Scottish Sanitary Survey Programme

Sanitary Survey Report
Production Area: South Uist 1 and 2
UB 537 and UB 538
July 2011

Cefas

Food Standards Agency
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Report Distribution – South Uist 1 & 2

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I. Executive Summary

Loch Skipport is located on the east side of the island of South Uist in the Outer Hebrides. The loch is 4.6 km long and ranges in width from less than 0.2 km in the inner loch (Linne Arm) to 1.6 km in the outer loch. There are 4 basins and 4 sills within the loch. The harvester has identified that he intends to put three sets of mussel lines on the northern side of the outer loch basin. One of these corresponds to the previously identified South Uist 1 production area and another to the South Uist 2 production area. The third lies to the west of the latter. Neither of the named production areas has been classified to date and there is currently no equipment on site. Baskets of mussels have been suspended from buoys at two of the sites in order to allow sampling. However, samples to date have been transferred from the baskets to sampling bags hung off a pier some way from the fisheries, and then taken from the bags for sending to the laboratory. The samples represent neither the quality at the fisheries nor at the pier.

The area surrounding Loch Skipport is sparsely populated and there are no sewage discharges in the vicinity of the proposed mussel farms. Two small private septic tanks are located inland off the coastline of the western water body of the loch, both discharge to soakaway. Another four private septic tanks are located inland north of the mussel farms. Two of the septic tanks discharge to soakaway and the remaining two discharge to Loch Sheileabhaig.

Sheep and ponies were the only livestock observed in the area during the shoreline survey. In total 6 ponies were counted in total along the western shoreline of the loch, with a large amount of horse manure found in several places along the shoreline. A small number of sheep (14) were observed grazing along the western shoreline adjacent to the shellfish farms.

Deposition of faeces onto grazing areas is likely to be higher in summer, when the number of sheep is likely to be higher due to the presence of lambs. Therefore, sheep faeces are likely to be a source of faecal bacteria carried via streams or direct runoff from land adjacent to the fishery. No significant concentrations of wild animals have been identified in the area. Very few seabirds were recorded in the vicinity of the fishery during the shoreline survey, and no significant nesting areas are located near the mussel farms.

All the streams entering Loch Skipport are located on the western side of the water body, at least 1 km in distance away from the shellfish farms. Freshwater samples taken from the three observed streams on the day of the shoreline survey all had *E. coli* concentrations less than the limit of detection.

Faecal contamination is therefore expected to be low in the outer loch and to derive mainly from farm animals and wildlife. Rainfall tends to be higher from September to February. However, high rainfall events tend to occur through most of the year. Any effects from faecal contamination are expected to be greatest following heavy rainfall during the summer and early autumn months. Currents in the loch are weak to moderate, and therefore local sources of contamination may have the most significant effect at the edges of the sites nearest to the northern shore of the outer loch.

Although seabed leases have been established, and the proposed locations of the mussel farms have been identified by the harvester, it will not be possible to assure than any recommended sampling point would actually coincide with the mussel farm until the equipment has been put in place. Once the equipment has been installed on the site, a bacteriological survey should be undertaken to establish the relative levels of contamination at the eastern and western ends of the fishery and whether there is variation in contamination at the surface versus at depth. It would be possible to conduct the bacteriological survey before mature stock was available on the lines by using bagged shellfish at different depths (1 m and 6 m) on either end of the proposed fishery. The bacteriological survey could be done 6-12 months prior to planned harvest to allow time for establishment of an RMP and initiation of sampling. It would not be cost effective to commence routine monitoring more than 6 months prior to anticipated harvest.

The recommendations are therefore as follows:

Production area: It is recommended that the production area encompass the Crown Estate lease areas established for the farm, including the westernmost site identified by the harvester. The boundaries recommended are NF 8580 3985 to NF 8580 3878 and NF 8580 3878 to NF 8400 3878 and NF 8400 3878 to NF 8400 3888 and NF 8554 3979 to NF 8537 3971 and extending to MHWS.

This area should be reviewed once the mussel farm has been established.

RMP: It is recommended that an RMP be established once the mussel farm has been installed and a bacteriological survey undertaken.

Frequency: Once an RMP is established, monthly monitoring is recommended until there is sufficient history built up to assess stability.

Depth of sampling: A recommended sampling depth will be contingent on the outcome of the bacteriological survey.

Tolerance: With most long line mussel farms, a tolerance of 40 metres is set to allow for some movement of the lines on the anchors.

II. Sampling Plan

PRODUCTION AREA	South Uist 1& 2
SITE NAME	TBD
SIN	
SPECIES	Common mussel
TYPE OF FISHERY	Longline aquaculture
NGR OF RMP	TBD
EAST	-
NORTH	-
TOLERANCE (M)	TBD
DEPTH (M)	TBD
METHOD OF SAMPLING	Hand
FREQUENCY OF SAMPLING	Monthly
LOCAL AUTHORITY	CnES
AUTHORISED SAMPLER(S)	Samantha Muir
LOCAL AUTHORITY LIAISON OFFICER	Samantha Muir

III. Report

1. General Description

The South Uist 1 & 2 shellfish sites are located in Loch Skipport, on the east side of the island of South Uist in the Outer Hebrides. Loch Skipport is approximately 4.6 km long, consisting of an outer part oriented east-west and an inner basin angled toward the northwest. The loch lies in a remote and very sparsely populated part of the island and the nearest road is over 1 km from the fishery.

A standard application was submitted to the Food Standards Agency in Scotland for classification of two new mussel farms, which were assigned separate production area numbers. As the two sites are adjacent to one another, they have been considered together in this survey.

Figure 1.1 Location of Loch Skipport

2. Fishery

No equipment had been installed on site at the time of shoreline survey. The harvester identified that he intended to install 12 longlines at Loch Skipport East and 18 longlines at Loch Skipport West, with the western area split into two farms, the easternmost of which would have 10 longlines and the one further west 8 longlines (this farm is identified as Loch Skipport 3 in Table 2.1). Five lines were scheduled to be installed before the end of 2011. All lines were to be 220 metres in length, with 6 metre droppers. The harvester intended to begin harvesting in 2013.

The harvester has marked the proposed locations of the sites, South Uist 1 and South Uist 2 using a buoy with a creel basket attached with mussels inside to allow monthly sampling (see Figure 2.1). The Loch Skipport West basket is at a depth of 14 m and the Loch Skipport East basket is at a depth of 20 m. Maps detailing the location of the proposed mussel fishery were provided by the harvester. Co-ordinates of the proposed mussel fishery boundaries at Loch Skipport were provided by the harvester post-survey via email. Details of the sites are listed in Table 2.1 below.

Table 2.1 Loch Skipport shellfish farms

Production Area	Site	SIN	Species
South Uist 1	Loch Skipport E	UB 537 966 08	Common mussels
South Uist 2	Loch Skipport W	UB 538 967 08	Common mussels
TBD	Loch Skipport 3	TBD	Common mussels

Planning documents related to the proposed mussel farms show seabed lease areas and planning permission granted for two locations, based on applications for mussel farms of 12 longlines each.

Figure 2.1 shows the relative positions of the mussel farms proposed by the harvester, the locations of the sampling creels, and the seabed lease areas.

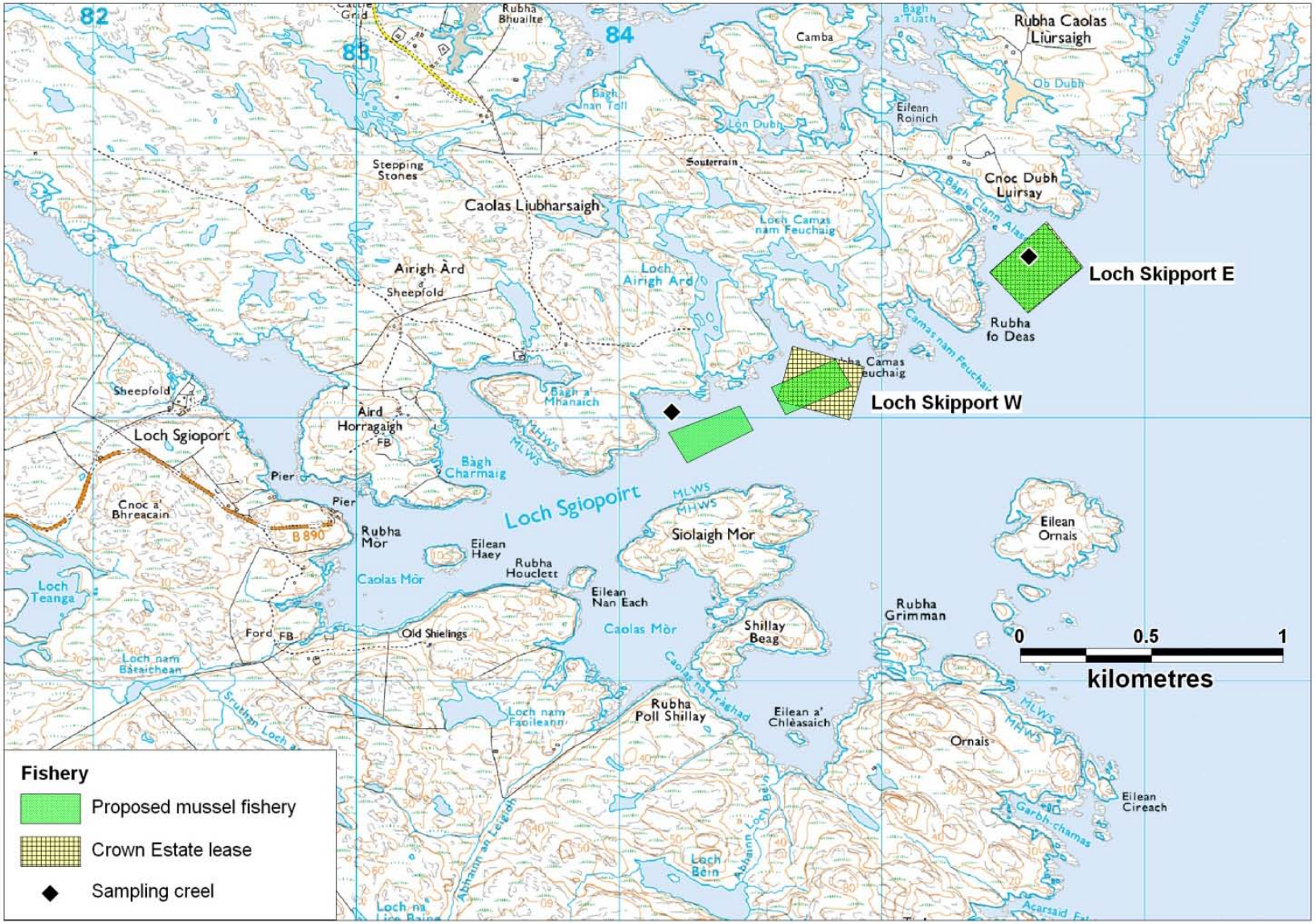

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Figure 2.1 South Uist 2 Fishery

3. Human Population

Figure 3.1 shows information obtained from the General Register Office for Scotland on the population within the census output in the vicinity of Loch Skipport. The last census was undertaken in 2001.

