A, 10A), one *Gracilechinus* sp. (photo 21A) and a dark, thin-tentacled cerianthid (photo 20A). A single specimen of the pale, *Arachnanthus*-like anemone is also visible on photo 28A, making a total of three individuals of this species observed at R1000. The eel *Synaphobranchus kaupi* is frequently present. Photo 19A also shows a larger fish whose general body shape and elongate dorsal fin-ray suggests it is one of the deep-water cods, probably *Lepidion eques.* The only visible

evidence of anthropogenic disturbance in this series are shallow, faint linear furrows on the seabed of photo 6A, which may be relict trawl marks almost erased by current flow.

The lack of uniformity in the benthic environments and biota recorded at R1000 can probably be accounted for by the positioning of the photographic stations. The station position data (recorded in the Excel™ spreadsheet accompanying this report) show that the four camera drops differ in longitude, and are arranged from east to west in the following order: December 1995 (easternmost), August 1996, May 1996, April 1995 (westernmost). The December 1995 and August 1996 series both show a conspicuously rippled seabed with a biological community dominated by abundant *Ophiocten gracilis.* Slightly further west, the May 1996 station shows only slight current-rippling, and *O. gracilis* is present at low density. At the westernmost station (April 1995), the seabed is current-smoothed rather than rippled, and *O. gracilis* is not observed. The four photographic series therefore represent points along an environmental and biotic gradient marking the lower boundary of the *O. gracilis*- dominated zone which continues down from the 700m stations, accompanied by a decrease in overall hydrodynamic energy indicated by the transition from strongly- rippled sediment to a more uniform, smoothed seabed.

The water depth and substratum observed at station R1000 would fall within the Upper Bathyal Sand (or perhaps in some cases Mixed Sediment) category defined by Howell (2010). Howell lists a biotope in this group termed "Ophiuroids on rippled sediment" (which ophiuroids are not specified). This fits the December 1995 and August 1996 series from R1000, in which *Ophiocten gracilis* was abundant, though not perhaps the other two sets of images in which both ripples and ophiuroids were less prominent.

Station S1000: nominal position 56^0 30.85' N, 09^0 17.90' W, depth ~ 1025m

Twenty-five seabed images were obtained in August 1995. They show a benthic environment broadly similar to station R1000 in May 1996, with a seabed of sandy mud or muddy sand with scattered small gravel particles on the surface. Sea star traces are abundant, and there are many other epifaunal trails. There are occasional small burrow openings but overall little evidence of infaunal bioturbation. Current- induced ripples may be visible on some photos (e.g. image 21A). There is a small- scale "fuzzy" texture to the sediment surface which is probably created by small agglutinated Foraminifera. Benthic fauna is sparse. There are occasional small brittlestars, probably *Ophiocten gracilis*, and five images show a larger brittlestar which may be a different (unidentified) species. A large anemone, possibly *Phelliactis* sp. is just visible in photo 8A, and there is also one specimen of the pale-tentacled arachnactid anemone (image 18A). The eel *Synaphobranchus kaupi* is visible on image 13A. There are no obvious trawl marks or other signs of anthropogenic disturbance.

This station would be classed as an Upper Bathyal Mud according to Howell's (2010) system, but no biotope assignation is possible on the basis of the sparse biota recorded.

Station N1500: nominal position 56^0 43.55' N, 09^0 25.00' W, depth ~ 1500m

This station was visited in April 1995 (25 images), August 1995 (25 images), December 1995 (only three images obtained), May 1996 (24 images) and August 1996 (23 images). All five series of photographs show a seabed of fine mud (which at this depth will be biogenic ooze) intensely reworked by burrowing megafauna. Clusters (up to ~ 50cm across) of wide, circular burrow openings, often with raised rims or "bulldozed" piles of expelled sediment are the most conspicuous large biogenic features and are visible on almost all photographs. These structures are probably created by burrowing decapod crustaceans, although none are actually visible. The stellate traces created by the feeding activity of burrowing echiuran worms are also very common. For example, in the May 1996 series, these "spoke burrows" are visible on 17 of the 24 photos, often with two or three

examples per photograph. There are some linear epifaunal trails, possibly made by gastropods. There is some apparent seasonal variability in sediment surface texture, with a fine granular or "fuzzy"covering visible in August 1995 and 1996, but not at the other time intervals. This is likely to represent a seasonal proliferation of small agglutinating Foraminifera following the settlement of phytodetritus from the spring bloom.

Although 100 seabed photographs were taken at this station and the seabed is sculpted entirely by biological activity, very few animals are actually visible. A holothurian is visible on image 12 from April 1995. The body surface appears to be covered by attached sediment particles, a characteristic feature of *Pseudostichopus villosus.* A sharp-snouted macrourid fish on image 20 from April 1995 may be *Coryphaenoides guentheri.* Image 13 from August 1995 shows a macrourid with a more rounded snout which is likely to be *Coryphaenoides rupestris.* Image 17 from August 1995 has the tail of a large macrourid extending into the field of view, and also a very small dark-coloured fish which may be a big-eye rockling (*Antonogadus macrophthalmus*). A few *Synaphobranchus kaupi* are also seen. There is no sign of anthropogenic disturbance on any of these photos.

Water depth and substratum place this station in the Mid Bathyal Mud category of Howell's (2010) system. Howell lists an "*Echinus alexandri-Psilaster- Plinthaster* assemblage" from this depth range and geographic area, but since none of these taxa are visible on the N1500 photographs it would be premature to assign the station to this biotope.

Station N2000: nominal position 57^0 00.00' N, 10^0 00.00' W, depth ~ 2070m

This station was visited in May 1996 (26 images) and August 1996 (25 images). At both times the seabed consisted of soft mud (biogenic ooze) heavily reworked by burrowing megafauna. The mix of biogenic features differs from those seen at N1500. The probable decapod burrow clusters common at N1500 are less evident at N2000, which shows a higher frequency of mounds. Sea star traces are very common. In sharp contrast to N1500, there are many large epifauna, although only a few species are common. The large brittlestar *Ophiomusium lymani* is the most common species, visible on at least 43 out of 51 photos, often with two, three or more individuals per photo. The brittlestars are often seen in close association with colonies of the bushy octocoral *Acanella arbuscula*, which appears on 22 photos out of 51. When not sitting on the sediment surface under an *Acanella* colony, the brittlestars are often seen in pits or hollows on the seabed. The white urchin *Gracilechinus affinis* is also frequently seen (visible on 19 photos). Rare species include macrourid fish, probably *Coryphaenoides guentheri* (May 1996, image 5A and August 1996, image 11A). A cluster of large polyps just entering the frame of image 31A from May 1996 probably belongs to a seapen of the genus *Umbellula*. There is no sign of anthropogenic disturbance at this station.

Howell (2010) lists an "*Acanella arbuscula* and *Ophiomusium lymani* assemblage" on Lower Bathyal Mud, and the observations made at N2000 clearly fit within this category.

3.1.2 March 1988 cruise to Hebridean slope north-west of St. Kilda

Seabed photographs were taken at nine stations on this cruise, along a transect down the slope of the broad extension of the Hebrides Shelf (the "Geikie Bulge") north-west of St. Kilda. The photo stations cover a more restricted depth range than the LOIS-SES series discussed above, representing the upper (350m) to upper-mid (885m) slope. Stations were designated by their nominal water depth. Position and depth data for individual photographs do not seem to have been recorded (or if recorded, these data have not been kept).

350m: nominal position 58^0 06.23' N, 09^0 24.12' W

Eighteen usable images were obtained from this station. They show a seabed of flat muddy sand with variable amounts of small gravel particles and shell fragments on the surface. There is no obvious sign of bottom current activity. The less stony areas show many epifaunal trails, and there are also occasional small sediment mounds and burrow openings. Image 27 shows a cluster of much larger pits or burrow openings. The most common animal is the irregular urchin *Spatangus raschi*, which is present on nine photos out of 18, with up to six individuals per photo. Single individuals are also seen of a small scallop (*Aequipecten* sp., image 14), a small sea star (possibly *Porania pulvillus*., image 21) and an unidentified flatfish (image 15). There is no sign of anthropogenic disturbance. In Howell's (2010) classification, water depth and substratum would place this station in the Upper Slope Mixed Sediment category, but the visible fauna does not match the single biotope listed under this heading.

Table 3.2. North-west St. Kilda: summary of benthic habitats and biota observed at each station.

Station depth (m)	Habitat(s)	Species identified	Comments
350	Flat muddy sand with surface gravel and shell fragments. Many epifaunal trails and occasional burrows	*Spatangus raschi, Porania pulvillus, Aequipecten* sp., unidentified flatfish	
390	Flat muddy sand with sparse surface gravel	*Gracilechinus* sp., *Stichopus tremulus, Eledone cirrhosa,* unidentified sabellids	
470	Muddy sand or sandy mud with patchy surface gravel. Some epifaunal trails and burrow openings	*Spatangus raschi,Gracilechinus* sp., *Stichopus tremulus,Troschelia berniciensis*, possible *Merluccius merluccius*	One relict trawl mark
600 (a)	Slightly rippled fine sand or muddy sand. Scattered surface pebbles with current-scour features.	*Ophiocten gracilis* (low density), *Hippoglossus hippoglossus*	Many trawl marks
600 (b)	Fine sand or muddy sand with scattered surface pebbles. Less	*Ophiocten gracilis* (abundant), *Synaphobranchus kaupi*	
750	Fine sand or muddy sand with patchy surface gravel. Many burrow openings and epifaunal trails	*Ophiocten gracilis* (abundant), *Stichopus tremulus, Troschelia berniciensis, Lepidion eques*	
775	Fine sand or muddy sand with patchy surface gravel. Many burrow openings and epifaunal trails	*Ophiocten gracilis* (abundant), *Stichopus tremulus, Synaphobranchus kaupi*	
863	Slightly rippled muddy sand or sandy mud with patchy surface stones, gravel to small cobbles	*Ophiocten gracilis* (abundant), *Gracilechinus* sp.,unidentified cerianthids, *Synaphobranchus kaupi*	
885	Fine mud or sandy mud, no evidence of current activity. Sparse surface gravel	*Ophiocten gracilis* (less abundant than at 863 m), *Gracilechinus* sp., *Stichopus tremulus*	Extensive trawl damage

390 m: nominal position 58^0 06.19' N, 09^0 28.17' W

This slightly deeper station produced 14 usable images. The seabed appears to differ from that of the 350m station in being muddier and less stony in most images. There is no obvious evidence of current activity. There are some epifaunal trails, but in contrast to the 350m series, the trail-maker *Spatangus raschi* is not seen. A muddy seabed in image 32A shows several large burrow openings. Image 17A shows several very small whitish urchins (*Gracilechinus* sp.) but these do not appear on any other photo. An octopus, probably *Eledone cirrhosa*, is clearly visible on image 25A. The holothurian *Stichopus tremulus* appears on photos 19A (two individuals) and 20A. Slender upright tubes, probably of sabellid polychaetes, are visible on a few photos. There is no obvious anthropogenic disturbance. This station would be classed as Upper Slope Mud, Sand or Mixed Sediment according to Howell's system. *Gracilechinus* sp. and *Stichopus tremulus* are characterizing species in two of Howell's biotopes, but from the limited number of images available neither could be said to define the community observed here.

470m: nominal position 58^0 08.14' N, 09^0 29.46' W

The 18 photos from this station show little obvious change in benthic environment from the previous two stations. The seabed is muddy sand or sandy mud with variable amounts of small gravel at the surface. Image 31 shows the edge of a patch of quite dense gravel adjoining a sandier area with far less stony material. Image 24 shows a group of very large burrow (probably decapod crustacean) openings in muddy sediment. There are also some epifaunal trails, in one case (image 28), clearly being made by the urchin *Spatangus raschi.* The regular urchin *Gracilechinus* sp. (either *G. acutus* or *G. elegans*) is visible on two photos (21 and 28), in both cases sitting on isolated large pebbles or cobbles on the sediment surface. Photo 32 shows a large gastropod, possibly *Troschelia berniciensis*, and at the top edge, the head of a silvery fish, possibly a hake (*Merluccius merluccius*). A single holothurian (*Stichopus tremulus*) is seen on photo 34. This station shows some evidence of anthropogenic disturbance in the form of a shallow linear furrow running across the frame of image 23. This is presumably an old trawl mark. In Howell's (2010) system, this station would be classed as Upper Slope Mud, Sand or Mixed Sediment. The presence of *Stichopus tremulus* is a point in common with Howell's "*Cidaris cidaris-Stichopus tremulus* assemblage", although *Cidaris* is not seen on these photos.

600m: nominal position 58^0 08.14' N, 09^0 34.52' W

Twenty-five photos were taken at a 600m-deep station on 16 March 1988. They show a uniform, slightly current-rippled seabed of fine sediment, either sand or muddy sand. Scattered small surface pebbles show conspicuous asymmetric scour and sediment "tail" features indicating bottom-current activity. There are a few burrow openings (large cluster on image 12). The small brittlestar *Ophiocten gracilis* is present in small numbers on all photos. Image 27 shows a flatfish, probably a halibut (*Hippoglossus hippoglossus*). This station could be assigned to the Upper Slope Sand "Ophiuroids on rippled sediment" as defined by Howell (2010).

This station shows considerable evidence of anthropogenic disturbance. Linear furrows and surface striations created by trawling are visible on seven out of the 25 photos. Image 20 shows a large boulder with accumulated sediment to one side of it. This may have been dragged across the seabed by a trawl.

600m: nominal position 58^0 06.08' N, 09^0 36.48' W

A second 600m station was visited on 20 March 1988, producing 13 usable photos. Benthic environment is generally similar to that described for the previous station, although the

seabed may be slightly muddier, with less evidence for current activity. There are occasional pebbles or small cobbles on the surface. *Ophiocten gracilis* is again the most common animal, and is much more abundant than at the previous station. Several specimens of the cut-throat eel *Synaphobranchus kaupi* are visible. An unidentified larger fish is also seen on image 34A. This station could also be classed as Upper Slope Sand "Ophiuroids on rippled sediment" as defined by Howell (2010). No obvious trawl marks can be seen here.

750m: nominal position 58^0 10.44' N, 09^0 29.46' W

Twenty-two photos were taken at this station. They show a seabed of fine sand or muddy sand, with variable quantities of small gravel particles on the surface. In some photos (e.g. images 22, 23) the surface has a rough, irregular appearance from the high density of gravel and small pebbles embedded in the sediment. There is much evidence of infaunal bioturbation, with large pits or burrow openings (usually in clusters) visible on 13 out of 22 photographs. Small mounds and epifaunal trails are also common. *Ophiocten gracilis* is present at high density in all photographs. Other species visible are the holothurian *Stichopus tremulus* (images 21 and 27), a large gastropod (image 33, possibly *Troschelia berniciensis*) and the deep-water cod *Lepidion eques* (image 18). This station is close to the Upper Slope Sand "Ophiuroids on rippled sediment" as defined by Howell (2010), although there is little evidence of current activity here. Image 28 shows the edge of a broad, linear depression but it is not clear whether this is natural or anthropogenic. A beer can is visible on the seabed in image 16.

775m: nominal position 58^0 07.32' N, 09^0 39.89' W

Only five usable photos were obtained at this station. The limited evidence suggests a benthic environment and biological community very similar to the 750m station. Fine sand or muddy sand with burrows and a variable small stone content supports abundant *Ophiocten gracilis,* with *Stichopus tremulus* also present. The eel *Synaphobranchus kaupi* is seen on one photo (image 30A). There is no sign of anthropogenic disturbance.

863m: nominal position 58^0 08.72' N, 09^0 39.92' W

Fifteen usable photos were taken at this station. A seabed of muddy sand or sandy mud shows slight rippling. The surface is strewn with small stones ranging in size from gravel to occasional small cobbles. Density of stones is patchy, with some areas (e.g. image 35) having very few, while others (e.g. image 27) are much stonier. There are some epifaunal trails but not much evidence of infaunal bioturbation. *Ophiocten gracilis* is abundant throughout. Urchins (*Gracilechinus* sp.) are present on two photos. Two large cerianthid anemones are also seen, one with dark and one with pale-coloured tentacles. Substratum and water depth place this station in the Upper Bathyal Mud or Sand categories of Howell (2010), and the community fits her "Ophiuroids on rippled sediment" biotope. The edge of a broad, linear depression is seen in the corner of image 36, but it is not clear whether this is natural or anthropogenic.

885m: nominal position 58^0 07.33' N, 09^0 40.49' W

The 21 photos from this station show a seabed of fine sediment (mud or sandy mud) with scattered gravel or small pebbles but no obvious signs of current activity. *Ophiocten gracilis* is present throughout at varying density, but is generally far less abundant than at the 863 m station. Two individuals of *Gracilechinus* sp. and one *Stichopus tremulus* are also seen. This station is notable for the high frequency of anthropogenic disturbance attributable to trawling. Unmistakeable trawl marks are present on 17 out of 21 images. These range from

deep, fresh-looking furrows with upturned masses of sediment (e.g. image 21) to smoother expanses of sediment where infaunal burrows have opened through the disturbed seabed (e.g. image 13). These latter features are presumably older, relict trawl marks.

3.1.3 SAMS cruises to Hebridean slope north-west of Lewis, 1998

Seabed photographs were taken on two cruises in 1998, organized by SAMS when contracted to carry out baseline surveys of areas licensed for hydrocarbon exploration on the continental slope north-west of the Isle of Lewis. The cruise on behalf of Enterprise Oil Ltd. took place in February 1998 and covered 11 photographic stations over a depth range from 721-1316m. On the May 1998 cruise, 13 stations were surveyed for Statoil Ltd. over a depth range from 1293-1492m. The Statoil stations therefore extended the depth range of the Enterprise survey and were also aligned with them geographically, so that this combined dataset can be treated as a single transect down the continental slope. The Agip survey area was located to the north of the Enterprise-Statoil group and covered a more limited depth range (seven stations at 707-992m).

Benthic environments and communities observed in each survey area are summarized in turn, with individual stations presented in order of increasing depth. Figures from the corresponding cruise reports are reproduced to show the relative positions of the stations in each area.

Agip stations (AG)

Five Agip stations were arrayed along a bathymetric transect, with two additional stations in the 840-850m depth horizon (see Figure below).

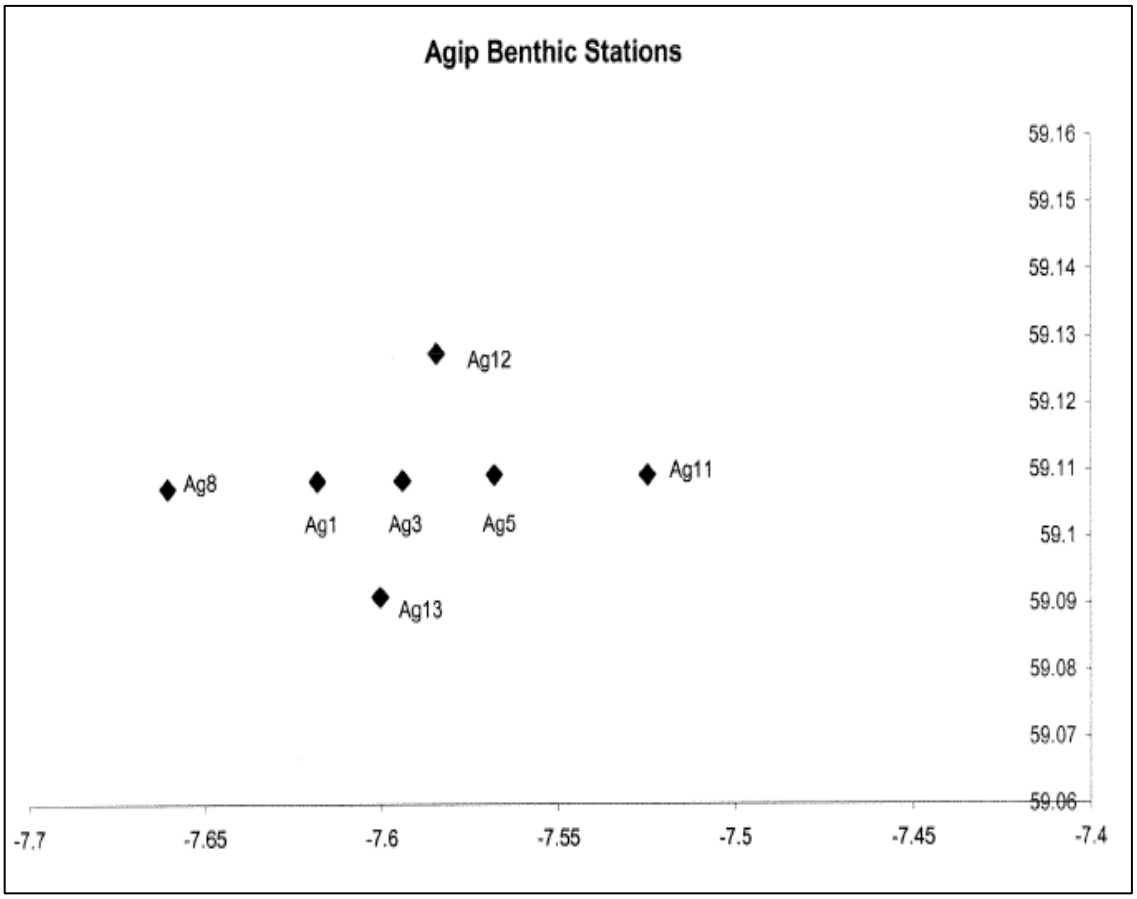

Figure 3.2. Benthic stations surveyed in the May 1998 cruise for Agip Ltd.

Table 3.3. North-west Lewis, Agip stations: summary of benthic habitats and biota observed.

Station	Depth (m)	Habitat(s)	Species identified	Comments
AG11	707	Sandy mud or muddy sand with variable gravel content and occasional larger stones. Stone content very patchy. Burrow openings in muddier areas	*Spatangus raschi, Gracilechinus* sp., *Munida* sp., *Lepidion eques*, unidentified sabellids. Brachiopods and other small sessile epifauna on stones	
AG5	794	Slightly rippled sandy mud or muddy sand with patchy gravel/pebbles. Less stony than AG11. Many epifaunal trails	*Ophiocten gracilis* (low density), *Spatangus raschi, Gracilechinus* sp., *Munida* sp., unidentified small hermit crabs, *Lepidion eques, Synaphobranchus kaupi*	
AG13	843	Rippled sandy mud or muddy sand with patchy surface gravel	*Ophiocten gracilis* (low density), *Gracilechinus* sp., unidentified small hermit crabs	Probable trawl damage on one photo
AG12	847	Rippled sandy mud or muddy sand with patchy surface gravel	*Ophiocten gracilis* (abundant), unidentified sabellids	
AG3	854	Rippled sandy mud or muddy sand with patchy surface gravel	*Ophiocten gracilis* (abundant), *Synaphobranchus kaupi*	Some trawl marks
AG1	898	Strongly rippled sandy mud or muddy sand. Very low stone content	Xenophyophores, *Ophiocten gracilis* (rare), *Synaphobranchus kaupi, Chimaera monstrosa*	
AG8	992	Slightly rippled sandy mud or muddy sand. Surface gravel/pebbles with current scour features	*Ophiocten gracilis* (abundant), unidentified cerianthid anemone	

Station AG11: nominal position 59^0 06.55' N, 07^0 31.55' W, depth 707m

Twenty-five usable photographs were taken at this station. They show a seabed of muddy sediment with variable, but locally high, content of gravel, and with occasional larger pebbles and cobbles on the surface. The seabed appears quite patchy, with some areas (e.g. image 13) being predominantly muddy, while others (e.g. image 23) have a much higher content of small stones. Image 13 shows clear evidence of infaunal bioturbation in the form of a small conical mound associated with five or six burrow openings). Sessile epifauna, probably bryozoans and/or encrusting sponges, can be seen on the larger pebbles and cobbles (e.g. image 14). Small brachiopods are also sometimes visible attached to stones (e.g. image 14) but it is difficult to assess their abundance at the available level of resolution as they are often not clearly distinguishable from the stones. Epifaunal trails are visible on several photos. These are probably made by urchins, as the species *Spatangus raschi* is present on four photos and *Gracilechinus* sp. on three. The latter usually have fragments of shell attached to the test. Very small squat lobsters (*Munida* sp.) are seen on four photos and there are also a few small hermit crabs. Photo 10 shows a much larger decapod that appears to be a spider crab (species unidentified). A fish, probably the deep-water cod *Lepidion eques* appears on images 17 and 18. The first photo in the sequence (image 5) shows many small organisms projecting above the sediment with expanded tentacle crowns (all facing roughly south). At the available resolution it is difficult to be certain of their identity but they may be sabellid polychaetes. They are not seen on subsequent images so this appears to be a localized patch of these organisms. Water depth and substratum would place this station in the Upper Slope Mixed Sediment category of Howell (2010). Howell lists a "Brachiopods on coarse sediment" biotope, but the abundance of brachiopods at AG11 does not seem to be high enough to consider them as characterizing the station.

Image 19 shows an area of muddy seabed scored by a linear furrow which may be a trawl mark.

Station AG5: nominal position 59^0 06.41' N, 07^0 33.81' W, depth 794m

The 27 photos from this station show a muddy sand or sandy mud seabed with surface stones ranging from small gravel fragments to pebbles and cobbles. Density of stones is patchy but in general is lower than at the slightly shallower station AG11. There is some evidence of current-induced ripples and some areas (e.g. image 28) are also heavily marked by epifaunal trails. Encrusting epifauna can be seen on the larger stones (e.g. image 13). The urchins *Spatangus raschi* (two photos) and *Gracilechinus* sp. (two photos) are visible, but the most frequently-seen animal is the small brittlestar *Ophiocten gracilis,* which is present in small numbers on all images. Small hermit crabs and a few tiny *Munida* sp. can also be seen. The deep-water cod *Lepidion eques* appears on image 20 but the most common fish is the eel *Synaphobranchus kaupi,* which can be seen on five photos. A linear furrow which may be a trawl mark is just visible in the corner of image 20. This station can be classed in the Upper Bathyal Mixed Sediment category of Howell (2010). The presence of *Ophiocten gracilis* and some evidence for current activity places it closest to the "Ophiuroids on rippled sediment" biotope in Howell's system.

Station AG13: nominal position 59^0 05.47' N, 07^0 35.95' W, depth 843m

The 25 photos from this station show a benthic environment continuing the trends described for AG11 and AG5. There is more evidence for current activity, with the seabed much more conspicuously current-rippled than at the shallower stations.

Stones, from gravel to small cobbles, are patchily distributed on the sediment surface. *Ophiocten gracilis* is present throughout but generally at low density. A few small hermit crabs and four specimens of the urchin *Gracilechinus* sp. can also be seen. There are no visible trawl furrows but image 10 shows a highly disturbed seabed covered with large irregular clods of sediment. This is likely to be a result of trawling. This station falls in the Upper Bathyal zone of Howell (2010), with either Mud or Sand sediment, and can be assigned to the "Ophiuroids on rippled sediment" biotope.

Station AG12: nominal position 59^0 07.62' N, 07^0 34.91' W, depth 847m

Station AG12 (11 photos) has a very similar benthic topography to AG13 at essentially the same depth. Patchy gravel and pebbles overlie a strongly rippled muddy sand or sandy mud sediment. *Ophiocten gracilis* is present on all photos and occurs at consistently higher density than at AG13. The last photo in the series (image 15A) also shows a high density of small organisms extending from tubes, with tentacle crowns expanded in a roughly north-westerly direction. These appear to be small sabellid polychaetes. Their presence on only one image suggests that this is a localized patch of these animals. There is no obvious anthropogenic disturbance visible at this station. This station falls in the Upper Bathyal zone of Howell (2010), with either Mud or Sand sediment, and can be assigned to the "Ophiuroids on rippled sediment" biotope.