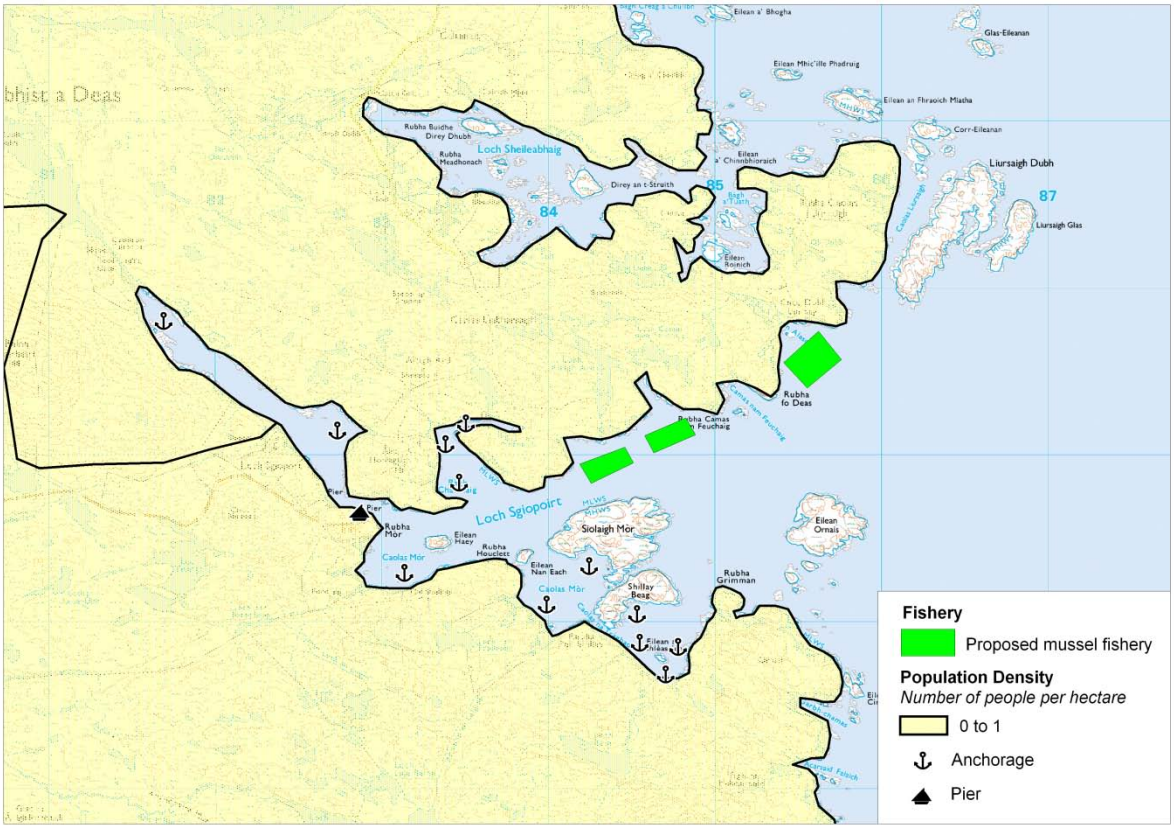


Figure 3.1 Population map of Loch Skipport

Figure 3.1, shows that there is a low population density for the census output areas surrounding Loch Skipport indicating that the area surrounding the fishery is sparsely populated. There are no main settlements in the surrounding area. On the northern shoreline adjacent to the fishery there is no access to the shoreline and the nearest road ends 1.7 km inland. On the western shoreline there is a single track road leading down to the pier which provides access to the fish farms.

In addition to the pier on the western shoreline there are twelve anchorages scattered throughout the loch. There are no anchorages in the immediate vicinity of the fisheries.

4. Sewage Discharges

Information on sewage discharges in the vicinity of the proposed fishery at Loch Skipport was sought from Scottish Water and the Scottish Environment Protection Agency (SEPA). Scottish Water reported no community septic tanks or sewage discharges for the area. SEPA reported a small number of private septic tank discharges, which are listed in Table 4.1 below.

Table 4.1 Discharge consents identified by SEPA

No.	Ref No.	NGR of discharge	Discharge Type	Level of Treatment	Consented/ design PE	Discharges to
1	CAR/R/1037703	NF 8199 3886	Continuous	Septic tank	5	Soakaway
2	CAR/R/1059942	NF 8198 3976	Continuous	Septic tank	5	Soakaway
3	CAR/R/1076952	NF 8305 4074	Continuous	Septic tank	5	Soakaway
4	CAR/R/1057313	NF 8323 4057	Continuous	Septic tank	5	Loch Sheileabhaig
5	CAR/R/1061109	NF 8336 4042	Continuous	Septic tank	5	Loch Sheileabhaigh
6	CAR/R/1052232	NF 8345 4016	Continuous	Septic tank	5	Soakaway

As the discharges are small, no consented flow volumes were applicable. Two of the discharges were to the waters of Loch Sheileabhaig, which lies to the north of Loch Skipport. These discharges lie over 4km by water from the fishery. Only two consents related to septic tanks along the shores of Loch Skipport itself. One of these is located 250 meters from the nearest track, and over 3 km by track from the nearest road. It is therefore unlikely to be permanently occupied. A small number of other dwellings are apparent from the OS map along the track on the north shore of the loch. As there has not historically been a requirement in Scotland to register private septic tanks, there are likely to be additional discharges to those listed in the table above.

Sewage discharges or infrastructure recorded during the shoreline survey are listed in Table 4.2.

Table 4.2 Discharges and septic tanks observed during shoreline surveys

No.	Date	NGR	Description
1	27/06/2011	NF 82440 39093	Outfall pipe covered in concrete leading from Marine Harvest Workshop to a septic tank with no cover. Outfall pipe leading out other side of septic tank on to the shoreline, however no flow.

One outfall pipe was observed on the south shore of the western part of Loch Skipport. The north side of the loch was viewed by boat, and no discharges were noted. Any further dwellings along the north side of the loch would be presumed to be on private septic tanks.

The total number of likely discharges in the area is low, and most do not discharge directly to water. Therefore, the impact from human sewage discharge to the outer loch is expected to be very low.

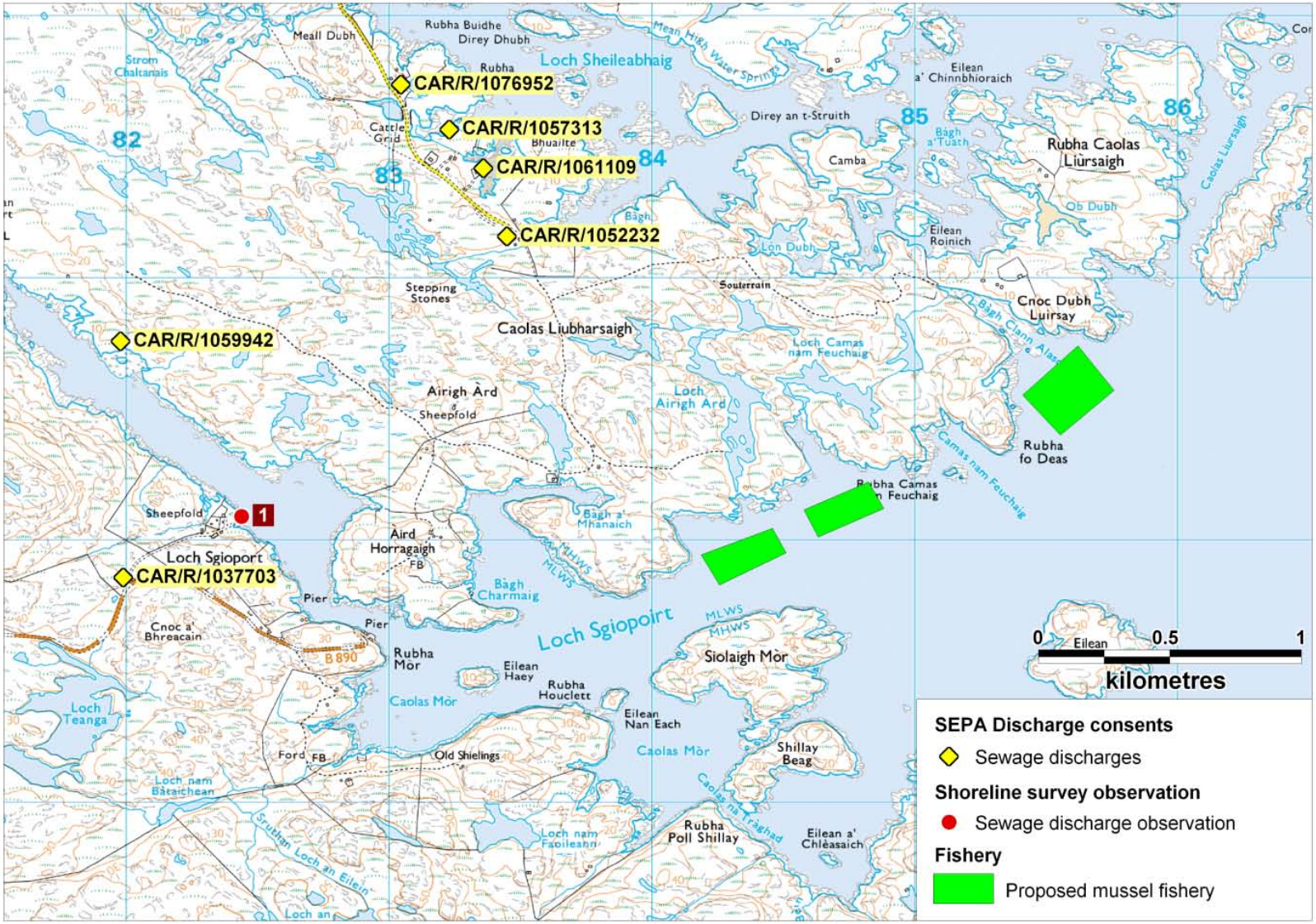


Figure 4.1 Map of discharges for Loch Skipport

5. Geology and Soils

Geology and soil types were assessed following the method described in Appendix 2. A map of the resulting soil drainage classes is shown in Figure 5.1. Areas shaded red indicate poorly draining soils.

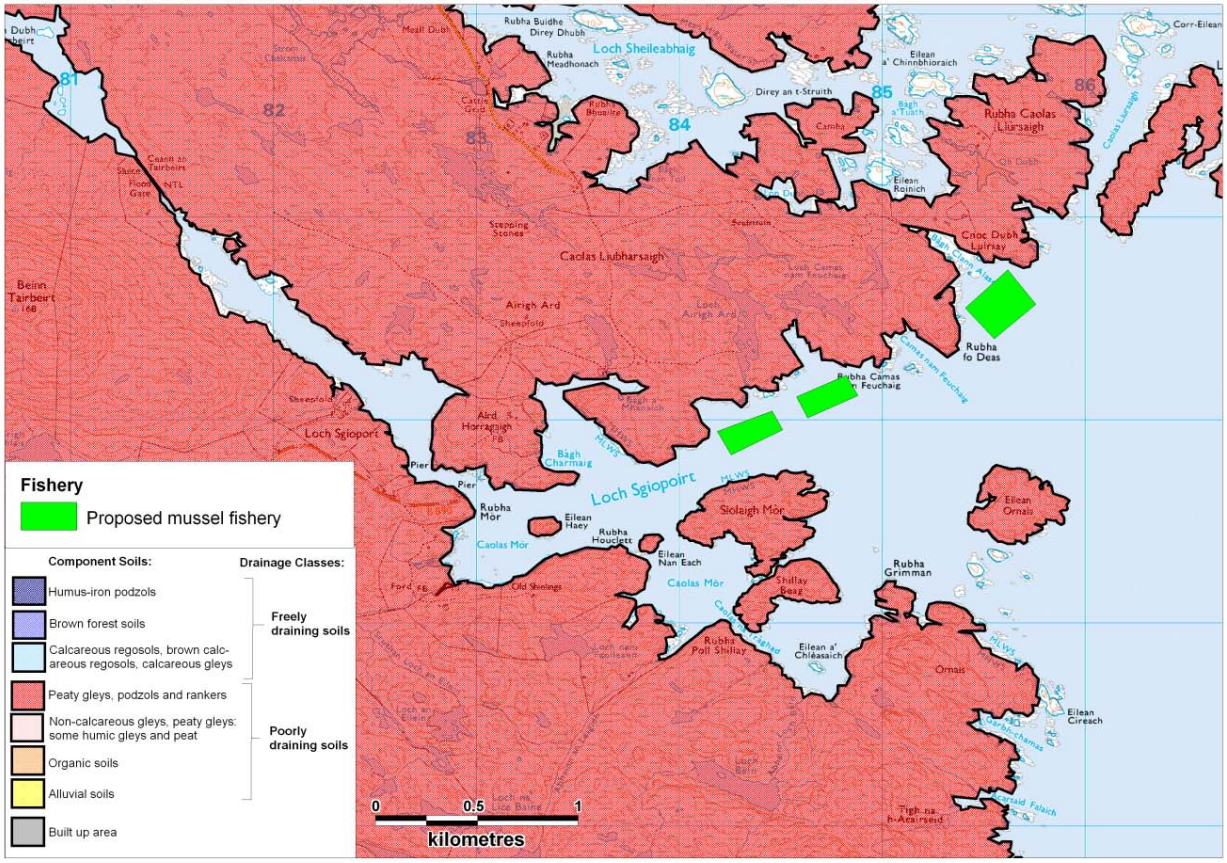


Figure 5.1 Component soil and drainage class for Loch Skipport

A single class of component soil (peaty gleys, podzols and rankers) is found in the area surrounding Loch Skipport and it is classed as poorly draining.

The potential for runoff is therefore high along the entire coastline of Loch Skipport. The degree of impact of such runoff at the proposed fishery locations will depend on the amount of faecal material on the land, proximity to the fishery, and movement of contaminants within the loch.

6. Land Cover

The Land Cover Map 2000 data for the area is shown in Figure 6.1 below:

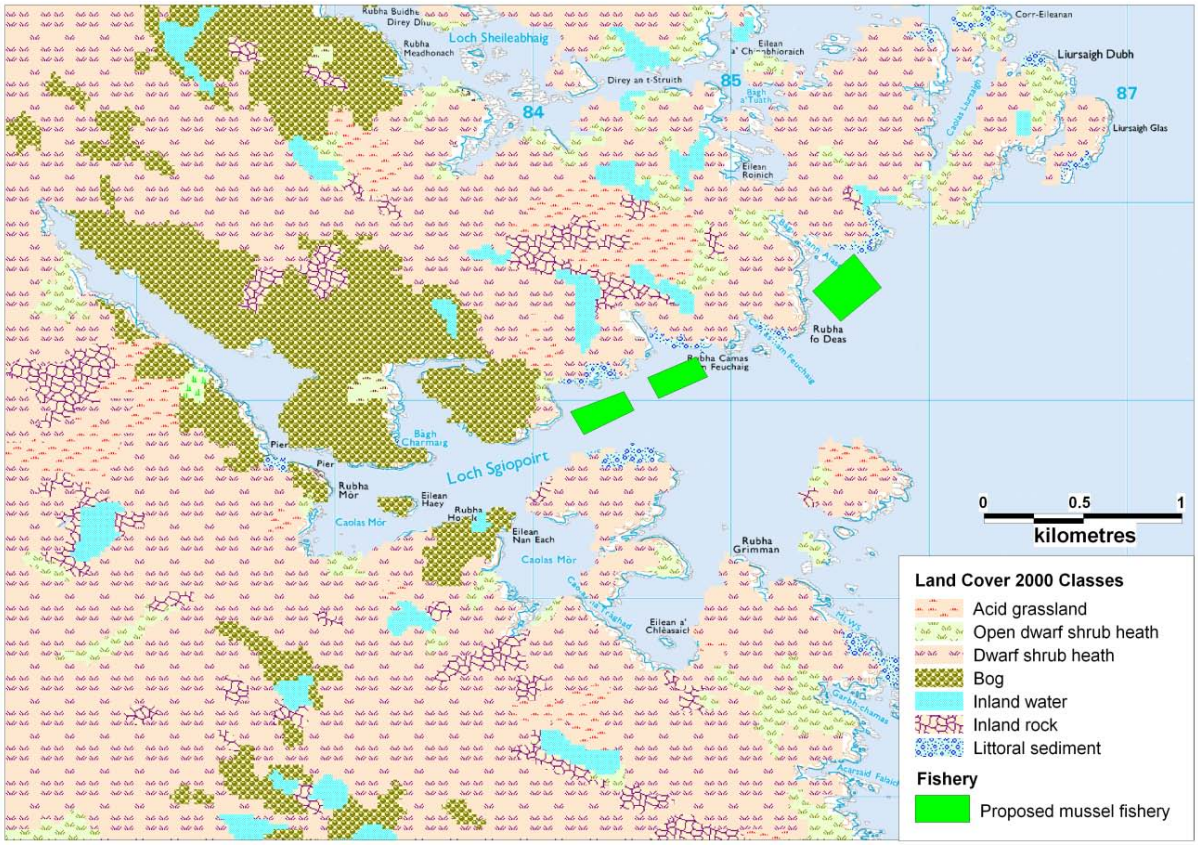


Figure 6.1 LCM2000 class land cover data for Loch Skipport

The land on the shoreline immediately adjacent to the fishery and Loch Portain is predominantly classed as bog, dwarf shrub heath, open dwarf shrub heath and some areas of inland rock. There are also small areas of acid grassland, neutral grassland and littoral sediment.

Studies undertaken by Kay et al (2008) found that faecal indicator organism export coefficients for faecal coliform bacteria were highest for urban catchment areas (approx 1.2 – 2.8x10^9 cfu km^{-2} hr^{-1}) and lower for areas of improved grassland (approximately 8.3x10^8 cfu km^{-2} hr^{-1}) and rough grazing (approximately 2.5x10^8 cfu km^{-2} hr^{-1}) areas. Lowest contributions would be expected from areas of woodland (approximately 2.0x10^7 cfu km^{-2} hr^{-1}) (Kay *et al*. 2008). The contributions from all land cover types would be expected to increase significantly after marked rainfall events, however this effect would be particularly marked from improved grassland areas (roughly 1000-fold) (Kay *et al*. 2008).

There are no developed areas or improved grassland adjacent to the fisheries. Therefore, the expected contribution of faecal indicator bacteria attributable to land cover type would be low.

7. Farm Animals

Information on the spatial distribution of animals on land adjacent to or near the fishery can provide an indication of the potential amount of organic pollution from livestock entering the shellfish production area. Agricultural census data to parish level was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for South Uist parish. Reported livestock populations for the parish in 2009 and 2010 are listed in Table 7.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data. Any entries which relate to less than five holdings, or where two or fewer holdings account for 85% or more of the information, are replaced with an asterisk.

Table 7.1 Livestock numbers in South Uist parish 2009 - 2010

	South Uist 317 km^2			
	2009		2010	
	Holdings	Numbers	Holdings	Numbers
Pigs	*	*	*	*
Poultry	59	728	69	787
Cattle	155	2100	154	2078
Sheep	362	27251	362	26288
Deer	0	0	0	0
Horses used in Agriculture	*	*	*	*
Other horses and ponies	20	64	23	82

Sheep and cattle are the predominant livestock animals kept on South Uist. Agricultural practices in Uist were observed by Osgathorpe et al (2011) to consist predominantly of mixed sheep and cattle production on grazed land with some grass and arable silage production. Grazing was found to occur on machair, which is limited to the western side of the island, semi-improved grassland within the enclosed croft 'inbye' areas, and less commonly on moorland common grazings. Crofters were found to be less likely to use the moorland areas and more likely to keep stock on inbye.

During the shoreline survey a large number of sheep droppings, horse manure and pony tracks were observed along most of the western coastline of Loch Skipport. In total, 6 ponies were observed on the western shoreline and approximately 14 sheep in total were observed from the boat on the northern shoreline. Livestock counts taken during the shoreline survey relate only to the time of the site visit on 27th June, 2011 and are dependent upon the viewpoint of the observer.

The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 7.1.

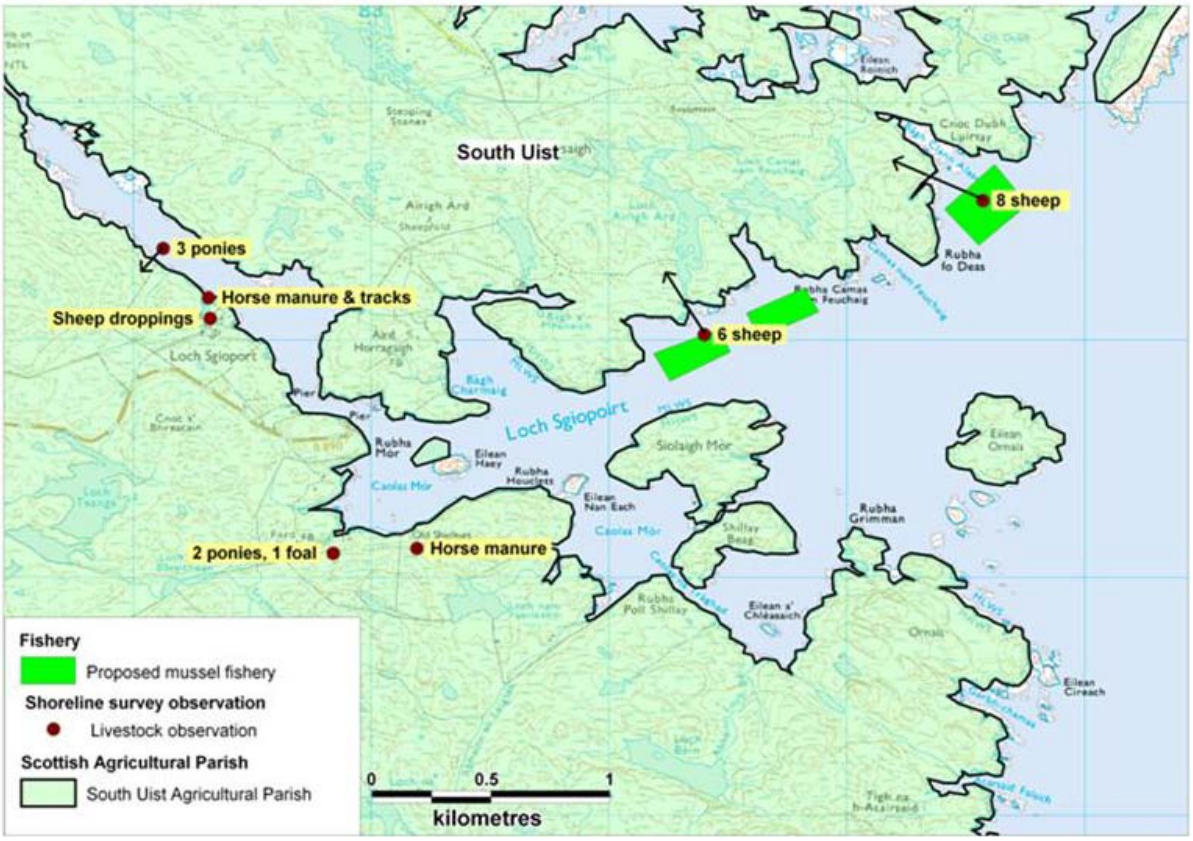


Figure 7.1 Livestock observations at Loch Skipport

Overall, the most likely impact to the fishery from diffuse agricultural pollution would be from the rough grazing areas near shore where runoff from land reaches the edges of the proposed mussel farms.

8. Wildlife

Wildlife are likely to be present in fishery areas and may contribute to the faecal bacterial load in a water body either via direct deposition of faeces or via diffuse runoff from land areas.

The South Uist Machair and Lochs Special Protection Area (SPA) and RAMSAR site and the South Uist Machair Special Area of Conservation (SAC) are located to the west of Loch Skipport, but these designated areas do not include the loch or its shoreline.

The following are considered most likely to be present at or near the fishery.

Seabirds
Results from the Seabird2000 census (Mitchell *et al*. 2004) were used to ascertain the likely distribution and numbers of seabirds at or near the Loch Skipport sites. Records within 3 km of the Loch Skipport mussel farms are listed in Table 8.1.

Table 8.1 Seabird counts within 5km of the site.

Common name	Species	Count	Method
Arctic Tern	*Sterna paradisaea*	10	Individuals on land/Occupied nests
Herring Gull	*Larus argentatus*	1	Individuals on land/Occupied territory or nests
Common Gull	*Larus canus*	10	Individuals on land/Occupied territory or nests

Very few seabirds were recorded in the vicinity of the fishery, and no significant nesting areas have been identified near the mussel farms. Birds such as gulls or terns may alight on mussel floats, directly depositing droppings on the floats and into the water. However, given the lack of large breeding populations and the low numbers observed, this is not expected to pose a significant threat to water quality at the Loch Skipport mussel farms.