Station AG3: nominal position 59^0 06.52' N, 07^0 35.58' W, depth 854m

This station (25 photos) lies at virtually the same depth as AG13 and AG12 and shows much the same benthic environment and community, characterized by current-rippled sediment, scattered surface stones, and the brittlestar *Ophiocten gracilis.* The eel *Synaphobranchus kaupi* is present on two photos. Image 23 shows a large cobble with encrusting epifauna. There is evidence of anthropogenic impact here in the form of a broad linear furrow on image 17, probably a relict trawl mark, and scattered clods of disturbed sediment on image 22. As for stations AG13 and AG12, this station can be classed as Upper Bathyal Mud or Sand, with "Ophiuroids on rippled sediment".

Station AG1: nominal position 59^0 06.53' N, 07^0 37.02' W, depth 898m

The 25 photos from this station show a seabed of sandy mud or muddy sand sculpted into conspicuous ripples by strong bottom currents. There are few if any stones on the sediment surface. Unlike the previous three stations, *Ophiocten gracilis* is very rare, with only a few individuals visible. Giant protists or xenophyophores (possibly *Syringammina fragilissima*) are the most conspicuous organisms and are seen on almost every image. Densities are variable but most photos show several individuals, and up to 20 per photo are present in some cases (e.g. image 17). The xenophyophores occur in the troughs between the sediment ripple crests. The eel *Synaphobranchus kaupi* is occasionally seen, and image 12 shows a rabbitfish or chimaera (*Chimaera monstrosa*). Depth and substratum place this station in the Upper Bathyal Mud or Sand categories of Howell (2010), and the abundance of xenophyophores matches the "Xenophyophore field" biotope defined in her classification. There is no sign of anthropogenic disturbance at this station.

Station AG8: nominal position 59^0 06.47' N, 07^0 39.55' W, depth 992m

The sediment seabed at AG8 (26 photos) is also rippled by currents, but less strongly than at AG1. This station more closely resembles AG12, AG13 and AG3 in having a low density of surface gravel and pebbles and a community numerically dominated by *Ophiocten gracilis.* Current scour and tail features can be clearly seen around the surface pebbles/ Brittlestars are present on every photo, often at high density (e.g. image 25). A large, dark-tentacled cerianthid anemone is seen on images 19 and 26, but there are no

xenophyophores. Like AG12, AG13 and AG3 this station can be classed as Upper Bathyal Mud or Sand, with “Ophiuroids on rippled sediment”. There is some evidence of anthropogenic disturbance. Image 13 is crossed by a narrow linear furrow, while faint surface striations are visible on image 19, both presumably indicative of trawling activity.

Enterprise stations

The benthic stations were arrayed along four parallel transect lines (A, B, C, D, see Figure below). Stations are discussed here in order of increasing water depth.

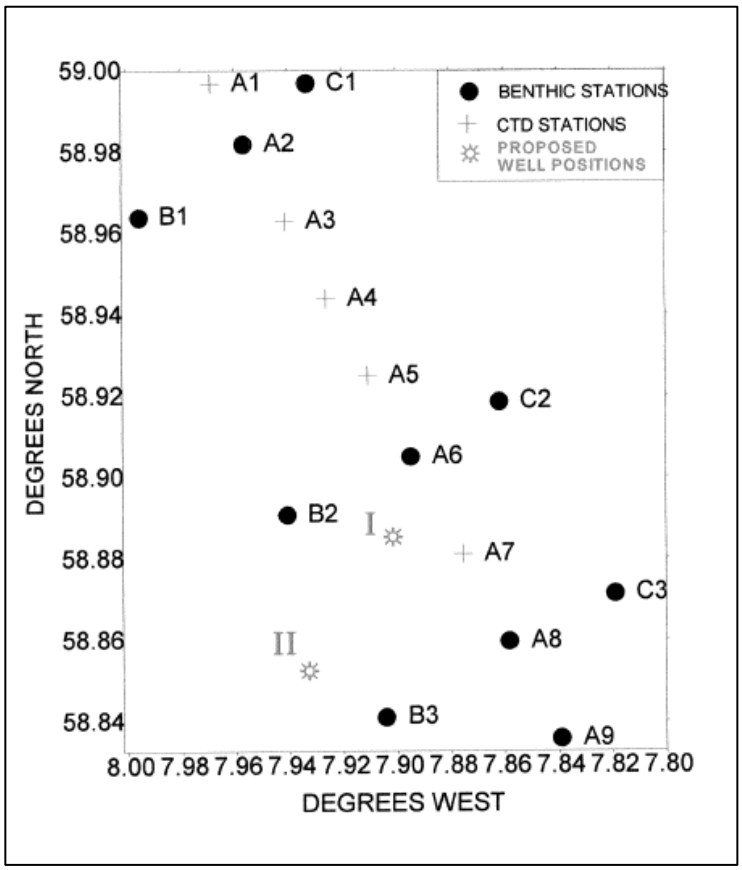

Figure 3.3. Benthic stations surveyed in the February 1998 cruise for Enterprise Oil Ltd.

Table 3.4. North-west Lewis, Enterprise stations: summary of benthic habitats and biota observed.

Station	Depth (m)	Habitat(s)	Species identified	Comments
A9	721	Muddy sand or sandy mud with high gravel content and many larger surface stones, up to small boulder size. Some burrow openings in less stony areas.	Foliose sponges and encrusting sessile epifauna on larger stones. Unidentified small brachiopods, *Gracilechinus* sp., *Helicolenus dactylopterus*	
A8	885	Muddy sand or sandy mud with low gravel content and sparse surface stones	*Ophiocten gracilis* (common), *Gracilechinus* sp., *Synaphobranchus kaupi, Beryx decadactylus*	
B3	890	Muddy sand or sandy mud with low gravel content. Sparse surface stones with current scour features	*Ophiocten gracilis* (common), *Gracilechinus* sp., *Synaphobranchus kaupi,* unidentified small crinoid, unidentified octocoral.	
C3	918	Muddy sand or sandy mud with low gravel content and sparse surface stones	*Ophiocten gracilis* (common), *Gracilechinus* sp., *Spatangus raschi, Synaphobranchus kaupi,*	
D1	1088	Strongly rippled muddy sand or sandy mud with very low gravel content	Xenophyophores, unidentified holothurian, unidentified echinothuriid urchin, fecampid egg capsule	
B2	1104	Strongly rippled muddy sand or sandy mud with very low gravel content	Xenophyophores, *Laetmogone violacea, Synaphobranchus kaupi, Chimaera monstrosa*	
C2	1105	Strongly rippled muddy sand or sandy mud with very low gravel content. Some burrow openings and many epifaunal trails	*Phormosoma placenta, Laetmogone violacea, Synaphobranchus kaupi*, *Troschelia berniciensis,* fecampid egg capsule	
A6	1108	Rippled muddy sand or sandy mud. Some epifaunal trails	Xenophyophores (abundant), *Calveriosoma hystrix, Synaphobranchus kaupi*	
A2	1295	Fine mud with megafaunal burrows	Xenophyophores, *Acanella arbuscula, Munida tenuimana, Hyalonema* sp.	Some trawl marks
C1	1304	Fine mud with megafaunal burrows	Xenophyophores, *Acanella arbuscula, Munida tenuimana, Hyalonema* sp.	Predominant burrows are probably made by *Munida tenuimana*
B1	1316	Fine mud with megafaunal burrows	Xenophyophores, *Munida tenuimana*	

Station A9: nominal position 58^0 50.15' N, 07^0 50.05' W, depth 721m

Twenty photos were taken at this station. Seabed environment is relatively uniform throughout, consisting of a bed of muddy sand or sandy mud mixed with large quantities of gravel and with many larger stones (up to the size of small boulders) on the surface. Infaunal bioturbation is apparent on a few photos where the gravel content is relatively low (e.g. image 20, which shows a distinct cluster of burrow openings). The larger surface stones can be seen to be colonized by sessile epifauna, including serpulid polychaetes and encrusting sponges and/or bryozoans (clearly shown on the small boulder in image 24). Erect foliose white sponges are also present in some cases (e.g. images 6 and 10). Small brachiopods are also present, although their inconspicuous appearance makes it difficult to accurately assess their abundance. Mobile epifauna are rare. Urchins (*Gracilechinus* sp.) are visible on two photos. A small perciform fish on image 16 is probably a bluemouth (*Helicolenus dactylopterus*). The depth and substratum type place this station in the Upper Slope Coarse or Mixed Substratum categories of Howell (2010) and the sparse visible fauna possibly corresponds to the "White encrusting sponges and serpulids on coarse sediment" biotope defined in her paper. There is no visible evidence of anthropogenic impact at this station.

Station A8: nominal position 58^0 51.45' N, 07^0 51.48' W, depth 885m

The 22 photos from this station show a benthic environment of muddy sediment differing from that of station A9 in having a much lower density of gravel and pebbles. Some larger cobbles occur on the surface (e.g. images 13, 18) but in contrast to A9, these seem to carry very little encrusting epifauna. There are no erect white sponges of the type seen at A9. Some epifaunal trails are visible. These are possibly made by urchins, as *Gracilechinus* sp. is visible on three photos. The most common animal is the brittlestar *Ophiocten gracilis*, which is present throughout the sequence. The eel *Synaphobranchus kaupi* is also present, with up to eight individuals visible in some photos (image 30). Image 18 shows a dark-coloured, deep-bodied fish which is probably an alfonsino (*Beryx decadactylus*). There is no obvious sign of anthropogenic impact at this station. Water depth places this station in the Upper Bathyal zone of Howell (2010), while substratum could be regarded as either Mud, Sand or Mixed Sediment. The prominence of *Ophiocten gracilis* places the community closest to the "Ophiuroids on rippled sediment" biotope in Howell's classification.

Station B3: nominal position 58^0 50.61' N, 07^0 53.62' W, depth 890m

Benthic environment at this station (21 photos) is broadly similar to that of A8 at approximately the same depth, but with more evidence of current activity. Surface pebbles show clear asymmetric scour pits and sediment "tails" indicative of bottom current flow. The sediment is distinctly rippled in some photos (e.g. image 18). *Ophiocten gracilis* is common in all photos, and *Synaphobranchus kaupi* is also frequently visible. A small comatulid crinoid is seen on image 22 and the urchin *Gracilechinus* sp. on image 27. Image 23 shows a white, branched colony which is probably an alcyonacean octocoral. A distinct linear furrow, presumably a trawl mark, is seen on image 5. This station can be assigned to the Upper Bathyal Mud or Mixed Sediment categories of Howell (2010) and to the biotope "Ophiuroids on rippled sediment".

Station C3: nominal position 58^0 52.34' N, 07^0 49.06' W, depth 918m

Only 16 usable photos were obtained at this station. They show a very similar benthic environment to station B3, with slightly rippled muddy sand or sandy mud sediment and patchy surface gravel and pebbles. There are also occasional larger stones up to the size of large cobbles or small boulders (e.g images 20A, 21A). *Ophiocten gracilis* is again the

most abundant organism, with *Synaphobranchus kaupi* also present on six photos. The urchins *Spatangus raschi* (image 20A) and *Gracilechinus* sp. (present on three photos) are also present, and are presumably responsible for the epifaunal trails visible on the sediment surface. There is no obvious evidence of anthropogenic disturbance. This station can be assigned to the Upper Bathyal Mud or Mixed Sediment categories of Howell (2010), and to the biotope "Ophiuroids on rippled sediment".

Station D1: nominal position 58^0 56.42' N, 07^0 49.78' W, depth 1088m

The 13 photos taken at this station show a very uniform benthic environment of stongly rippled sediment, probably muddy sand or sandy mud, virtually devoid of surface stones. Most photos (e.g. image 5A) show heavily-shadowed depressions which may be burrow openings. *Ophiocten gracilis* is not seen here. The most frequently-visible organisms are xenophyophores, which are present on five of the 13 images. These giant protists appear to be patchily distributed, as up to seven are present on some photos (image 16A). A possible holothurian is visible on image 12A, while image 11A shows an organism which may be an echinothuriid urchin. Photo 17A shows a distinctive coiled object standing erect with one end attached to the seabed. This is the egg capsule of a fecampid flatworm, which as adults are parasites of benthic crustaceans. There is no sign of anthropogenic disturbance. Benthic environment and water depth would place this station in the Upper Bathyal Sand or Mud categories of Howell (2010), and the most conspicuous benthic organisms allow assignment to her "Xenophyophore field" biotope.

Station B2: nominal position 58^0 53.36' N, 07^0 56.00' W, depth 1104m

Twenty-two photos were taken at this station. They show a benthic environment very similar to D1, with strongly rippled sediment lacking surface stones. The pits or burrow openings seen at D1 are also present here. Xenophyophores are again the most conspicuous organisms, being visible on 10 of the 22 photos. Up to nine specimens are visible on some images (e.g. image 26A). The only other benthic organisms visible are a hermit crab and a holothurian, possibly *Laetmogone violacea*, on image 10A. The eel *Synaphobranchus kaupi* is seen on four images, and there is also a single small specimen of the rabbitfish *Chimaera monstrosa* on image 18A. A narrow linear furrow, presumably a trawl mark, is visible on image 19A. Like station D1, this locality can be classed as Mid Bathyal Sand or Mud, with "Xenophyophore fields".

Station C2: nominal position 58^0 55.27' N, 07^0 51.57' W, depth 1105m

Eighteen usable photos were obtained at this station. The substratum consists of muddy sand or sandy mud, and is clearly rippled by bottom-current activity. Unlike D1 and B2 there is more evidence of infaunal bioturbation in the form of wide pits or burrow openings (e.g image 15). Sea star traces and other epifaunal trails are also common and visible on most photographs. No xenophyophores are visible here. Echinothuriid urchins are seen on three photos, most clearly on image 7. Species identity is uncertain, but from the station depth *Phormosoma placenta* is a likely candidate. A holothurian, possibly *Laetmogone violacea*, can be seen on image 11.