Waders and Waterfowl
Significant populations of geese, ducks and wading birds are present on South Uist, though most notably on the freshwater lochs inland and along the west coast of the island.

Post-moult counts of Greylag geese undertaken in August 2008 were 5,948 in the Uists (Mitchell *et al*. 2010). Over 77% of birds recorded were observed on grassland, and the bulk of these (65.9% of the total) were recorded on agricultural land, indicating a strong association of birds with grassland feeding areas. However this report did not break down the data between the two islands, and no count data was available for populations occurring around Loch Skipport. As the majority of land around the proposed fishery was recorded as heath and bog, and there were no crofts identified in the area, it is unlikely that geese will pose a significant source of faecal contamination to the mussel farms.

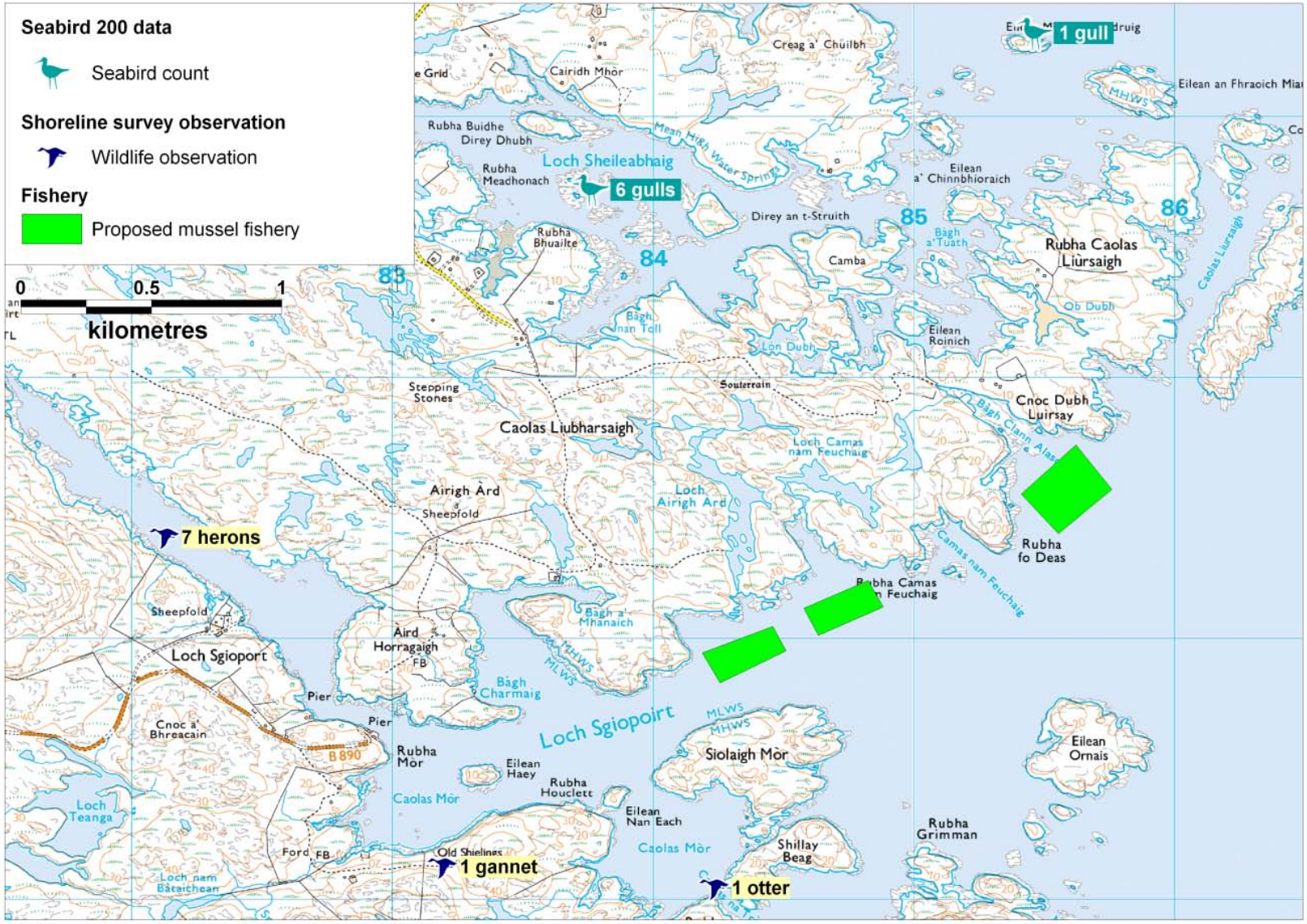
Only 1 gannet and 7 herons were observed during the shoreline survey.

Seals
The Uists host a significant population of both grey and common seals, though common seals are most likely to occur in the area of Loch Skipport. The common seal population of the Outer Hebrides in 2008 was estimated at 1,815, and a proportion of these (estimated in the low 100s) were recorded in or near Loch Skipport (SMRU 2010). Seals forage widely for food and are likely to range throughout the loch and beyond, and therefore may only be present for a proportion of the time. These animals are likely to contribute to background faecal bacterial levels within the loch generally, however any direct impact to the fishery is likely to be limited due to the relatively open aspect of the outer loch where the proposed farms are to be sited.

Otters
Otters are known to be present on the island and within the SAC and so are likely to be present along the shores of Loch Skipport. However, the typical population densities of coastal otters are low and their impacts on the shellfishery are expected to be very minor. One otter was seen along the south shore of the loch during the shoreline survey.

Deer
Deer are known to inhabit many parts of the island so it is likely that they may be present around Loch Skipport. Faecal contamination from deer is most likely to be carried to the loch via freshwater streams and burns. The Visit Uist website lists the population of red deer as roughly 1200 over both North and South Uist (http://www.visit-uist.co.uk/Default.asp?Page=42, accessed 15/08/2011). The Visit Hebrides website lists the North Uist population at around 850, with around 350 in South Uist (http://www.visithebrides.com/wildlife/topten/index.php, accessed 15/08/2011). No deer were seen during the shoreline survey.

Summary
Wildlife species in and around Loch Skipport are likely to have a limited impact on bacteriological quality of water around the fishery due to the relatively small number of animals likely to be present compared with the large and open water area of the outer loch. Seals and seabirds may potentially directly deposit faeces to waters at the mussel farms, this is likely to be limited in extent and duration and relatively unpredictable. Other wildlife sources of faecal contamination are waterfowl and deer, though these are most likely to reach the fishery via fresh water sources. Therefore impacts may be higher near where streams reach the loch. However, there is little other information to suggest strongly geographic variation in the presence of wild animals or the effects of their droppings.



Produced by Cefas Weymouth Laboratory.

Figure 8.1 Map of seabird distributions in Loch Skipport

9. Meteorological data

The nearest weather station for which rainfall records were available is located at Loch Carnon Power Station, approximately 4 km to the north of Loch Skipport. Rainfall data was available for 2003-2010 inclusive: however, daily rainfall values were missing for more than 260 of the 2922 days, including the whole months of January 2004 and March 2006 (accumulated values were given instead). Rainfall data was also available for South Uist Range, located approximately 8 km to the north-west of Loch Skipport. Rainfall data was available for 2003-2010 inclusive: data was missing for more than 100 of the 2922 days, including the whole months of February 2006, January 2007 and February 2008 (accumulated values were given instead). The nearest weather station for which wind data was available is located at Benbecula, about 19 km to the north-west of Loch Skipport. Data for the stations was purchased from the Meteorological Office. Due to the extensive missing rainfall data, summaries for both rain stations are presented below. Unless otherwise identified, the content of this section (e.g. graphs) is based on further analysis of this data undertaken by Cefas. This section aims to describe the local rain and wind patterns in the context of the bacterial quality of shellfish at Loch Skipport.

9.1 Rainfall

High rainfall and storm events are commonly associated with increased faecal contamination of coastal waters through surface water run-off from land where livestock or other animals are present, and through sewer and waste water treatment plant overflows (e.g. Mallin et al, 2001; Lee & Morgan, 2003). Figures 9.1 and 9.2 present box and whisker plots summarising the distribution of individual daily rainfall values by year and by month. The grey box represents the middle 50% of the observations, with the median at the midline. The whiskers extend to the largest or smallest observations up to 1.5 times the box height above or below the box. Individual observations falling outside the box and whiskers are represented by the symbol *.

Due to the high number of missing/accumulated values in both rainfall data sets, a new data set was prepared preferentially using the daily rainfall values from Loch Carnan where these were available but substituting those from Range where they were missing. This combined data set had no missing values: it is referred to simply as South Uist in the analyses that follow. A Spearman rank correlation was undertaken on the two data sets, for the days when both had valid daily rainfall values: this yielded a correlation coefficient of 0.845, indicating good similarity between the two.

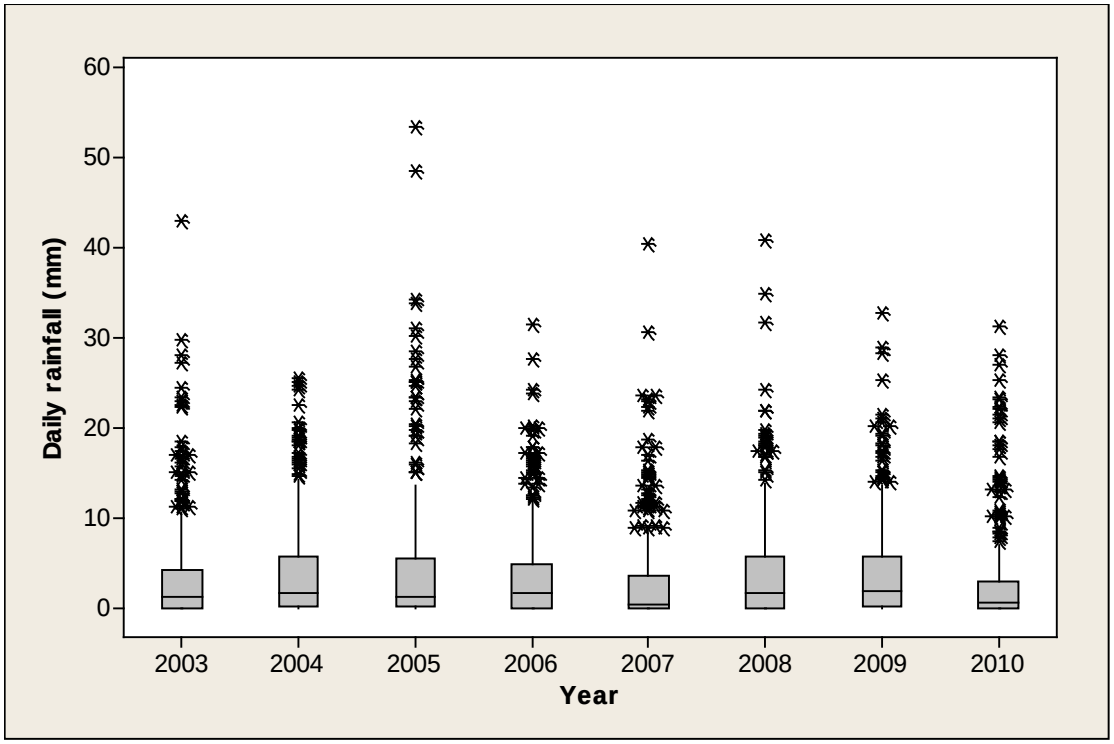


Figure 9.1 Box plot of daily rainfall values by year at South Uist, 2003-2010

Figure 9.1 shows that rainfall patterns varied markedly between the years. 2007 and 2010 were drier than the other years in the period.

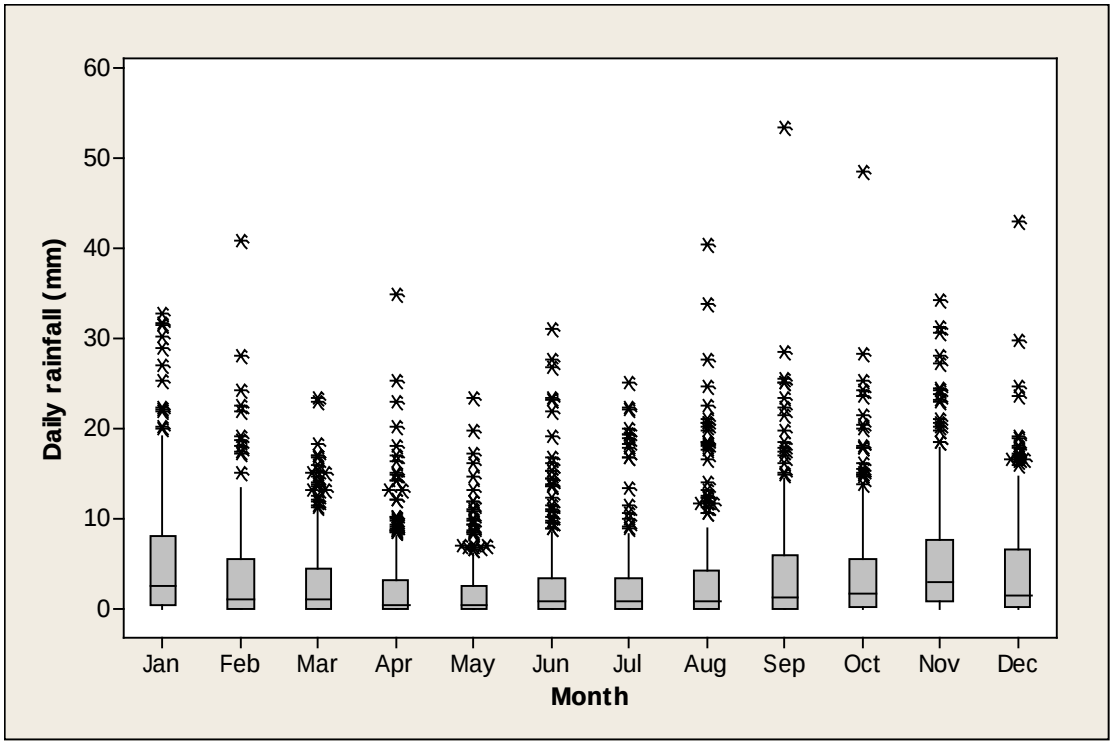


Figure 9.2 Box plot of daily rainfall values by month at South Uist, 2003-2010

Weather was wettest in the period from September to February. More extreme rainfall events (in which over 30mm fell in a day) occurred in most months. For the period considered here (2003-2010), 46% of days

experienced rainfall less than 1 mm, and 11% of days experienced rainfall of 10 mm or more.

The potential for increased run-off is therefore highest in autumn and winter. However, the amount of contamination in any run-off will depend on the higher rainfall levels occurring when faecal contamination is present on the land. This is most likely in the late summer and early autumn periods.

9.2 Wind

Wind data collected at the Benbecula weather station is summarised by season and presented in Figures 9.3 and 9.4, as provided by the Meteorological Office. The prevailing wind direction at Benbecula is from the south-west. There is a higher occurrence of north-easterly winds during the spring and summer. Winds are generally lightest in the summer and strongest in the autumn and winter.

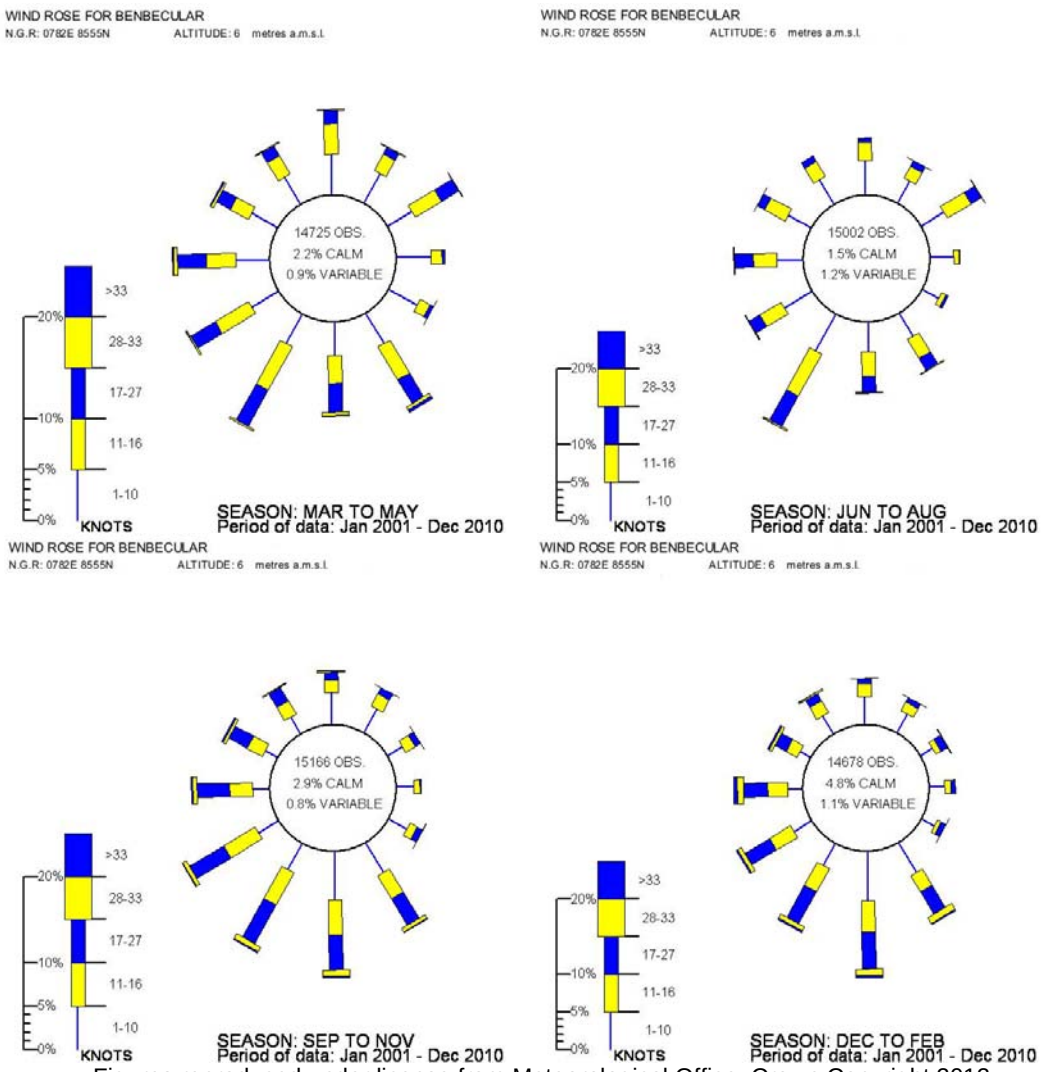


Figure 9.3 Seasonal wind roses for Benbecula

Outer Loch Skipport is aligned in a roughly west-south-west to east-north-east direction. Although there are hills to the south-west and south of the loch, the land between the loch and the west coast of the island is relatively flat. Prevailing winds will therefore tend to blow along the direction of the outer loch. Winds typically drive surface water at about 3% of the wind speed (Brown, 1991) so a gale force wind (34 knots or 17.2 m/s) would drive a surface water current of about 1 knot or 0.5 m/s. Therefore strong winds may significantly alter the strength of currents at Loch Skipport, rather than the direction. Strong winds may also affect tide height depending on wind direction and local hydrodynamics. A strong wind combined with a spring tide may result in higher than usual tides, which will carry accumulated faecal matter from livestock, in and above the normal high water mark, into the production area.

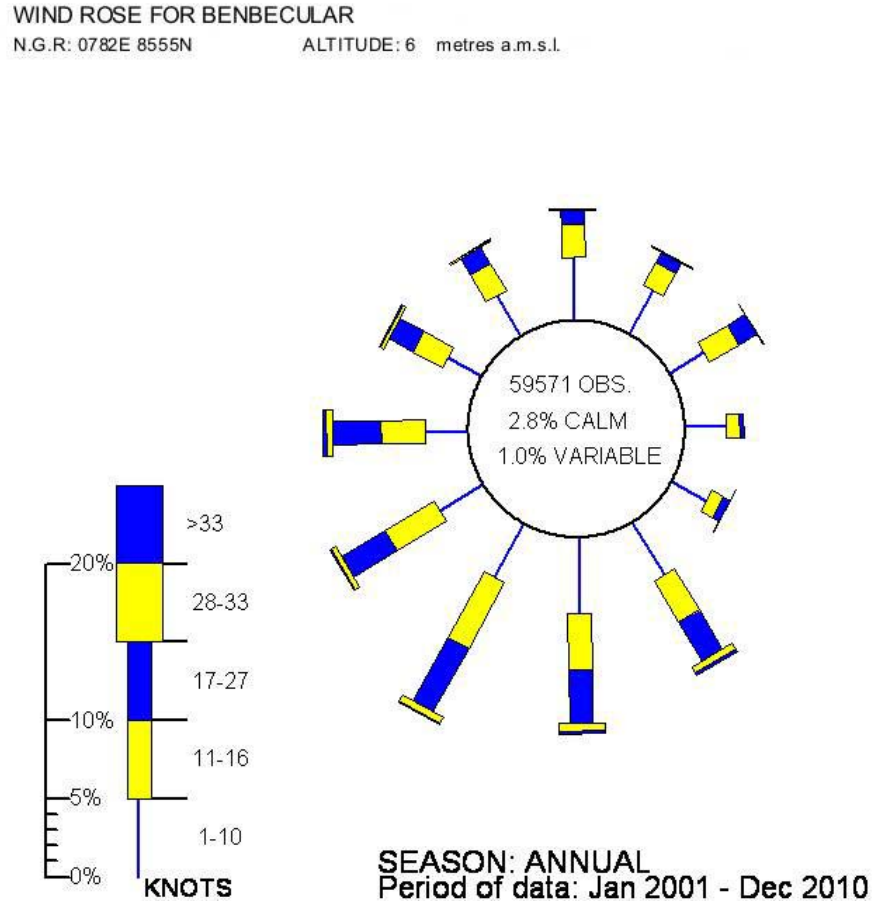


Figure 9.4 Annual wind rose for Benbecula

10. Current and historical classification status

Loch Skipport has not previously been classified for the production of bivalve molluscan shellfish.

11. Historical *E. coli* data

11.1 Validation of historical data

Sampling from a basket at South Uist 1 was initiated in 2011. All shellfish samples taken at Loch Skipport from the beginning of 2011 up to the 6th October 2011 were extracted from the database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data.

All samples came from within the area of Loch Skipport, and all samples were received by the testing laboratory within 24 hours of collection. Five samples had the result reported as <20. All samples were of common mussels (*Mytilus* spp).

All *E. coli* results are reported in most probable number per 100g of shellfish flesh and intravalvular fluid.

11.2 Summary of microbiological results

A total of six classification samples have been submitted for South Uist 1, the results are shown in Table 7.1.

Table 11.1 Shellfish sample *E. coli* results for South Uist 1

No.	Production Area	Site	Position	Collection Date	Species	Analysis Date	*E. coli* MPN/100 g
1	South Uist 1	Loch Skipport E	NF 8320 3860	22/03/2011	Mussels	23/03/2011	<20
2	South Uist 1	Loch Skipport E	NF 8296 3860	05/04/2011	Mussels	06/04/2011	<20
3	South Uist 1	Loch Skipport E	NF 8296 3860	31/05/2011	Mussels	01/06/2011	<20
4	South Uist 1	Loch Skipport E	NF 8425 3902	28/06/2011	Mussels	29/06/2011	<20
5	South Uist 1	Loch Skipport E	NF 8425 3902	19/07/2011	Mussels	20/07/2011	330
6	South Uist 1	Loch Skipport E	NF 8425 3902	02/08/2011	Mussels	03/08/2011	<20

One sample was reported to have come from off Rubha Mor near the pier, two were reported from near the pier and three from a location near the westernmost of the three proposed mussel farm sites.