Large neogastropods, possibly *Troschelia berniciensis*, are visible on images 12 and 18. The coiled egg capsule of a fecampid flatworm is present on image 13. *Synaphobranchus kaupi* is the most common fish, and a small unidentified ray is just visible in the background of image 25. A very faint, shallow linear furrow, probably a relict trawl mark, appears on image 21. This station would be classed as Mid Bathyal Mud or Sand according to Howell (2010), but too little biota is visible to allow assignment to one of her biotopes.

Station A6: nominal position 58^0 54.11' N, 07^0 53.48' W, depth 1108m

The 22 photos from this station show a very uniform benthic environment of rippled sediment (muddy sand or sandy mud) without surface stones and with little or no evidence of infaunal burrowing. Some sea star traces are visible. Xenophyophores are present in abundance, appearing on all but one photo, with up to 30 specimens per image (e.g. image 20). An echinothuriid urchin, probably *Calveriosoma hystrix*, is seen on image 6. The only other visible organisms are a few small hermit crabs and the eel *Synaphobranchus kaupi.* Shallow linear tracks, probably old trawl marks, are present on three photos (images 5, 6, 24). This locality can be classed as Mid Bathyal Sand or Mud, with "Xenophyophore fields".

Station A2: nominal position 58^0 58.66' N, 07^0 57.40' W, depth 1295m

The 14 photos from this station show a fine muddy seabed with no evidence of bottom current activity. The sediment is heavily-bioturbated, with many small mounds, pits and burrow openings. The stellate feeding trace of an echiuran worm is clearly visible on image 9. Xenophyophores are visible on at least eight of the photos but do not dominate the benthic community to the extent seen at station A6. The bushy octocoral *Acanella arbuscula* also appears on seven photos. Small decapod crustaceans, probably *Munida tenuimana*, appear on several photos and there is one example (image 9) of a glass sponge (*Hyalonema* sp.). The head of an elongate fish is just visible at the left edge of image 17. Its identity is not clear but the head shape suggests that it may be a notacanthid eel. This station can be classed as Mid Bathyal Mud, but assignation to one of Howell's (2010) biotopes is less certain. The visible biota has taxa in common with both "Xenophyophore fields" and the "*Acanella arbuscula* and *Ophiomusium lymani* assemblage".

Parallel linear striations created by the passage of a trawl can be seen on images 18, 19 and 27. In all three cases the trawl marks are punctuated by holes and mounds indicating infaunal survival or recolonization of the disturbed area since the time of impact.

Station C1: nominal position 58^0 59.67' N, 07^0 55.77' W, depth 1304m

The 18 photos from this station also show a heavily-bioturbated fine mud seabed. Small mounds, pits and holes are abundant and there are also clusters of very large, oblique burrow openings associated with piles of expelled sediment (e.g. image 23A). In several cases, individuals of the squat lobster *Munida tenuimana* are present in close association (e.g. images 18A, 24A), suggesting that they are the creators of these burrows. Xenophyophores are visible on at least ten of the photos. Image 22A shows at least ten of these giant protists. Colonies of the bushy octocoral *Acanella arbuscula* are occasionally seen, and there are also some twig-like upright objects which are probably the relict skeletons of dead colonies. Relict talks of glass sponges (*Hyalonema* sp.) can be seen on several images (e.g. 16A, 17A). Image 30A shows four sponge stalks, only one of which still retains the "body" of the sponge at its distal end. The eel *Synaphobranchus kaupi* is present on several photos, and a small unidentified grenadier is also just visible in the background of image 9A. Like station A2, this locality can be classed as Mid Bathyal Mud, and it has taxa in common with the "Xenophyophore fields" and "*Acanella arbuscula* and *Ophiomusium lymani* assemblage" biotopes in Howell's system.

Surface striations or areas of artificially smooth seabed can be seen on six of the 18 photos, indicating trawl impacts. The "headless" sponge stalks referred to above may also be specimens damaged by trawling.

Station B1: nominal position 58^0 57.74' N, 07^0 59.90' W, depth 1316m

Only six usable images were obtained here. They indicate a benthic environment of bioturbated fine mud very similar to that of station C1. Xenophyophores and *Munida tenuimana* are present. Faint parallel striations, presumably old trawl marks, can be seen on two photos (images 10A, 18A).

Statoil stations

The benthic stations were arrayed along three parallel transect lines (X, Y, Z, see Figure below). Stations are discussed here in order of increasing water depth.

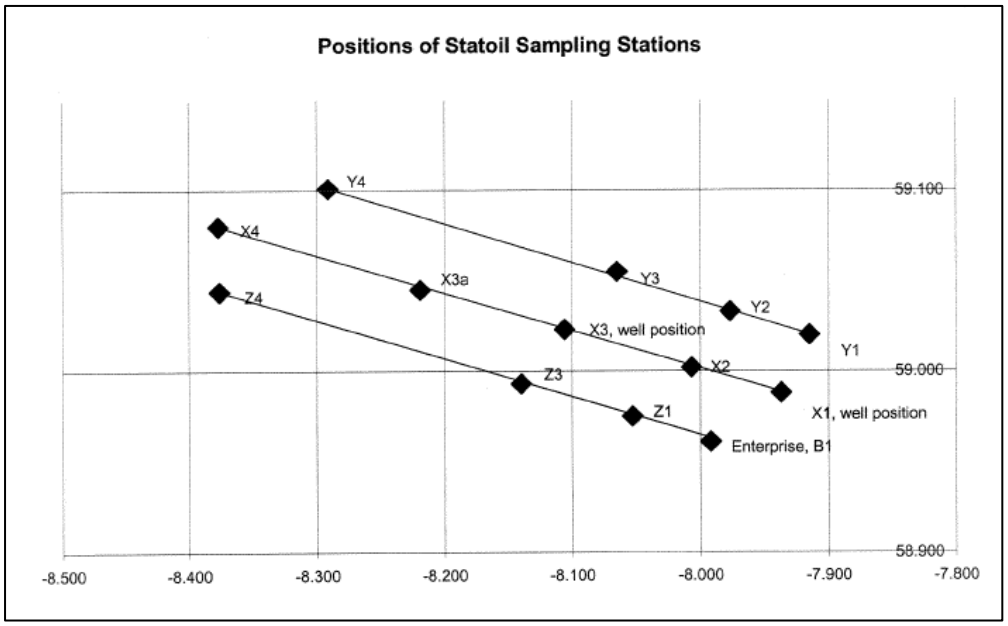

Figure 3.4. Benthic stations surveyed in the May 1998 cruise for Statoil Ltd.

Table 3.5. North-west Lewis, Statoil stations: summary of benthic habitats and biota observed.

Station	Depth (m)	Habitat(s)	Species identified	Comments
X1	1293	Fine mud with megafaunal burrows	Xenophyophores, *Munida tenuimana, Hyalonema* sp.	
Y1	1300	Fine mud with megafaunal burrows	Xenophyophores, *Munida tenuimana, Synaphobranchus kaupi*	Extensive trawl damage
Y2	1376	Fine mud with megafaunal burrows	Unidentified cerianthid anemone	Predominant burrows probably made by *Munida tenuimana.* Echiuran "spoke burrows" also common
X2, X2a	1379	Fine mud (burrows erasedby trawling)	*Munida tenuimana*	Extensive trawl damage on all
Y3	1429	Fine mud with megafaunal burrows	*Synaphobranchus kaupi*	Extensive trawl damage
Y4	1451	Fine mud with megafaunal burrows	*Synaphobranchus kaupi, Hyalonema* sp.	
Z3	1453	Fine mud with megafaunal burrows	*Zoroaster fulgens*	
X3, X3a	1455	Fine mud with megafaunal burrows	*Synaphobranchus kaupi, Hyalonema* sp.	
X4	1477	Fine mud with megafaunal burrows	Unidentified anemone	
Z4	1492	Fine mud with megafaunal burrows	Unidentified anemone, *Coryphaenoides guentheri,* possible *Notacanthus bonapartei*	

Station X1: nominal position 58^0 59.30' N, 07^0 56.35' W, depth 1293m

The 25 images obtained from this station are of poor quality. Water turbidity was high, and there seem also to have been problems with the film processing. The available detail shows a substratum of fine mud with burrows, much as recorded at the deepest Enterprise stations. Xenophyophores are visible on most of the photos, and there are also occasional glass sponges (*Hyalonema* sp.) and squat lobsters (*Munida tenuimana*). There are no obvious signs of anthropogenic disturbance, but faint trawl marks, if present, would probably be difficult to see on these images. The limited information available allows this station to be classed as Mid Bathyal Mud, and tentatively as a "Xenophyophore field".

Station Y1: nominal position 59^0 01.21' N, 07^0 54.85' W, depth 1300m

This station is at essentially the same water depth as X1. The 25 photographs obtained here are of much better quality. They confirm the substratum as bioturbated fine mud with many small mounds and burrow openings. Large, oblique burrow openings occupied by *Munida tenuimana* are seen on image 16. The most common organisms are xenophyophores. These protists are absent from most of the photos but appear in large numbers towards the end of the sequence, with at least 20 individuals on image 30. Two large specimens of *Synaphobranchus kaupi* are seen on image 6. This station shows a high frequency of trawl damage. Smoothed sediment, furrows or parallel striations are visible on 13 out of the 25 photos. In some cases (e.g. images 11, 16), enough time has elapsed for infauna to recolonize or reopen their burrows in the areas crossed by the trawl. The erect stalks of glass sponges (*Hyalonema* sp.) are present in several photos (e.g. images 16, 21), but in all cases the "body" of the sponge is missing from the distal end of the stalk. This may be the result of the sponge tissue being stripped from the stalk during passage of a trawl. The high frequency of disturbance creates difficulty in assessing the biological community, but in some areas this Mid Bathyal Mud station probably meets the criteria for a "Xenophyophore field" as defined by Howell (2010).

Station Y2: nominal position 59^0 02.02' N, 07^0 58.59' W, depth 1376m

The 21 photos obtained here also show a bioturbated fine mud environment. The most conspicuous biogenic features are the large burrow openings associated with *Munida tenuimana* (e.g. image 23A) and the stellate feeding traces of echiuran worms (e.g image 15A). A dark-tentacled cerianthid anemone appears on one photograph (22A). No xenophyophores are visible here. Two images (19A, 21A) show evidence of trawling impact, in the form of broad, shallow linear furrows. The example on image 21A appears to be old, as burrows can be seen to have opened through the trawl track.

Station X2: nominal position 59^0 00.17' N, 08^0 00.52' W, depth 1379m

The 25 photos obtained here again show a seabed of fine mud. This series is notable in that every photo shows evidence of trawling impact, and virtually no undisturbed seabed is visible. Examples are seen of areas smoothed and flattened by trawl passage (e.g. image 7), deep furrows carved into the sediment (28), parallel linear striations (22) and large masses of disturbed sediment covering the seabed (9). A single specimen of *Munida tenuimana* appears on image 14, but otherwise no benthic biota or natural bioturbation features can be seen.

Station X2a: nominal position 59^0 00.14' N, 08^0 00.58' W, depth 1379m

A second camera deployment at this station produced 25 usable photos. Water turbidity was high, but the visible features agree with the observations reported above.

Every photo shows evidence of trawl disturbance to the seabed, and no benthic biota are visible.

Station Y3: nominal position 59^0 03.21' N, 08^0 03.70' W, depth 1429m

This station, at slightly greater depth than X2, produced 24 seabed photos. Trawl disturbance to a fine mud seabed is again very extensive, with some impacts visible on every photograph. Visible impacts include broad, single furrows (e.g. image 16A) and multiple, parallel striations (e.g. image 18A). A few *Synaphobranchus kaupi* are seen, but there are no visible benthic organisms. However, in a few cases (e.g. images 18A, 22A, 26A) infaunal burrowers have recolonized or reopened existing burrows in the areas covered by trawl tracks.

Station Y4: nominal position 59^0 05.99' N, 08^0 17.77' W, depth 1451m

The 22 photos taken here show a benthic environment of fine, bioturbated mud very similar to that described from the previous Statoil stations. Clusters of large burrow openings with elevated rims of expelled sediment are frequent (e.g. image 15A), and there are many smaller holes and domed or conical mounds. The stellate feeding traces made by echiuran worms are also seen (e.g. image 14A). An intact glass sponge (*Hyalonema* sp.) is seen on one image (26A) and there is one specimen of Synaphobranchus kaupi (9A) but no other visible biota. In contrast to stations X2, X2a and Y3 there is no visible evidence of trawling here.

Station Z3: nominal position 58^0 59.55' N, 08^0 08.19' W, depth 1453m

There is no change in benthic environment at this station (25 photos), which shows a sebed of fine mud with the usual burrow openings, mounds and epifaunal trails. Large echiuran feeding traces are visible on seven photos. The only visible benthic animal is a large sea star, probably *Zoroaster fulgens*, of which six individuals are seen on seven photos. There is evidence of trawling on at least six photos, either single shallow linear furrows or multiple, parallel striations. A few other photos may show very old, relict features which have been largely erased by faunal activity. Like the previous Statoil stations, this locality can be classed as a Mid Bathyal Mud environment, but the sparse visible biota do not allow assignment to any of Howell's (2010) biotopes.

Station X3: nominal position 59^0 01.36' N, 08^0 06.37' W, depth 1455m

The 24 photos from this station show once again a seabed of bioturbated fine mud. The sediment surface has a faintly granular appearance which is likely to be caused by small agglutinating Foraminifera. An intact glass sponge (*Hyalonema* sp.) is seen on image 25, and one specimen of *Synaphobranchus kaupi* on image 26, but there are no other visible animals. There are also no obvious signs of trawling activity.

Station X3a: nominal position 59^0 02.73' N, 08^0 12.96' W, depth 1456m

A second deployment at station X3 produced only four usable photos. Seabed environment is entirely consistent with the description given above, and no additional taxa are visible.

Station X4: nominal position 59^0 04.80' N, 08^0 22.63' W, depth 1477m

This station produced 24 photos which indicate no change in benthic environment from the preceding stations. The fine mud seabed is heavily bioturbated. A glass sponge stalk is

visible on image 17, and an unidentified anemone appears on image 26, but there is other visible fauna. There are also no obvious trawl marks.

Station Z4: nominal position 59^0 02.66' N, 08^0 22.64' W, depth 1492m

The deepest Statoil station produced 24 usable photos. Sediment type and seabed topography created by bioturbating infauna show no change from the preceding stations in this survey. Clusters of large burrow openings are very conspicuous (e.g. image, 9A, 10A). Image 20A shows four clear piles of faecal pellets left by an epifaunal organism, possibly a holothurian. An unidentified anemone appears on image 24A. Two species of fish can be seen, a notacanthid eel on image 19A may be either *Notacanthus bonapartei* or *Polyacanthanotus rissoanus.* A grenadier on image 24A is probably *Coryphaenoides guentheri.* There are no visible signs of trawling at this station.

4 Discussion

4.1 Benthic environments and communities of the Scottish continental slope

The benthic ecology of the SEA7 region, which includes the areas discussed in this report, has been reviewed in detail by Davies *et al* (2006). With respect to the Scottish continental slope, most of the available information comes from the benthic sampling programmes conducted by the late Professor John Gage (and various co- workers at SAMS) from the early 1970s onwards. Selected seabed photographs taken using the "bed-hop" camera system have been featured in a number of publications dealing with particular features of the continental slope, including geological bedforms and current activity (Howe & Humphery, 1995), brittlestar beds (Lamont & Gage, 1998), trawling impacts (Roberts *et al,* 2000), Environmental Impact Assessment (Gage, 2001), bryozoan distribution (Hughes, 2001) and benthic biodiversity patterns (Gage *et al,* 2000; Gage, 2002). However, this report marks the first detailed analysis of the entire photographic archive (1,483 individual images have been examined here) and the first comparison of the three main survey areas.

The bathymetric extent of the photographic stations was not identical in all three surveys, a factor which prevents a comprehensive inter-regional comparison of downslope trends. The LOIS-SES series covered the full bathymetric extent of the margin from the outer shelf (135m) to the base of the slope at >2000m. The 1988 St. Kilda series covered the upper to mid-slope only (350-885m), while the three NW Lewis transects together cover the depth range from 707-1492m. However, with this caveat in mind, direct comparisons at particular depth ranges can be made to integrate the three datasets and produce a synthesis of depth-related trends down the Scottish continental slope. There is also an issue of change over time, with approximately a decade separating the St. Kilda cruise (1988) from the other two surveys in the mid-late 1990s. Although recent research suggests that deep-sea benthic communities are much more variable over interannual to decadal timescales than formerly believed (Glover *et al,* 2010), the major benthic habitats described here (and their associated biota) are largely determined by bathymetric trends in substratum type and hydrodynamics, factors which will be highly persistent over time. It is therefore probably reasonable to conclude that the ten-year time difference between the St. Kilda survey and the other two datasets will not significantly confound comparisons between them. One possible exception to this is the assessment of anthropogenic impact by bottom-trawling, which will be discussed further below.

4.2 Bathymetric trends and regional variation

Gage (1986) summarized bathymetric trends in habitat type and megafaunal distribution down the Scottish continental slope, mainly in the area later covered by the LOIS-SES study. This work was based on the results of benthic sampling programmes using towed sleds and trawls, and at the time, very little seabed photography had been carried out in the area. The present study confirms the broad trends identified by Gage but also provides much additional detail and allows us to assess whether the same zonation can be observed along the full extent of the slope west of the Hebrides. The photographic dataset allows the following broad bathymetric zones to be identified (depths listed are the minimum and maximum at which this habitat/community was observed):

Outer shelf and shelf break (135 – 227m)

The LOIS-SES photos show that from the outer shelf to immediately below the shelf break at ~ 200m depth, benthic environments are characterized by strong current activity (stations N140, S140, N200, S200). Bottom sediments are coarse, ranging from strongly rippled sand to gravel plains, dense fields of cobbles and small boulders. The full spectrum of these coarse substrata was seen at station S200 (152-185m), indicating a patchy seabed with sand or gravel plains interspersed with cobble and boulder fields. This high-energy region supports a very sparse visible biota, with large echinoderms (particularly the urchin *Cidaris cidaris*) the most obvious inhabitants. Cobbles and small boulders are colonized by encrusting sessile epifauna. It is not possible to characterize these at the available level of resolution, but bryozoans, serpulid polychaetes and brachiopods are all likely to be present. Small mobile epifauna such as *Munida* sp. and unidentified sea stars are visible on some images among the the cobbles, which presumably provide some shelter from water movement. No stations in this depth range were visited in the St. Kilda or NW Lewis areas.

A striking exception to the prevailing environmental conditions of the outer shelf is seen at station S5 in the LOIS-SES series. This appears to represent a depression (172-175m) with fine sediments inhabited by burrowing megafauna. Visually, the benthic environment here is most similar to the circalittoral fine muds best known from sea lochs and other inshore depositional basins along the Scottish west coast. The spatial extent and community composition of this outer shelf depression are unknown but deserve further investigation.

Upper slope (279-470m)

Stations in this general depth range were surveyed in the LOIS-SES area (stations N300, S300) and near St. Kilda (350, 390 and 470m). Images from the two LOIS- SES stations show coarse bottom sediments (gravelly sand with cobble patches) and a sparse benthic megafauna. Conditions at the St. Kilda stations at comparable depths are somewhat different and suggestive of lower hydrodynamic activity. Sediments here are finer than at the LOIS-SES stations and there is a more abundant benthic fauna including the epifaunal echinoderms *Spatangus raschi, Stichopus tremulus* and *Gracilechinus* sp. Urchin trails are conspicuous on the sediment surface, and some images show burrow openings or pits made by burrowing megafauna. Muddier sediments with biogenic traces suggest that current speeds are lower at these St. Kilda stations than at the upper slope LOIS-SES stations. The NW Lewis surveys did not cover any stations in this depth band.

Ophiocten gracilis zone (600-1020m)

A depth zone characterized by dense populations of the small brittlestar *Ophiocten gracilis* was described by Lamont & Gage (1998), based on seabed photographs (from the archive analyzed here) from the LOIS-SES and St. Kilda areas of the Scottish continental slope. Lamont & Gage recorded densities of up to 792 individuals m^{-2} with a peak in abundance at ~ 700m depth. The NW Lewis photographic surveys show that the *O. gracilis* zone can also be identified this far north. In the absence of any major topographic boundaries it can be inferred to extend in a continuous or near- continuous band along the Scottish continental slope south of the Wyville Thomson Ridge. Analysis of the complete photographic archive provides additional details of the bathymetric extent of this zone, and suggests that there may be some regional variation in its upper and lower limits.

Ophiocten gracilis is seen in large numbers on sedimentary seabeds which may consist of fine sand, muddy sand or sandy mud. There is usually some surface gravel or scattered

pebbles, and current-induced ripples are often also present. Below aprroximately 700m depth the sediment on the Scottish continental slope contains an increasing proportion of fine-grained calcareous particles (biogenic ooze), contrasting with the coarser, mainly terrigenous sediments higher up the slope (Gage, 1986). This "mud line" was first identified by Sir John Murray in the 19th century (Murray & Hjort, 1912). The *O. gracilis* zone also coincides roughly with the bathymetric extent of the slope current (500-1100m) which flows northwards along the Scottish continental margin (Howe & Humphery, 1995). In the LOIS-SES area, *O. Gracilis* was present in large numbers at stations N700, P700, R700 and S700 (total depth range 659-732m) and was also seen in abundance at the two most easterly localities recorded as station R1000 (visits in December 1995 and August 1996, depths 982-990m). The species was seen in small numbers at station S1000 (1,021-1,026m) and in May 1996 at R1000 (990-1,004m). In this area therefore, the lower limit of the *O. gracilis* zone appears to be at approximately 1020m depth. North-west of St. Kilda, *O. gracilis* was seen at all stations between 600-885m depth, with maximum abundance from 750-863m.

Off NW Lewis, *O. gracilis* was not seen at stations AG11 (707m) or A9 (721m), but was present from 885-918m (Enterprise stations A8, B3 and C3) and 794-992m (Agip stations AG5, AG13, AG12, AG3 and AG8). These patterns suggest that the upper boundary of the *O. gracilis* zone may be slightly deeper off NW Lewis than in the St. Kilda and LOIS-SES areas further south. The species was not seen at station D1 in the Enterprise survey (1,088m), indicating a lower depth limit around 1000m, as found previously.

Advective transport of organic particles in the northwards-flowing slope current may play an important role in sustaining the high benthic biomass seen in the *O. gracilis* zone. In addition to the brittlestars, benthic megafauna present in this community include the urchins *Spatangus raschi* and *Gracilechinus* sp. (*G. acutus* and *G. elegans* co-occur in this depth zone, Gage *et al,* 1985), the holothurian *Stichopus tremulus* and the gastropod *Troschelia berniciensis.* Small cerianthid anemones were seen at high density at the 700m stations in the LOIS-SES area, typically with tentacle crowns expanded in a uniform orientation, presumably in relation to the prevailing near-bed currents. The cut-throat eel *Synaphobranchus kaupi* is the most commonly-seen fish at these depths, often with several individuals visible on an individual photograph.

Xenophyophore zone (NW Lewis, 1088-1108m)

In the Enterprise Oil survey off NW Lewis, stations D1, B2 and A6 (depths 1,088-1,108m) were characterized by strongly rippled muddy sand or sandy mud, with xenophyophores as the most abundant and conspicuous large organisms. No xenophyophores were visible at station C2 (1,105m) in this survey, although the benthic environment otherwise appeared very similar. Xenophyophores also occurred at the deeper Enterprise stations A2, C1 and B1 (1,295-1,316m) and at Statoil stations X1 and Y1 (1,293-1,300m) but on a different substratum of megafaunally-burrowed fine mud. Abundant xenophyophores, identified as *Syringammina fragilissima*, have also been recorded from the sediment "tails" of the Darwin Mounds (~ 1,000m depth), just south of the Wyville Thomson Ridge (Bett, 2001). The evidence therefore suggests that large populations of these giant protists may be particularly characteristic of the northern Rockall Trough at depths of 1,000-1,100m, on sediment seabeds exposed to bottom currents. Xenophyophores were very seldom seen at comparable depths in the LOIS-SES area, with only a few visible in the May 1996 series from station R1000. The St. Kilda station transect did not extend into this depth zone, so we cannot as yet determine whether a recognisable xenophyophore zone is present this far south.

Mobile epifauna observed in small numbers in the xenophyophore zone off NW Lewis are the holothurian *Laetmogone violacea* and the echinothuriid urchins *Phormosoma placenta* and *Calveriosoma hystrix.* The eel *Synaphobranchus kaupi* is often seen in images from this depth.

Decapod burrow zone (1293-1595m)

Gage (1986) noted that the sediments on the Hebridean slope at ~1,400m depth are a mixture of pelagic ooze and turbidite. Photographic stations from the approximate depth range of 1,300 – 1,600m in both the LOIS-SES and NW Lewis areas show a distinctive and relatively uniform benthic environment of fine mud heavily reworked by burrowing megafauna. It is important to note that despite a superficial resemblance, the bottom sediments and burrowing community here will be quite different to those present in the shelf depression (station S5) in the LOIS-SES survey, and should not be assigned to any of the circalittoral mud biotopes from the coastal zone. The most conspicuous and characteristic burrow type observed between 1,300-1,600m on the continental slope is a cluster of large (~ 10 cm diameter) openings at an oblique angle to the sediment surface, often with a adjacent pile or rim of sediment expelled in "bulldozer" fashion from the burrow. This mode of burrow construction is characteristic of the larger decapod crustaceans, and whenever an animal is seen in close association with one of these features, it is the squat lobster *Munida tenuimana.* This species is the most common galatheid at depths of 1,200-1,300m in the Porcupine Seabight (Hartnoll *et al,* 1992) and is also widespread in the Rockall Trough area (Hughes & Gage, 2004). *Munida tenuimana* has been previously suggested to be a burrower in soft sediments (Hartnoll *et al,* 1992) and is therefore likely to be the species responsible for the hole clusters described here.

In addition to the burrows of *Munida tenuimana*, the bottom sediments in this depth range are marked by a variety of other biogenic features, including smaller holes, pits and trails. Many of these are difficult to assign to species, but the star-shaped feeding traces made by echiuran worms are very distinctive (Ohta, 1984) and are visible in many of the images from this zone. Stellate feeding traces are made in fine circalittoral sediments by the echiuran *Maxmuelleria lankesteri* (Hughes *et al,* 1994), but in this continental slope setting one or more of the variety of echiuran species known from bathyal and abyssal depths (Biseswar, 2009) are more likely to be responsible.

At station N1500 on the LOIS-SES transect, epifauna were extremely sparse, despite the abundance of biogenic features on the sediment surface. Most images showed no visible animals at all. The holothurian *Pseudostichopus villosus*, and the fish *Synaphobranchus kaupi* and *Coryphaenoides* sp. were recorded. Epifaunal densities are often very low in photographic surveys at bathyal and abyssal depths, and the observed situation at N1500 is not particularly unusual. Stations at similar depth off NW Lewis appeared to have a more abundant and diverse epifauna, although many images still showed only burrows and other biogenic traces. Xenophyophores (probably *Syringammina fragilissima*), glass sponges (*Hyalonema* sp.) the octocoral *Acanella arbuscula* and the sea star *Zoroaster fulgens* were all recorded, along with frequent *Synaphobranchus kaupi.*

Base of continental slope (LOIS-SES area, 2056-2070m)

This zone is only represented in the LOIS-SES series as the Rockall Trough north- west of Lewis does not reach these depths and the St. Kilda transect did not extend below 885m. Station N2000 at the western end of the LOIS-SES transect was characterized by fine sediments extensively reworked by biological activity, but there are clear and consistent differences from the shallower decapod burrow zone discussed above. The large hole clusters probably made by *Munida tenuimana* are rare or absent, and the predominant biogenic traces are smaller holes and pits of indeterminate origin, and conical, volcano-like

sediment mounds which may be generated by burrowing holothurians such as *Molpadia blakei* (Rhoads & Young, 1971). Echiuran "spoke traces" are also visible at this station. Visible epifauna are more abundant than at the shallower N1500 station. The characteristic species are the bushy octocoral *Acanella arbuscula* and the large brittlestar *Ophiomusium lymani.* These two species are frequently seen in close association, with the brittlestar positioned at the base of an *Acanella arbuscula* colony. This interspecific association has been reported from other Rockall Trough localities at similar depth (Hughes & Gage, 2004) but its functional significance (if any) is unknown. The long-spined urchin *Gracilechinus affinis* is also quite common on images from N2000. The eel *Synaphobranchus kaupi* is not seen at N2000 but there are occasional macrourid fish.