In actuality, the sampling officer reported that all monitoring samples were collected from a sampling bag hung from the pier. Samples were taken from a creel at the mussel farm by the harvester during the weekend prior to sampling and therefore would have hung at the pier for 3-4 days before collection by the sampling officer. As samples must have been in situ for a minimum of 14 days prior to sampling, these cannot be considered representative of conditions at either the fishery or at pier. Therefore spatial variation in the results has not been considered further.

Due to the relaying of samples prior to collection, and variation in sampling locations, the above results may not be an accurate reflection of bacteriological conditions likely to be found on all three mussel farms.

12. Designated Shellfish Growing Waters Data

There are no designated shellfish growing waters or bathing waters within Loch Skipport.

13. River Flow

There are no river gauging stations on watercourses along the Loch Skipport coastline.

The watercourses listed in Table 13.1 were observed during the shoreline survey. The locations, together with the calculated loadings, are shown in Figure 13.1. The weather was dry on the day of the survey but there had been heavy rain the previous day.

Table 13.1 Watercourse loadings for Loch Skipport

No	Grid Ref	Description	Width (m)	Depth (m)	Flow (m/s)	Flow in m^3/day	*E.coli* (cfu/ 100ml)	Loading (*E.coli* per day)
1	NF 82709 38132	Stream	0.80	0.18	0.244	3040	<100	$<3.0x10^9$
2	NF 82690 38293	Stream	0.38	0.14	0.045	210	<100	$<2.1x10^8$
3	NF 82324 39090	Stream	0.30	0.20	0.127	660	<100	$<6.6x10^8$

The observed streams were all located on the western side of the loch. Despite the heavy rain the previous day, *E. coli* concentrations were all less than the limit of detection used for these samples. The majority of the shoreline was not walked due to access difficulties. The Ordnance Survey map shows only a small number of very small additional watercourses in the area, with none in the vicinity of the proposed fishery. Drainage from the freshwater lochs dotted around the area would be expected to respond more slowly and over a longer period due to their larger catchment areas. Therefore, it is possible that the rainfall response is less immediate than has been observed in other areas.

Given that the streams were small, contained no detectable *E. coli* (at the limit of detection used), and were located more than 1 km from the nearest proposed mussel site, it is not anticipated that they will have an impact on the *E. coli* levels at the fishery. However, direct run-off into the loch in the vicinity of the fishery may occur during heavy rain and this will be a potential source of contamination.

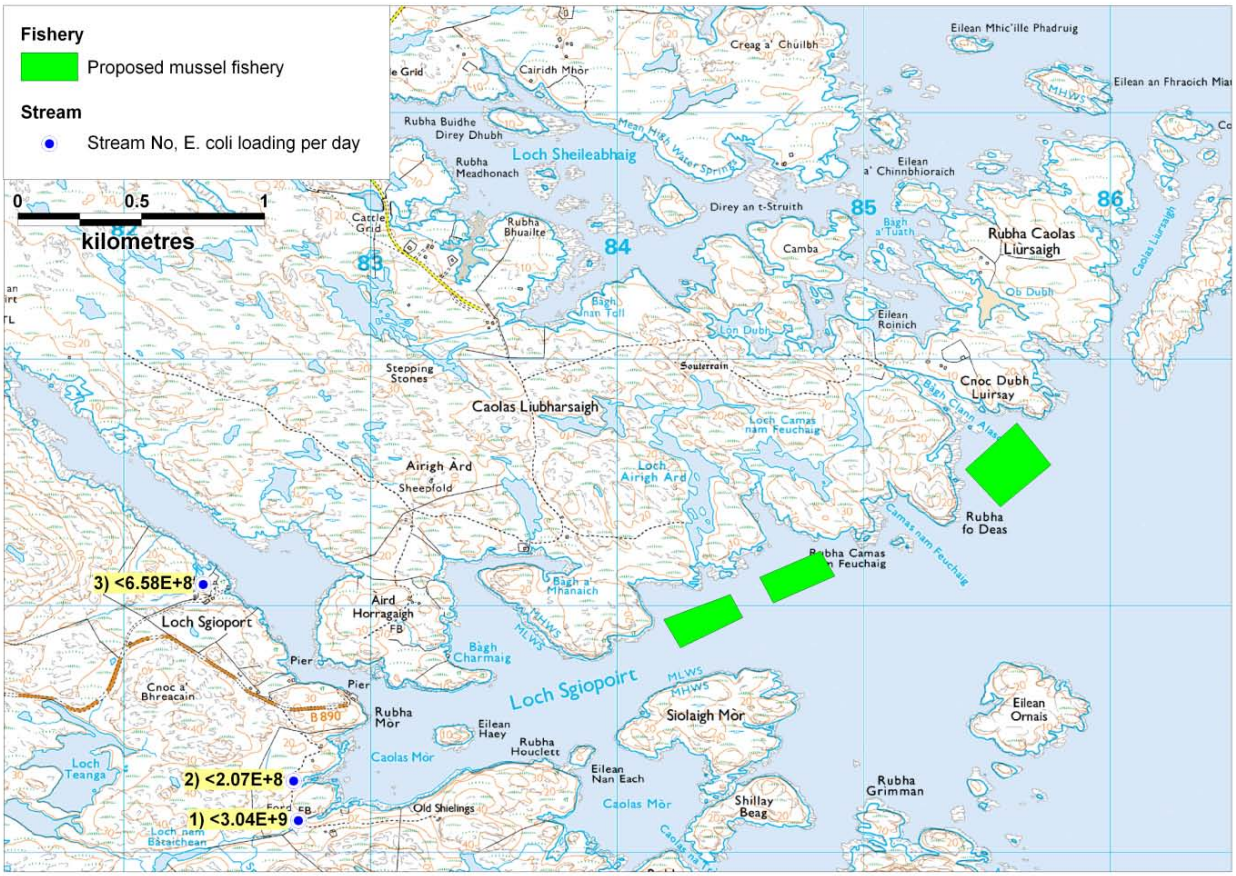


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Figure 13.1 Map of stream loadings at Loch Skipport

14. Bathymetry and Hydrodynamics

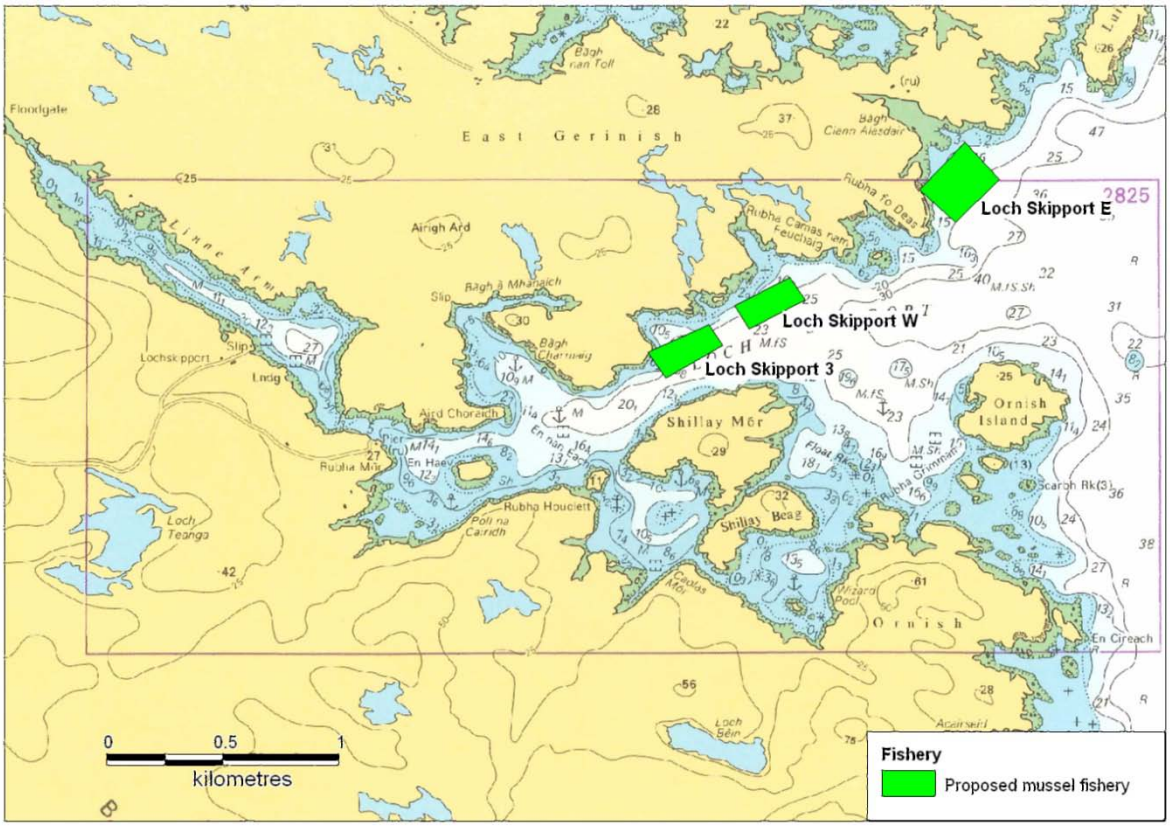

Figure 14.1 Bathymetry at Loch Skipport

Loch Skipport (also: Loch Skiport; Lochskiport; Loch Sgiopoirt (Gaelic)) is 4.6 km long and ranges in width from less than 0.2 km in the inner loch (Linne Arm) to 1.6 km in the outer loch. The bathymetry of the area is shown in Figure 14.1. The maximum depth is given by Edwards and Sharples (1991) as 36 m although the hydrographic chart gives the maximum depth between Rubha fo Deas and Ornish Island as 40 m. There are 4 sills and 4 basins within the loch. There is a sluice and floodgate at the western end of the Linne Arm. Several islands, and 3 of the sills, are located on the southern side of the outer loch. There is an intertidal strip along the entire shore of the loch and around the islands within it. Bàgh Clann Alasdair, in the immediate vicinity of the easternmost proposed mussel site, is almost entirely intertidal. The areas identified for the three proposed mussel line sites are located on the northern side of the outer loch basin, in depths ranging from <5 m to >20 m.

14.1 Tidal Curve and Description

The two tidal curves below are for Loch Skipport, located in Linne Arm of the inner loch. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 BST on 27/06/11 and the second is for

seven days beginning 00.00 BST on 04/07/11. Together they show the predicted tidal heights over high/low water for a full neap/spring tidal cycle and cover the period during which the shoreline survey was undertaken.

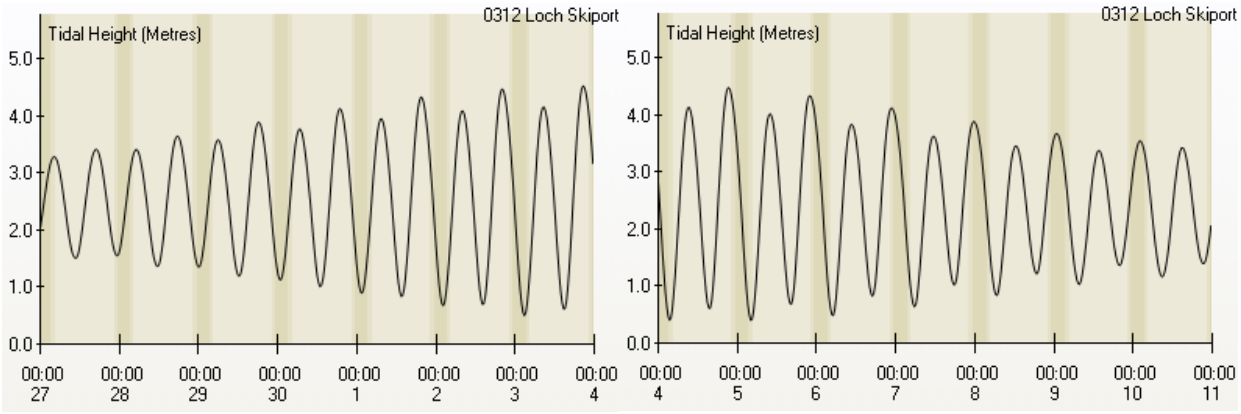

Figure 14.2 Tidal curves for Loch Skipport

The following is the summary description for Loch Skipport from TotalTide:

0312 Loch Skiport (*sic*) is a Secondary Non-Harmonic port.
The tide type is Semi-Diurnal.

HAT	5.5 m
MHWS	4.6 m
MHWN	3.3 m
MLWN	1.7 m
MLWS	0.5 m
LAT	-0.2 m

Predicted heights are in metres above chart datum. The average tidal range at spring tide is 4.1 m and at neap tide 1.6 and so tidal ranges at this location are relatively large (macrotidal).