4.3 Anthropogenic impacts

Roberts *et al* (2000) discussed the frequency of trawl marks in seabed photos from the February 1998 Enterprise Oil survey off NW Lewis, and noted evidence of trawling in the St. Kilda photographic survey a decade earlier. The addition of the LOIS-SES, Agip and Statoil photographic datasets now provides a larger base for comparison. However, assessment of the relative impacts of bottom-trawling in the three main areas can only be partial, given the time differences between the surveys and the mis-matches in depth intervals sampled. The earliest series, taken off St. Kilda in March 1988, shows evidence of trawling from 470-885m. The highest frequency was seen at 885m, where trawl disturbance was visible on 17 out of 21 photos (81%). In contrast, the LOIS-SES series from 1995-96 showed very little evidence of trawling. Apart from one possible trawl mark in the fine-sediment shelf depression (station S5), marks were recorded at only one slope station, R1000, where they were visible on 15% of the images.

The highest frequency of visible trawl damage was seen in the NW Lewis area. Combining all three areas surveyed in 1998 (Enterprise, Agip and Statoil surveys) and pooling stations into 100m-depth intervals, shows that some evidence of trawling was visible across the entire bathymetric range investigated (approximately 700-1,500m). As summarized in the figure below, distinguishable trawl marks were present at low frequency from 700-1,200m, peaked in the 1,300-1,400m interval (63% of photos), and were still fairly frequent in the deepest stations sampled (1,400-1,500m, 20% of photos).

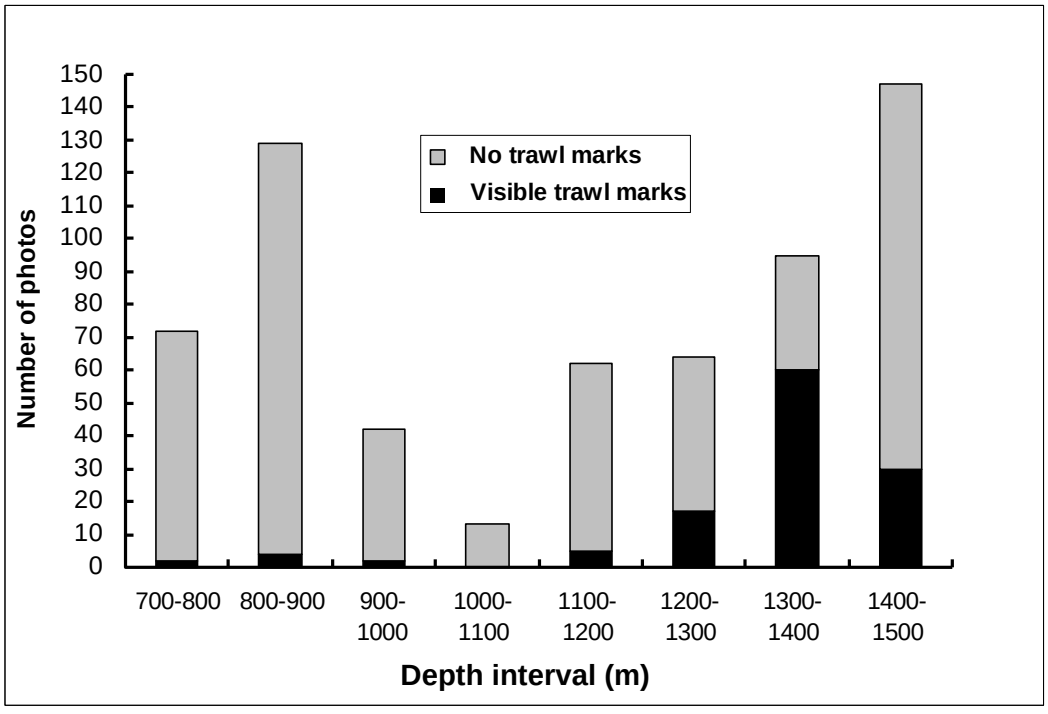

Figure 4.1. NW Lewis 1998: frequency of seabed photos showing trawl marks.

Gordon (2001) reports that in the Rockall Trough, the total abundance and biomass of all fish species caught by bottom-trawling is maximal at depths between 1,000m and 1,500m. This resource distribution is consistent with the observed frequency of trawl marks in the NW Lewis photographic dataset shown above. Some deep-water bottom- trawling was carried out in the Rockall Trough as early as the 1970s, but fishing intensity increased rapidly from about 1989 onwards, when French trawlers began to target roundnose grenadiers (*Coryphaenoides rupestris*), black scabbardfish (*Aphanopus carbo*) and various deep-water sharks (Gordon 2001, 2003). The trawl marks seen on the 1988 St. Kilda photos, some of which appear to be very fresh, may therefore have been made near the outset of this intensified phase of activity.

The LOIS-SES dataset suggests a relatively low intensity of trawl impact in the area at the time the photographs were taken (1995-96), although it should be noted that this series does not include any stations between 1,000m and 1,500m, which was the most-heavily impacted depth range off NW Lewis. However, it is likely that the LOIS-SES area has been subjected to significant deep-water fishing pressure. Gordon (2003) notes that the 1,000m depth contour on the Hebrides Terrace was sampled regularly by SAMS over the period from 1975 to 1992, with no damage recorded to the nets or trawls. An attempted re-sampling in 1999 resulted in extensive damage to sampling gear by large rocks up to 1.5m in diameter. Gordon suggests that these were glacial dropstones originally buried in the bottom sediments but unearthed by the heavy rockhopper trawls of commercial fishing vessels. The apparent contrast between LOIS-SES and NW Lewis in visible evidence of trawling may therefore reflect only the times at which the photos were taken, and may not be representative of the cumulative impact on these areas since the surveys were carried out.

4.4 MPA search features and benthic biotopes

Of the Nature Conservation MPA search features and their components specifically listed in Annex 3 of the Guidelines on the selection of MPA's (Marine Scotland, 2011) (shown in Annex 1 here), only one – burrowed mud – can be identified in the photographic dataset described here. The habitat and community recorded in the shelf depression (station S5) in the LOIS-SES series can be tentatively assigned to "Burrowing megafauna and *Maxmuelleria lankesteri* in circalittoral mud" (SS.SMu.CfiMu.MegMax), although a more intensive survey will be required to confirm or revise this identification. However, this station lies just outside Scottish waters. The fireworks anemone (*Pachycerianthus multiplicatus*) and the tall sea pen (*Funiculina quadrangularis*) were not observed in the small sample of photos obtained from this station, and neither was seen at any of the deeper continental slope stations. There was also no evidence for any of the following deep-sea communities regarded as Priority Marine Features in UK waters:

- Cold-water coral (*Lophelia pertusa*) reefs
- Coral gardens
- Carbonate mounds
- Deep-sea sponge aggregations

Whilst the Guidelines (Marine Scotland, 2011) list existing biotopes as components of search features, the majority of the still images may be assignable to offshore subtidal sands and gravels and offshore deep sea mud as well as burrowed mud search features since the Project must consider their geographic range and ecological variation. The results of this study provide further evidence of the presence of deep water communities of these three sedimentary habitat features.

The correspondence of the macrofaunal samples collected in the SEA7 area to the infaunal offshore sediment biotopes in Annex 1 will be assessed in the following section (4.5).

The benthic environments recorded in the photographic dataset can all be matched to substrata (Level 3) in the classification system of Howell (2010) tough in some cases the attribution is tentative owing to the difficulty of accurately assessing sediment granulometry from a seabed photograph (e.g. distinguishing between fine sand/sandy mud/muddy sand). Where very few benthic animals are visible (e.g. from the upper slope stations in the LOIS-SES series), classification has been limited to Level 3, as a much greater number of images, covering a larger total seabed area, would be required to determine the characterizing species for Level 4 (Biology) in Howell's system. Continental slope stations with a higher density of benthic fauna could be compared with the Level 4 categories in Howell (2010), with some correspondence to the following biotopes identified:

Table 4.1. Classes of the classification system of Howell (2010) applicable to this study

Level 1 Biogeography	Level 2 Depth	Level 3 Substratum	Level 4 Biology
Atlantic	Upper Slope 200-750m	Sand	*Cidaris cidaris – Stichopus tremulus* assemblage
			Ophiuroids on rippled sediment
	Upper Bathyal 750-1100m	Mud	*Echinus acutus norvegicus* assemblage
		Sand	Ophiuroids on rippled sediment
	Mid Bathyal 1100-1800m	Mud	Xenophyophore fields
	Lower Bathyal 1800-2700m	Mud	*Acanella arbuscula* and *Ophiomusium lymani* assemblage

Some difficulty was found in making a distinction between Howell's "Ophiuroids on rippled sediment" and her *"Echinus acutus norvegicus* assemblage". The descriptions in Howell (2010) and Howell *et al* (2010) of this biotope seem to correspond to the *Ophiocten gracilis* zone identified by Lamont & Gage (1998) and described here from all three survey areas at an approximate depth range of 600-1,000m. Although *Gracilechinus* (formerly *Echinus*) *acutus* is found here, the numerical dominant is the small brittlestar *Ophiocten gracilis.* Howell's "Ophiuroids on rippled sediment" biotope is described very briefly, and does not name any particular ophiuroid species, but again seems to match the *Ophiocten gracilis*-dominated zone on the Scottish continental slope. Since the *Ophiocten gracilis* zone on the continental slope occupies parts of both Howell's Upper Slope and Upper Bathyal Zones, and can be found on sediments with and without obvious current ripples, the two biotopes defined by Howell could be regarded as falling on a continuum, without a clear distinction between them.

4.5 Macrofaunal samples from the SEA7 area

4.5.1 Introduction and sampling areas

Benthic sampling was conducted on the *Kommandor Jack* survey cruise to the SEA7 area between 13 August and 4 September 2005. Samples were collected opportunistically using different gear appropriate to the depth and substratum type. Most samples on finer sediments were collected using a multiple corer ("Megacorer") which takes cylindrical cores

10cm in diameter. On coarser sediments, a spade boxcorer which takes a single 0.25m^2 core was used. At the shallowest stations, which were generally characterized by the coarsest sediments, a 0.1m^2 Day Grab was deployed.

Sampling areas included stations on the Scottish continental slope (in the area of the LOIS-SES transect), the north-central Rockall Trough, the eastern slope of the Rockall Bank, the George Bligh Bank and the Hatton Bank. The general sampling areas and the location of individual stations are indicated on the chart below. Sediments were fixed in 4% buffered formaldehyde with Rose Bengal stain. On return to the laboratory the material was sieved on 0.5mm mesh and sorted under binocular dissecting microscope. Only the uppermost 5cm of each core was sorted and processed. In deep-sea sediments this surface later usually contains almost all the benthic macrofauna, so it is unlikely that much will have been missed in the unprocessed material.

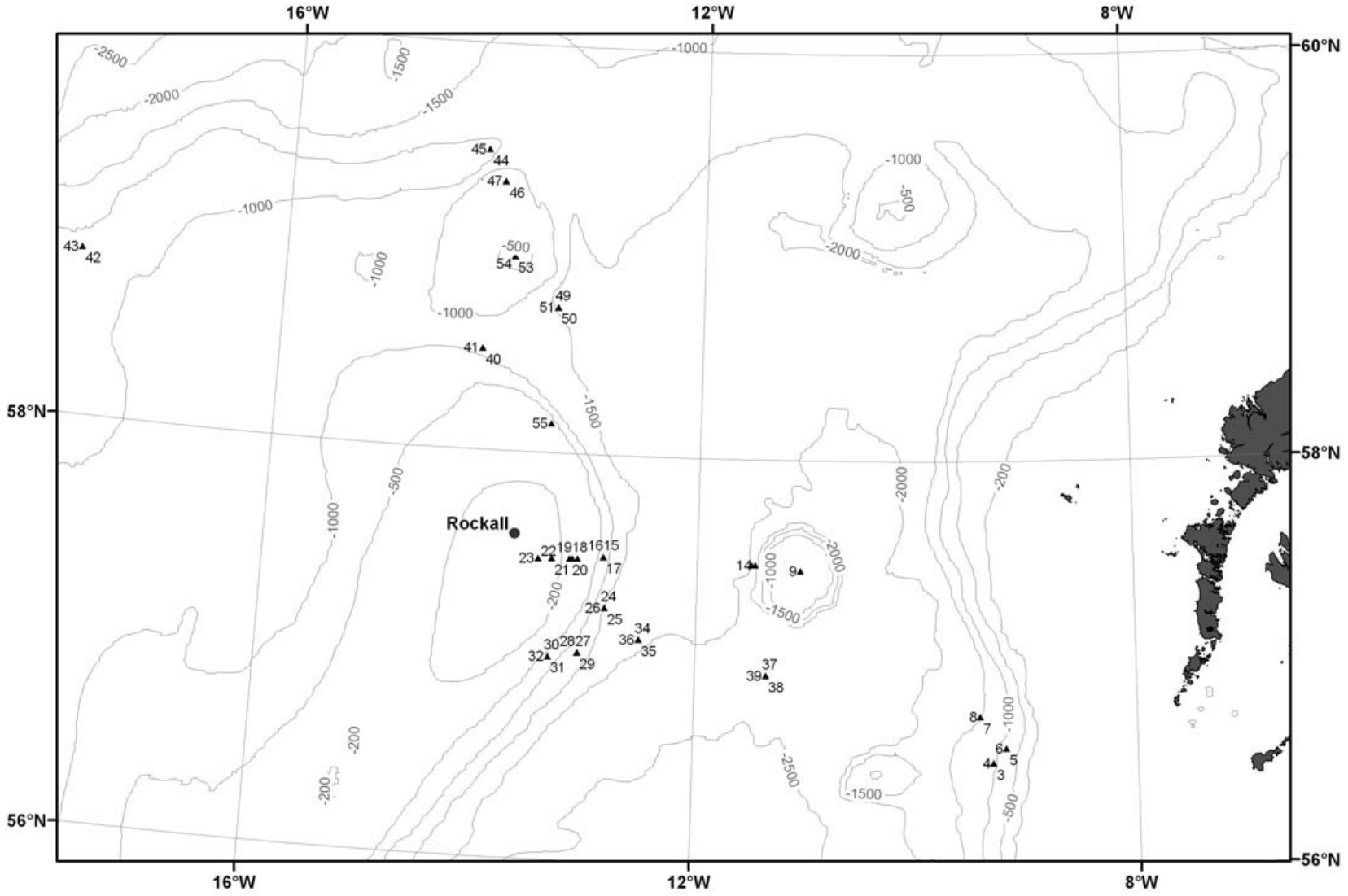

Figure 4.2. Location of SEA7 stations sampled in August-September 2005. Station numbers with processed and analyzed macrofaunal samples correspond to those listed in the summary table on the following page.

Table 4.2. List of SEA7 macrofaunal samples analyzed and discussed in this report.

No. on chart	Location	SAMS sample no.	Lat. °N	Long. °W	Depth (m)	Sampler type
2	Hebridean Slope	LOIS-SES2#6	56.513978	-9.297559	995	Megacorer
4	Hebridean Slope	LOIS-SES2#8	56.513763	-9.297411	995	Megacorer
6	Hebridean Slope	LOIS-SES1#2	56.587225	-9.181687	695	Megacorer
9	Summit of Anton Dohrn	AD-A#2	57.457797	-11.052918	600	Boxcorer
11	Base of Anton Dohrn Seamount	AD-E#2	57.483373	-11.500130	1970	Megacorer
12	Base of Anton Dohrn Seamount	AD-E#3	57.483337	-11.500145	1970	Megacorer
13	Base of Anton Dohrn Seamount	AD-E#5	57.483454	-11.500603	1970	Megacorer
39	Central Rockall Trough	SAMS-NS-15#3	56.939688	-11.353286	2330	Megacorer
33,34	West Rockall Trough	BENBO-C#1+2	57.099969	-12.516653	1900	Megacorer
35	West Rockall Trough	BENBO-C#3	57.099971	-12.516290	1900	Megacorer
36	West Rockall Trough	BENBO-C#4	57.099840	-12.516497	1900	Megacorer
31	East Rockall Bank	ER-D#3	57.000041	-13.333688	740	Megacorer
32	East Rockall Bank	ER-D#5	56.999967	-13.333527	740	Megacorer
27,28	East Rockall Bank	ER-E#1+2	57.024685	-13.067261	1605	Megacorer
29	East Rockall Bank	ER-E#3	57.024954	-13.067247	1605	Megacorer
15	East Rockall Bank	ER-F#2	57.499923	-12.861798	1040	Megacorer
17	East Rockall Bank	ER-F#4	57.499975	-12.862229	1040	Megacorer
24	East Rockall Bank	ER-G#2	57.249966	-12.833727	1560	Megacorer
25	East Rockall Bank	ER-G#3	57.249532	-12.834068	1560	Megacorer
23	East Rockall Bank	SAMS-2-L#3	57.480769	-13.462491	170	Day Grab
20	East Rockall Bank	SAMS-2-N#5	57.485006	-13.172612	230	Day Grab
18	East Rockall Bank	SAMS-2-P#5	57.486497	-13.099631	245	Day Grab
55	North Rockall Bank	ER-H#4	58.144997	-13.400318	285	Boxcorer
41	North Rockall Bank	ER-L#4	58.499677	-14.083806	1135	Megacorer
46	George Bligh Bank	GB-A#5	59.323094	-13.953958	820	Boxcorer
47	George Bligh Bank	GB-A#6	59.323331	-13.954407	820	Boxcorer
53	George Bligh Bank	GB-C#6	58.956652	-13.825036	445	Day Grab
54	George Bligh Bank	GB-C#7	58.956679	-13.825000	445	Day Grab
50	Base of George Bligh Bank	GB-G#4	58.716693	-13.386534	1430	Megacorer
49,51	Base of George Bligh Bank	GB-G#2+5	58.716708	-13.386274	1430	Megacorer
45	Hatton Bank	HB-J#4	59.476447	-14.128612	925	Megacorer

4.5.2 Assessment of macrofaunal samples against MPA search features

The samples considered here were collected opportunistically on a cruise whose main priority was seabed imaging using video and still photography. In most cases only one corer or grab deployment was made per station, and only one or two individual megacores were processed from a deployment. The level of sample replication therefore falls well below the standard normally considered acceptable for a quantitative community analysis, and no such analysis is attempted here. The species lists are assessed to determine whether these samples can be assigned to any of the offshore sediment macrofaunal biotopes listed in Annex 1, in the absence of JNCC deep water biotopes. The following biotopes listed by JNCC were considered:

Table 4.3. Biotopes considered in the assessment of SEA7 macrofaunal samples

MPA search feature	Component habitat / species	Biotope code / Species name
Offshore deep sea muds	*Ampharete falcata* turf with *Parvicardium ovale* on cohesive muddy sediment near margins of deep stratified seas	SS.SMu.OMu.AfalPova
	Foraminiferans and *Thyasira* sp. in deep circalittoral fine mud	SS.SMu.OMu.ForThy
	Levinsenia gracilis and *Heteromastus filifirmis* in offshore circalittoral mud and sandy mud	SS.SMu.OMu.LevHet
	Myrtea spinifera and polychaetes in offshore circalittoral sandy mud	SS.SMu.OMu.MyrPo
	Paramphinome jeffreysii, *Thyasira* spp. and *Amphiura filiformis* in offshore circalittoral sandy mud	SS.SMu.OMu.PjefThyAfil
Offshore subtidal sands and gravels	*Abra prismatica*, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	SS.SSa.CFiSa.ApriBatPo
	Echinocyamus pusillus, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	SS.SSa.CFiSa.EpusOborApri
	Glycera lapidum, *Thyasira* spp. and *Amythasides macroglossus* in offshore gravelly sand	SS.SCS.OCS.GlapThyAmy
	Hesionura elongata and *Protodorvillea kefersteini* in offshore coarse sand	SS.SCS.OCS.HeloPkef
	Maldanid polychaetes and *Eudorellopsis deformis* in offshore circalittoral sand or muddy sand	SS.SSa.OSa.MalEdef
	Owenia fusiformis and *Amphiura filiformis* in offshore circalittoral sand or muddy sand	SS.SSa.OSa.OfusAfil

Species lists for the 31 SEA7 samples were sorted on decreasing individual abundance and the percentage contribution of each taxon to the total abundance for each sample calculated. The Bioscribe 1 tool was downloaded from the JNCC website (www.jncc.gov.uk/bioscribe), and the macrofaunal data for each sample entered into the database for comparison with JNCC biotopes. At least six of the numerically most abundant taxa were entered into the biotope search if possible. These comparisons are presented below. Where one or two biotopes match the faunal composition, the JNCC biotope(s) are listed; when three or more biotopes are possible, no biotopes are cited. The number of taxa from the SEA7 sample present in the JNCC biotope are given, as are the number of taxa missing from the JNCC database for each station.

SEA7 sample: LOIS-SES2#6 (no. 2 on chart)

SEA7 sample taxa entered into database: Nematoda, *Prionospio* sp., *Paramphinone jeffreysii, Harpinia pectinata, Thyasira succisa,* Maldanidae.
Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment.
Notes: Top six LOIS-SES2#6 taxa all in JNCC database, five of these recorded in SS.SMx.CMx.MysThyMx description.

SEA7 sample: LOIS-SES2#8 (no. 4 on chart)

SEA7 sample taxa entered into database: *Echinus* sp., *Sclerobregma* sp., *Ampelisca odontoplax, Harpinia pectinata,* Spatangoida, *Glycera mimica.*
Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment.
Notes: Three of the five most abundant LOIS-SES2#8 taxa not listed in JNCC database.

SEA7 sample: LOIS-SES1#2 (no. 6 on chart)

SEA7 sample taxa entered into database: *Prionospio* sp., *Allia* sp., *Aonides oxycephala, Laonice* sp., *Thyasira succisa, Xenodice frauenfeldti,* Gadilidae.
Closest JNCC biotope match: SS.SSa.CMuSa.AalbNuc, *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment.
Notes: Two of the five most abundant LOIS-SES1#2 taxa not listed in JNCC database. Three taxa listed in SS.SSa.CMuSa.AalbNuc description.

SEA7 sample: AD-A#2 (no. 9 on chart)

SEA7 sample taxa entered into database: Nematoda, *Limopsis aurita, Spatangus raschi,* Limifossoridae, *Thyasira succisa, Thyasira subcircularis, Echinus* sp., *Ophiomyces grandis, Cadulus artatus.*
Closest JNCC biotope match: None identified.
Notes: Four of the eight most abundant AD-A#2 taxa not listed in JNCC database. Two taxa listed in 15 biotope descriptions.

SEA7 sample: AD-E#2 (no. 11 on chart)

SEA7 sample taxa entered into database: *Harpinia laevis,* Capitellidae, *Bradabyssa* sp., *Macrostylis spinifera,* Ampharetidae, *Amythassides* sp.
Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment.
Notes: Four of the seven most abundant AD-E#2 taxa not listed in JNCC database. Three taxa present in SS.SMx.CMx.MysThyMx description.

SEA7 sample: AD-E#3 (no. 12 on chart)

SEA7 sample taxa entered into database: *Jasmineira* sp., Capitellidae, *Spiophanes kroyeri, Sclerobregma branchiata, Prionospio* sp., *Bradabyssa* sp.
Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment.
Notes: Three of the seven most abundant AD-E#3 taxa not listed in JNCC database. Four taxa present in SS.SMx.CMx.MysThyMx description.

SEA7 sample: AD-E#5 (no. 13 on chart)

SEA7 sample taxa entered into database: *Poecilochetus* sp., *Spiophanes kroyeri, Glycera mimica,* Spionidae, *Prionospio* sp., Capitellidae.
Closest JNCC biotope match: None identified.
Notes: One of the seven most abundant AD-E#3 taxa not listed in JNCC database. Four taxa present in 24 biotope descriptions.

SEA7 sample: SAMS-NS-15#3 (no. 39 on chart)

SEA7 sample taxa entered into database: *Ophiocten gracilis, Sphyrapus tudes,* Polynoidae, *Echinus* sp., Ampharetidae, *Glycera mimica, Dentalium agile.*
Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment.
Notes: Four of the eight most abundant SAMS-NS-15#3 taxa not listed in JNCC database. Four taxa present in SS.SMx.CMx.MysThyMx description.

SEA7 sample: BENBO-C#1+2 (nos. 33,34 on chart)

SEA7 sample taxa entered into database: Foraminifera, Ischnomesidae, Myriotrochidae, *Ophiactis abyssicola, Ophiomusium lymani, Delectopecten vitreus.*
Closest JNCC biotope match: None identified.
Notes: Four of the six most abundant BENBO-C#1+2 taxa not listed in JNCC database. One taxon present in seven biotope descriptions.

SEA7 sample: BENBO-C#3 (no. 35 on chart)

SEA7 sample taxa entered into database: Nematoda, *Ledella pustulosa, Spiophanes kroyeri,* Tanaidacea, *Ophiocten gracilis, Schizobranchia* sp., *Prionospio* sp., Cossuridae.
Closest JNCC biotope match: None identified.
Notes: Three of the eight most abundant BENBO-C#3 taxa not listed in JNCC database. Four taxa present in five biotope descriptions.

SEA7 sample: BENBO-C#4 (no. 36 on chart)

SEA7 sample taxa entered into database: Nematoda, *Jasmineira* sp., *Paramphinome jeffreysii, Prionospio* sp., Oweniidae, *Paradoneis* sp.
Closest JNCC biotope match: None identified.
Notes: All six most abundant BENBO-C#4 taxa not listed in JNCC database. Four taxa present in four biotope descriptions.

SEA7 sample: ER-D#3 (no. 31 on chart)

SEA7 sample taxa entered into database: Edwardsiidae, *Ilyarachna triangularis,* Polynoidae, Nematoda, Capitellidae, *Prionospio* sp., *Ophiocten affinis, Thyasira succisa.*

Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment, and SS.SCS.ICS.SLan, Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand.
Notes: One of the seven most abundant ER-D#3 taxa not listed in JNCC database. Five taxa present in the descriptions of the two biotopes listed above.

SEA7 sample: ER-D#5 (no. 32 on chart)

SEA7 sample taxa entered into database: Nematoda, Capitellidae, *Prionospio* sp., *Ophiocten affinis, Campanulina panicula, Echinus* sp.
Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment.
Notes: Two of the six most abundant ER-D#5 taxa not listed in JNCC database. Five taxa present in the SS.SMx.CMx.MysThyMx biotope description.

SEA7 sample: ER-E#1+2 (nos. 27, 28 on chart)

SEA7 sample taxa entered into database: *Jasmineira* sp., *Paramphinome jeffreysii, Ophiocten gracilis, Glycera mimica, Poecilochaetus* sp., *Spiophanes kroyeri, Amythasides macroglossus.*
Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment.
Notes: Two of the seven most abundant ER-E#1+2 taxa not listed in JNCC database. Three taxa present in the SS.SMx.CMx.MysThyMx biotope description.

SEA7 sample: ER-E#3 (no. 29 on chart)

SEA7 sample taxa entered into database: *Jasmineira* sp., Nematoda, *Amythasides macroglossus, Paramphinome jeffreysii, Glycera mimica,* Tanaidacea.
Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment.
Notes: One of the six most abundant ER-E#3 taxa not listed in JNCC database. Four taxa present in the SS.SMx.CMx.MysThyMx biotope description.