14.2 Currents

There is no tidal stream information for the area within, or close to, Loch Skipport. SEPA provided current study information for two locations within the loch. Summary information on the sites is given in Table 14.1 and the positions are shown on the map in Figure 14.3. Plots of the current directions and speeds, together with the wind direction and speeds over the relevant periods, are shown in Figure 14.4.

Table 14.1 Survey periods for the current meter studies

Location	NGR	Survey period
Eilean Haey	NF 83698 38481	01/12/03 – 16/12/03
Ornish	NF 85314 38580	05/10/05 – 20/01/05

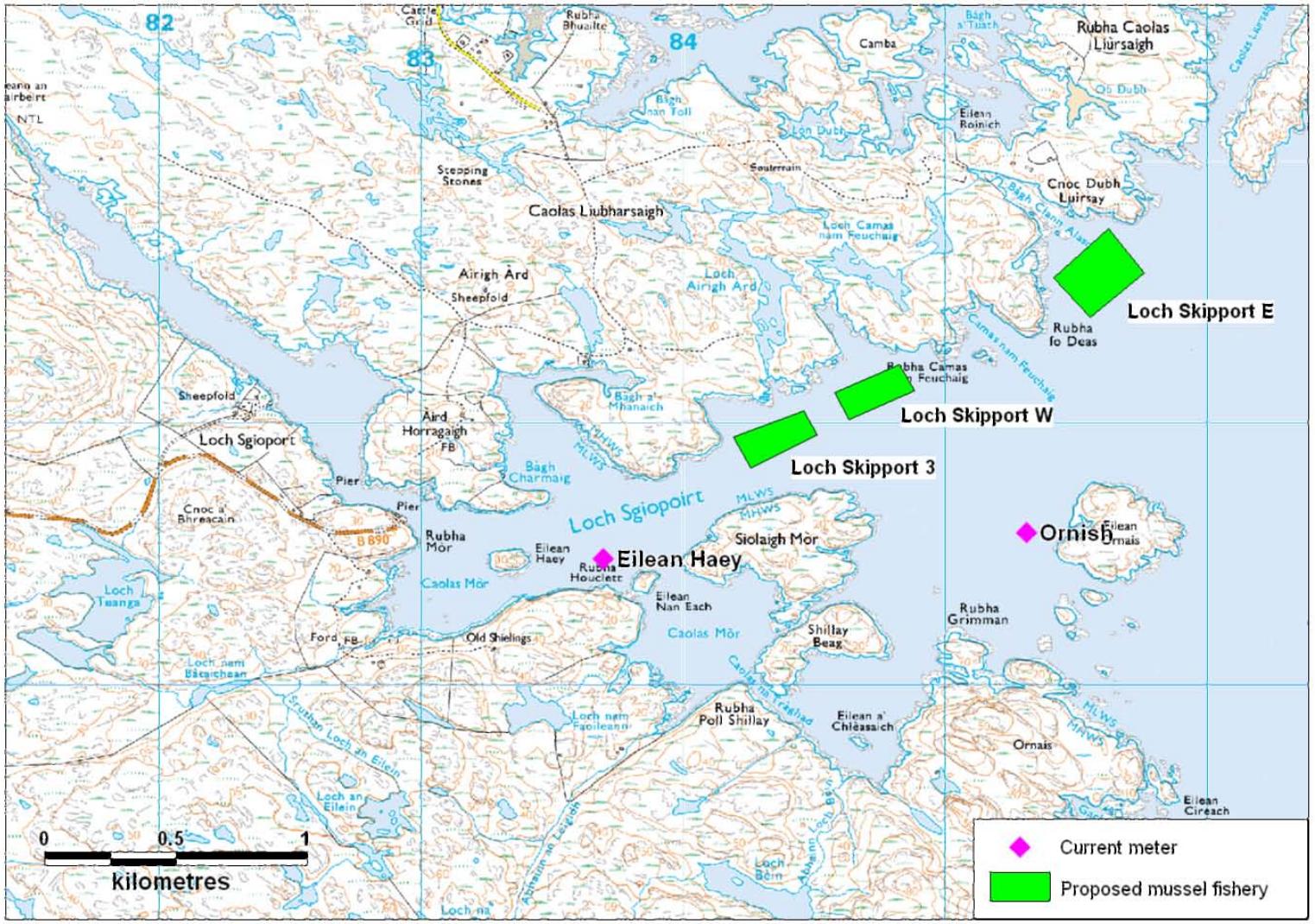

Figure 14.3 Current meter locations

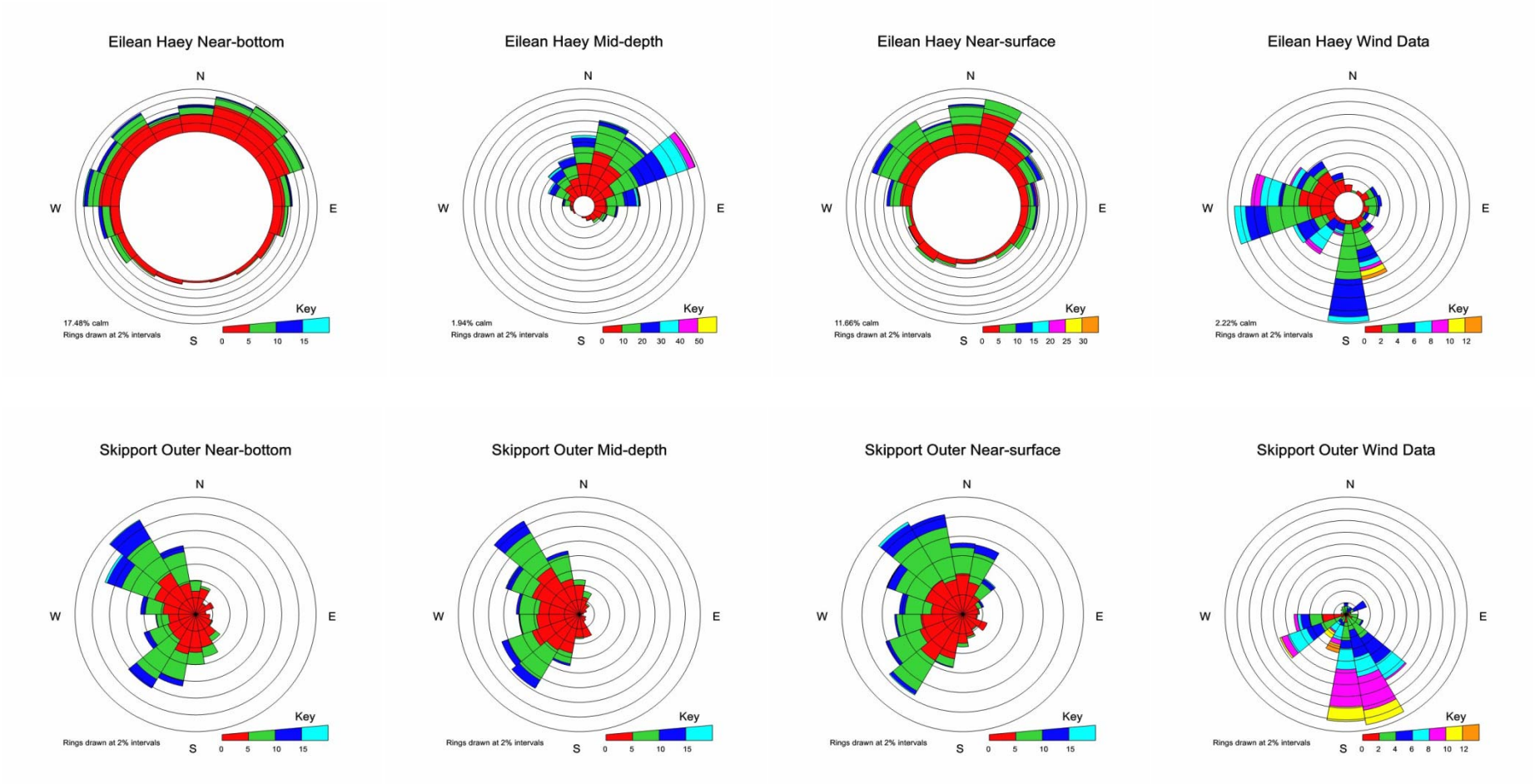

Figure 14.4 Current and wind plots for the Loch Skipport current meter studies

Currents measured in cm/s. Wind measured in m/s. As per convention, currents are plotted against the direction towards which they are travelling while winds are plotted against the direction from which they are travelling. The length of each segment in a plot relates to the proportion of observations lying in that direction. The speed relates to the colour key beneath each plot. The proportion that each colour takes up in an individual segment relates to the proportion of observations in that direction having speed in that range. Directions are in degrees magnetic.

Neither current meter location was ideal from the viewpoint of informing consideration of currents at the proposed mussel fishery locations: neither lay in the channel where the mussel sites will be located and at both the currents may be influenced by nearby islands.

At Eilean Haey, both the near-bottom and near-surface measurements showed very large proportions of time when the current speeds were negligible (indicated by the blank inner circles in the respective plots in Figure 14.4. The rest of the time the current directions were quite variable at those depths. However, at mid-depth, the currents were more directional, generally between north and east, with a significant element flowing east-north-east. The near-surface current did not appear to be influenced by wind during the survey.

Current speeds at mid-depth were stronger (median = 11 cm/s; maximum = 53 cm/s) than at near-bottom (median = 3 cm/s; maximum = 18 cm/s) or near-surface (median = 4 cm/s; maximum = 33 cm/s). However, even at mid-depth the current speeds would be regarded as low to moderate: the maximum current is equivalent to 0.5 m/s or 1 knot.

At Skipport Outer, the current direction tended to lay generally north-west and south-west at all three depths. These two directions are likely to be due to the survey site being located immediately to the east of the island of Ornish. The greater proportion of north-west flowing current may have been influenced by the wind, which blew principally from the south to south-west during the study.

Current speeds at the three depths were low and approximately the same with medians varying between 3.6 and 4.2 cm/s (approximately 0.04 m/s; 0.08 knots) and maxima varying between 16.3 and 17.3 cm/s (approximately 0.17 m/s; 0.33 knots).

Current directions are likely to differ at the proposed mussel fishery given that the sites are in a channel with no nearby islands. The currents will tend to flow in the direction of the channel, although the presence of promontories along the northern shore may modify this tendency. However, current speeds are likely to be of the same order as those observed at the study sites: i.e. low to moderate. At a maximum speed of 0.5 m/s, contaminants would travel a distance of approximately 7 km over an ingoing or outgoing tide, ignoring any effects of dilution or dispersion. However, current speeds within Loch Skipport will usually be less than this and transport distances are unlikely to exceed 1.5 km most of the time.

The Clyde Crusing Club sailing directions for the area identifies that “Inside the loch the flow rates are imperceptible or weak even in the narrow channels”.

Edwards and Sharples (1991) give a flushing time for the loch as 2 days, which is low.

14.3 Salinity effects

Edwards and Sharples (1991) give the salinity reduction for the loch as 0.3 ppt. This reduction was worked out on a theoretical basis for the whole loch. During the shoreline survey, salinity profiles were measured in the vicinity of the westernmost and easternmost mussel sites. Values ranged between 34.7 and 35.0 ppt, with difference between the surface at one site being of the order of 0.3 ppt and at the other <0.1 ppt. There is therefore not evidence for marked influence of fresh water at the fishery and density-driven flows are not expected to be a significant factor in the area.