SEA7 sample: ER-F#2 (no. 15 on chart)

SEA7 sample taxa entered into database: *Ophiocten gracilis, Sphyrapus tudes,* Polynoidae, *Echinus* sp., Ampharetidae, *Glycera mimica, Dentalium agile,* Capitellidae.
Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment.
Notes: Four of the eight most abundant ER-F#2 taxa not listed in JNCC database. Four taxa present in the SS.SMx.CMx.MysThyMx biotope description.

SEA7 sample: ER-F#4 (no. 17 on chart)

SEA7 sample taxa entered into database: *Sphyrapus malleolus,* Polynoidae, Urothoidae, Copepoda, *Leptostylis* sp., *Ampelisca* sp., *Harpinia antennaria, Bruzelia typica, Leucon* sp.
Closest JNCC biotope match: None identified.
Notes: Two of the seven most abundant ER-F#4 taxa not listed in JNCC database. Three taxa present in seven biotope descriptions.

SEA7 sample: ER-G#2 (no. 24 on chart)

SEA7 sample taxa entered into database: *Glycera mimica, Dentalium agile, Ledella pustulosa, Micronephthys* sp., *Thyasira subovata,* Ampharetidae.

Closest JNCC biotope match: None identified.
Notes: Five of the six most abundant ER-G#2 taxa not listed in JNCC database.

SEA7 sample: ER-G#3 (no. 25 on chart)

SEA7 sample taxa entered into database: Nematoda, *Dentalium agile, Harpinia laevis, Ophiocten gracilis,* Thyasiridae, *Glycera mimica*, *Dacrydium ockelmani,* Hemiasteridae.
Closest JNCC biotope match: None identified.
Notes: Five of the eight most abundant ER-G#3 taxa not listed in JNCC database.

SEA7 sample: SAMS-2-L#3 (no. 23 on chart)

SEA7 sample taxa entered into database: Paraonidae, *Spiophanes* sp., *Paramphinome jeffreysii,* Maldanidae, Syllidae, Capitellidae.
Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment, and SS.SCS.CCS.MedLumVen, *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel.
Notes: All six most abundant SAMS-2-L#3 taxa listed in JNCC database. Five taxa present in two biotope descriptions.

SEA7 sample: SAMS-2-N#5 (no. 20 on chart)

SEA7 sample taxa entered into database: *Ophiocten affinis, Echinocyamus pusillus,* Amphinomidae, Spionidae, Ophiuridae, Solenogastres, Nematoda.
Closest JNCC biotope match: None identified.
Notes: One of the seven most abundant SAMS-2-N#5 taxa not listed in JNCC database. Four taxa present in four biotope descriptions.

SEA7 sample: SAMS-2-P#5 (no. 18 on chart)

SEA7 sample taxa entered into database: *Cistenides* sp., Spatangoida, *Paramphinome jeffreysii,* Oweniidae, *Spiophanes* sp., *Prionospio* sp., *Echinocyamus pusillus.*
Closest JNCC biotope match: None identified.
Notes: Two of the seven most abundant SAMS-2-P#5 taxa not listed in JNCC database. Four taxa present in three biotope descriptions.

SEA7 sample: ER-H#4 (no. 55 on chart)

SEA7 sample taxa entered into database: Nematoda, Cerianthidae, *Thyasira succisa, Sphyrapus tudes,* Ophiuridae, Podoceridae.
Closest JNCC biotope match: SS.SMx.CMx.OphMx, *Ophiothrix fragilis* and/or *Ophiocomina nigra* brittlestar beds on sublittoral mixed sediment.
Notes: One of the six most abundant ER-H#4 taxa not listed in JNCC database. Four taxa present in SS.SMx.CMx.OphMx biotope description.

SEA7 sample: ER-L#4 (no. 41 on chart)

SEA7 sample taxa entered into database: Pulsellidae, *Ophiocten gracilis, Echiurus abyssalis,* Ophiuridae, *Thyasira obsoleta,* Nematoda, Sipuncula.
Closest JNCC biotope match: SS.SSa.CMuSa.AalbNuc, *Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment, and SS.SCS.CCS.MedLumVen, *Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel.
Notes: Three of the nine most abundant ER-L#4 taxa not listed in JNCC database. Four taxa present in two biotope descriptions.

SEA7 sample: GB-A#5 (no. 46 on chart)

SEA7 sample taxa entered into database: *Asperarca nodulosa, Aega ventrosa,* Ascidiacea, *Pseudothyone raphanus,* Buccinidae, *Benthonella tenella,* Porifera.
Closest JNCC biotope match: None identified.
Notes: Three of the seven most abundant GB-A#5 taxa not listed in JNCC database. Three taxa present in four biotope descriptions.

SEA7 sample: GB-A#6 (no. 47 on chart)

SEA7 sample taxa entered into database: *Delectopecten vitreus, Megerlia truncata, Ophiacantha abyssicola, Amphissa acutirostrata,* Nematoda, Aoridae, *Ianira maculosa, Ophioscolex purpureus, Amphipholis pentacantha, Leptochiton alveolus.*
Closest JNCC biotope match: SS.SMx.SMxVS.AphPol, *Aphelochaeta* spp. and *Polydora* spp. in variable salinity infralittoral mixed sediment.
Notes: Six of the ten most abundant GB-A#6 taxa not listed in JNCC database. Three taxa present in SS.SMx.SMxVS.AphPol biotope description.

SEA7 sample: GB-C#6 (no. 53 on chart)

SEA7 sample taxa entered into database: *Myriochele* sp., *Thyasira subovata,* Edwardsiidae, *Cadulus propinquus, Glycera mimica, Prionospio* sp., Cirratulidae, Ampharetidae.
Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment.
Notes: Three of the eight most abundant GB-C#6 taxa not listed in JNCC database. Five taxa present in SS.SMx.CMx.MysThyMx biotope description.

SEA7 sample: GB-C#7 (no. 54 on chart)

SEA7 sample taxa entered into database: *Myriochele* sp., Gromiidae, *Glycera mimica, Ophiura* sp., *Thyasira succisa, Thyasira subovata, Aricidea* sp., *Cadulus propinquus, Prionospio* sp.
Closest JNCC biotope match: None identified.
Notes: Four of the nine most abundant GB-C#7 taxa not listed in JNCC database. Four taxa present in four biotope descriptions.

SEA7 sample: GB-G#4 (no. 50 on chart)

SEA7 sample taxa entered into database: *Paramphinome jeffreysii,* Nematoda, *Glycera mimica,* Polynoidae, *Pholoe* sp., *Poecilochaetus* sp., *Amythasides macroglossus.*
Closest JNCC biotope match: LS.LSa.MuSa.CerPo, *Cerastoderma edule* and polychaetes in littoral muddy sand, and SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment.
Notes: One of the seven most abundant GB-G#4 taxa not listed in JNCC database. Five taxa present in descriptions of the two listed biotopes.

SEA7 sample: GB-G#2+5 (nos. 49,51 on chart)

SEA7 sample taxa entered into database: *Paramphinome jeffreysii,* Amphiuridae, *Glycera mimica, Laonice* sp., *Gesaia* sp., *Poecilochaetus* sp., *Amythasides macroglossus, Ilyarachna triangularis.*
Closest JNCC biotope match: SS.SMx.CMx.MysThyMx, *Mysella bidentata* and *Thyasira* spp. in circalittoral muddy mixed sediment.

Notes: Three of the eight most abundant GB-G#2+5 taxa not listed in JNCC database. Three taxa present in SS.SMx.CMx.MysThyMx biotope description.

SEA7 sample: HB-J#4 (no. 45 on chart)

SEA7 sample taxa entered into database: *Ophiocten gracilis*, Copepoda, *Spiophanes* sp., *Hemilamprops assimilis, Campylaspis* sp., *Eurydice* sp.
Closest JNCC biotope match: SS.SCS.ICS.MoeVen, *Moerella* spp. with venerid bivalves in infralittoral gravelly sand
Notes: Three of the seven most abundant HB-J#4 taxa not listed in JNCC database. Three taxa present in SS.SCS.ICS.MoeVen biotope description.

The putative matches between JNCC biotopes and the SEA7 macrofaunal samples are extremely weak, relying on the presence of rare species, or of taxa defined at high taxonomic levels (e.g. Nematoda, Polynoidae) and not those that characterize the JNCC biotopes. Additionally, none of the Annex A Search Features (even the “deep sea” ones) appeared in the matches that Bioscribe 1 identified. These biotopes do not contain enough quantitative species data to enable valid comparisons to be made with the true deep sea communities in the SEA7 dataset (see, for example, the phrase “Characterising species data not applicable” from the “deep sea” biotope SS.SMu.OMu.MyrPo).

In conclusion, at the level of available taxonomic resolution none of the offshore macrofaunal biotopes listed in Annex 1 can be identified in the SEA7 samples, and the putative matches with other biotopes in the JNCC classification should be considered spurious.

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Annex 1 MPA Search Features

Seabed habitats and their components only – full list includes low or limited mobility species, mobile species and large-scale features (Marine Scotland, 2011)

MPA search feature	Component habitats / species	Scottish marine area
Blue mussel beds	*Mytilus edulis* beds on littoral sediments	Territorial waters
	Mytilus edulis and *Fabricia sabella* in littoral mixed sediment	Territorial waters
	Mytilus edulis beds on sublittoral sediment	Territorial waters
	Mytilus edulis beds on reduced salinity infralittoral rock	Territorial waters
Burrowed mud	Seapens and burrowing megafauna in circalittoral fine mud	Both
	Burrowing megafauna and *Maxmuelleria lankesteri* in circalittoral mud	Both
	Tall seapen *Funiculina quadrangularis*	Both
	Fireworks anemone *Pachycerianthus multiplicatus*	Both
	Mud burrowing amphipod *Maera loveni*	Offshore waters
Carbonate mound communities	Carbonate mound communities	Offshore waters
Coral gardens	Coral gardens	Offshore waters
Deep sea sponge aggregations	Deep sea sponge aggregations	Offshore waters
Flame shell beds	*Limaria hians* beds in tide-swept sublittoral muddy mixed sediment	Territorial waters
Horse mussel beds	*Modiolus modiolus* beds with hydroids and red seaweeds on tide-swept circalittoral mixed substrata	Territorial waters
	Modiolus modiolus beds on open coast circalittoral mixed sediment	Territorial waters
	Modiolus modiolus beds with fine hydroids and large solitary ascidians on very sheltered circalittoral mixed substrata	Territorial waters
	Modiolus modiolus beds with *Chlamys varia,* sponges, hydroids and bryozoans on slightly tide-swept very sheltered circalittoral mixed substrata	Territorial waters
Inshore deep mud with burrowing heart urchins	*Brissopsis lyrifera* and *Amphiura chiajei* in circalittoral mud	Territorial waters
Kelp and seaweed communities on sublittoral sediment	Kelp and seaweed communities on sublittoral sediment	Territorial waters
Low or variable salinity habitats	Faunal communities on variable or reduced salinity infralittoral rock	Territorial waters
	Kelp in variable or reduced salinity	Territorial waters

MPA search feature	Component habitats / species	Scottish marine area
Maerl beds	Maerl beds	Territorial waters
Maerl or coarse shell gravel with burrowing sea cucumbers	*Neopentadactyla mixta* in circalittoral shell gravel or coarse sand	Territorial waters
Native oysters	*Ostrea edulis* beds on shallow sublittoral muddy mixed sediment	Territorial waters
	Native oyster *Ostrea edulis*	Territorial waters
Northern sea fan and sponge communities	*Caryophyllia smithii* and *Swiftia pallida* on circalittoral rock	Territorial waters
	Mixed turf of hydroids and large ascidians with *Swiftia pallida* and *Caryophyllia smithii* on weakly tide-swept circalittoral rock	Territorial waters
	Deep sponge communities (circalittoral)	Both
	Northern sea fan *Swiftia pallida*	Both
Offshore deep sea muds	*Ampharete falcata* turf with *Parvicardium ovale* on cohesive muddy sediment near margins of deep stratified seas	Offshore waters
	Foraminiferans and *Thyasira* sp. in deep circalittoral fine mud	Offshore waters
	Levinsenia gracilis and *Heteromastus filifirmis* in offshore circalittoral mud and sandy mud	Offshore waters
	Paramphinome jeffreysii, *Thyasira* spp. and *Amphiura filiformis* in offshore circalittoral sandy mud	Offshore waters
	Myrtea spinifera and polychaetes in offshore circalittoral sandy mud	Offshore waters
Offshore subtidal sands and gravels	*Glycera lapidum*, *Thyasira* spp. and *Amythasides macroglossus* in offshore gravelly sand	Offshore waters
	Hesionura elongata and *Protodorvillea kefersteini* in offshore coarse sand	Offshore waters
	Echinocyamus pusillus, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand	Offshore waters
	Abra prismatica, *Bathyporeia elegans* and polychaetes in circalittoral fine sand	Offshore waters
	Maldanid polychaetes and *Eudorellopsis deformis* in offshore circalittoral sand or muddy sand	Offshore waters
	Owenia fusiformis and *Amphiura filiformis* in offshore circalittoral sand or muddy sand	Offshore waters

MPA search feature	Component habitats / species	Scottish marine area
Seagrass beds	*Zostera noltii* beds in littoral muddy sand	Territorial waters
	Zostera marina/angustifolia beds on lower shore or infralittoral clean or muddy sand	Territorial waters
	Ruppia maritima in reduced salinity infralittoral muddy sand	Territorial waters
Sea loch egg wrack beds	*Ascophyllum nodosum* ecad *mackaii* beds on extremely sheltered mid eulittoral mixed substrata	Territorial waters
Seamount communities	Seamount communities	Offshore waters
Shallow tide-swept coarse sands with burrowing bivalves	*Moerella* spp. with venerid bivalves in infralittoral gravelly sand	Territorial waters
Tide-swept algal communities	Fucoids in tide-swept conditions	Territorial waters
	Halidrys siliquosa and mixed kelps on tide-swept infralittoral rock with coarse sediment	Territorial waters
	Kelp and seaweed communities in tide-swept sheltered conditions	Territorial waters
	Laminaria hyperborea on tide-swept infralittoral mixed substrata	Territorial waters