14.4 Conclusions

Currents in the loch are weak to moderate, despite the relatively large tidal range. They will tend to follow the main channel at the fishery and any contamination arising in the inner loch will flow over the mussel sites on the outgoing tide and contamination arising on the outer northern shore of the loch will flow over the sites on the incoming tide. However, given the generally weak currents, local sources of contamination may have the most significant effect at the edges of the sites nearest to the northern shore of the outer loch.

15. Shoreline Survey Overview

The shoreline survey was conducted on the 27th June 2011 under dry and calm weather conditions.

The locations of the three proposed mussel sites were visited on the day of the survey. There is currently no equipment or stock on any of the sites. The harvester intends to install twelve long lines at Loch Skipport E, ten long lines at Loch Skipport W and eight long lines at Loch Skipport Site 3. There are plans for five of the long lines at Loch Skipport W to be installed before the end of 2011. The long lines will be 220 m in length with 8 m droppers and the harvester aims to begin harvesting in 2013. The harvester has marked the proposed locations of the sites, South Uist 1 and South Uist 2 using a buoy with a creel basket attached with mussels inside to allow monthly sampling. The Loch Skipport W basket is at a depth of 14 m and the Loch Skipport E basket is at a depth of 20 m.

A single septic tank and connected outfall pipe was observed during the shoreline survey. The outfall pipe led from the Loch Skipport Marine Harvest workshop, into a septic tank which was open at the top and then out the other side on to the shoreline. There was no flow coming out of the outfall pipe at the time of the shoreline survey. There are no large settlements in the area surrounding Loch Skipport and no dwellings were observed in the area during the shoreline survey.

Livestock was observed grazing along most of the western shoreline of Loch Skipport and were able to access the shoreline and fresh water streams. Ponies and sheep and their droppings and tracks were observed on the western shoreline. In total approximately 6 ponies and 14 sheep were observed over the course of the shoreline survey.

A small number of sea birds were observed including 1 gannet and 7 herons on the western shoreline. A single otter was observed on the southern shoreline.

Sea water samples taken in the vicinity of the proposed mussel fisheries contained no detectable *E. coli* (0 cfu/100ml) in all cases. Salinity profiles taken at the proposed mussel fisheries indicated no significant freshwater influence at the time of the shoreline survey.

Freshwater samples and discharge measurements were taken at the three streams draining into the survey area. The streams were small and drained areas of dense heath and bog land. The results of all three fresh water samples were <100 *E. coli* cfu/100 ml. Mussel samples were collected from Loch Skipport 1 and Loch Skipport 2 and returned results of <20 and 50 *E. coli* MPN/100 g, with the higher result being seen at the easternmost site.

Figure 15.1 shows a summary map of the most significant findings from the shoreline survey.

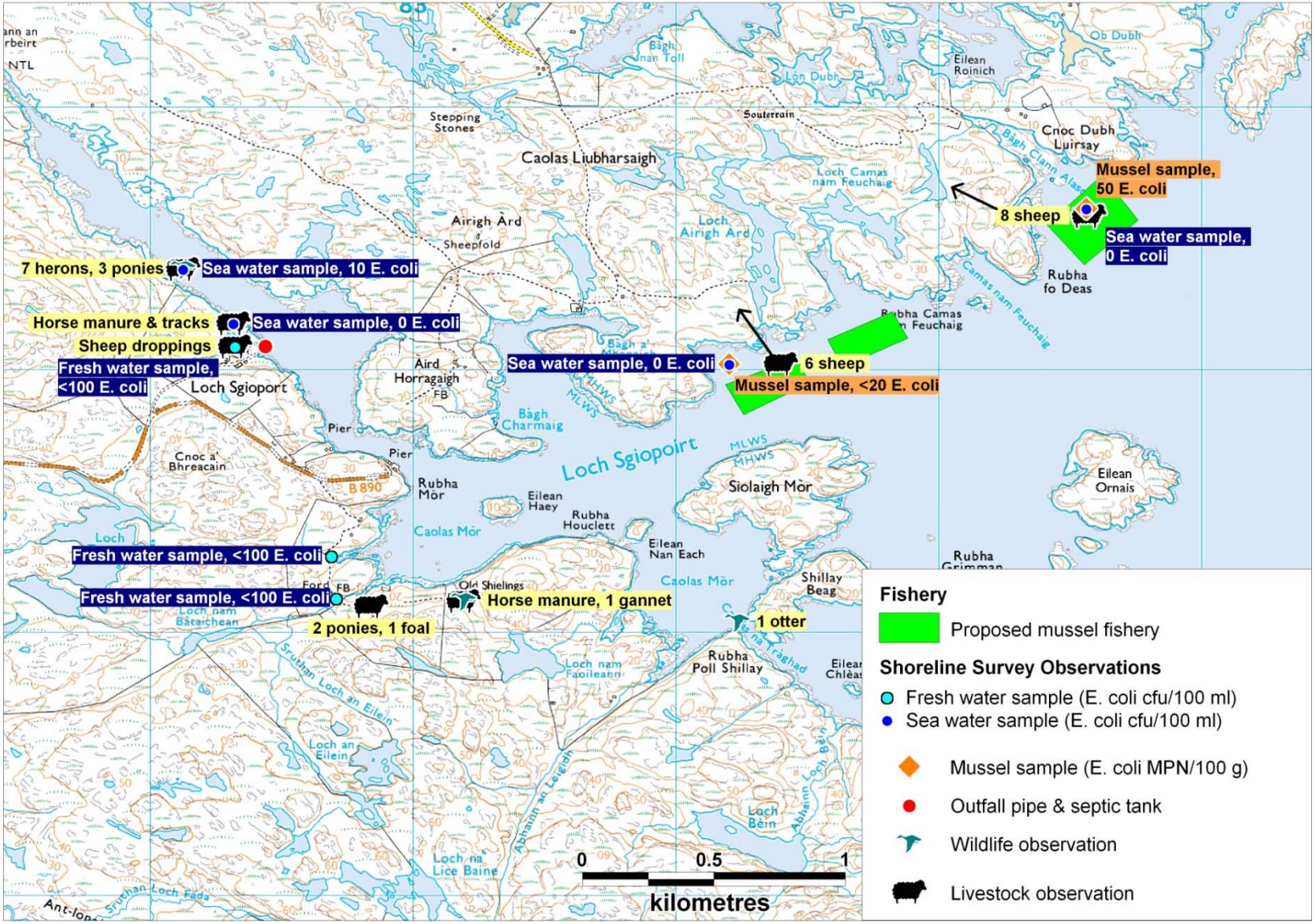

Figure 15.1 Summary of shoreline survey findings for Loch Skipport

16. Overall Assessment

Human sewage impacts

The area surrounding Loch Skipport is sparsely populated and access to the shoreline is restricted to a single track accessing the western end of the loch. No dwellings were observed on the shoreline adjacent to the fishery during the shoreline survey. There is little in the way of human sewage impact to the fishery area. There are no Scottish Water community septic tanks or sewage discharges in the area. Two small private septic tanks are located inland off the coastline of the western water body of the loch, both discharge to soakaway. Another four private septic tanks are located inland north of the mussel farms. Two of the septic tanks discharge to soakaway and the remaining two discharge to Loch Sheileabhaig. As the total number of discharges in the area is low, and most discharge to soakaway, the impact from human sewage discharge to the outer loch is expected to be very low.

Agricultural impacts

Sheep and ponies were the only livestock observed in the area during the shoreline survey. In total 6 ponies were counted in total along the western shoreline of the loch, with a large amount of horse manure found in several places along the shoreline. A small number of sheep (14) were observed grazing along the western shoreline adjacent to the shellfish farms. Deposition of faeces onto grazing areas is likely to be higher in summer, when the number of sheep is likely to be higher due to the presence of lambs. Therefore, sheep faeces are likely to be a source of faecal bacteria carried via streams or direct runoff from land adjacent to the fishery and any effect at the shellfishery may be highest following heavy rainfall during the summer and early autumn months.

Wildlife impacts

Wildlife impacts are likely to vary across the year, with some species such as gulls, geese and seals present year-round. The most likely impact to the fishery will be from direct deposition of faeces into or around the fishery by birds resting on the mussel floats or by seals passing through the area. This is no more likely to impact one part of the mussel farm than another, and the timing of impacts is likely to be unpredictable. Very few seabirds were recorded in the vicinity of the fishery during the shoreline survey, and no significant nesting areas are located near the mussel farms.

Waterfowl and deer are likely to contribute to faecal bacteria loadings carried via streams to Loch Skipport.

Seasonal variation

There is likely to be little seasonal variation in human population given that there are no dwellings in the area and access to the coastline is restricted.

There are likely to be more livestock present from late spring until autumn due to the presence of lambs. Impacts from seabirds are likely to be higher during the summer nesting period, roughly May-August. Rainfall tends to be higher from September to February. However, high rainfall events tend to occur through most of the year and the highest *E. coli* loadings to Loch Skipport may occur after high rainfall events that follow periods of dry weather between May to September, when livestock numbers are expected to be highest.

Rivers and streams

All the streams entering Loch Skipport are located on the western side of the water body, at least 1 km in distance away from the shellfish farms. Freshwater samples taken from the three observed streams on the day of the shoreline survey all had *E. coli* concentrations less than the limit of detection. The loadings of all sampled streams discharging to the western side of Loch Skipport were low at the time of shoreline survey. Given that the streams were small, contained no detectable *E. coli* (at the limit of detection used), and were located more than 1 km from the nearest proposed mussel site, it is not anticipated that freshwater inputs will have an impact on the *E. coli* levels at the fishery. However, direct run-off into the loch in the vicinity of the fishery may occur during heavy rain and this will be a potential source of contamination.

Movement of contaminants

The potential for contamination in reaching the fishery via rainfall run-off and streams is most likely to be higher in the late summer and early autumn periods. The most likely route of entry to the loch is via watercourses discharging to the north shore of the outer loch, near to the mussel farm sites.

Currents in the loch are weak to moderate, and therefore local sources of contamination may have the most significant effect at the edges of the sites nearest to the northern shore of the outer loch.

Temporal and geographical patterns of sampling results

Very few results (6) were available for analysis, all from samples taken over a 6-month period in 2011. Samples were taken from a location on the fishery and then relayed at the pier prior to collection and analysis. Therefore, the results cannot clearly be considered representative of contamination levels at either location. Given the limited monitoring history and the mixed locations of shellfish sampled, it is not possible to address geographical patterns amongst the sampling results.

Conclusions

Diffuse sources of contamination are those most likely to affect the proposed fishery at Loch Skipport, and any effects are likely to be localised. However, as equipment had not yet been installed on site, it is not yet possible to

address whether there is any variation in contamination levels between the eastern and western extents of the proposed sites.

Although seabed leases have been established, and the proposed locations of the mussel farms have been identified by the harvester, it will not be possible to assure that any recommended sampling point would actually coincide with the mussel farm until the equipment has been put in place.

Once the equipment has been installed on the site, a bacteriological survey should be undertaken to establish the relative levels of contamination at the eastern and western ends of the fishery and whether there is variation in contamination at the surface versus at depth.

It would be possible to conduct the bacteriological survey before mature stock was available on the lines by using bagged shellfish at different depths (1 m and 6 m) on either end of proposed fishery. This could be done 6-12 months prior to planned harvest to allow time for establishment of an RMP and initiation of sampling. It would not be cost effective to commence routine monitoring more than 6 months prior to anticipated harvest.

17. Recommendations

Production area

It is recommended that the production area encompass the Crown Estate lease areas established for the farm, including the westernmost site identified by the harvester. The boundaries recommended are NF 8580 3985 to NF 8580 3878 and NF 8580 3878 to NF 8400 3878 and NF 8400 3878 to NF 8400 3888 and NF 8554 3979 to NF 8537 3971 and extending to MHWS.

This area should be reviewed once the mussel farm has been established.

RMP

It is recommended that an RMP be established once the mussel farm has been installed and a bacteriological survey undertaken.

Frequency

Once an RMP is established, monthly monitoring is recommended until there is sufficient history built up to assess stability.

Depth of sampling

A recommended sampling depth will be contingent on the outcome of the bacteriological survey.

Tolerance

With most long line mussel farms, a tolerance of 40 metres is set to allow for some movement of the lines on the anchors.

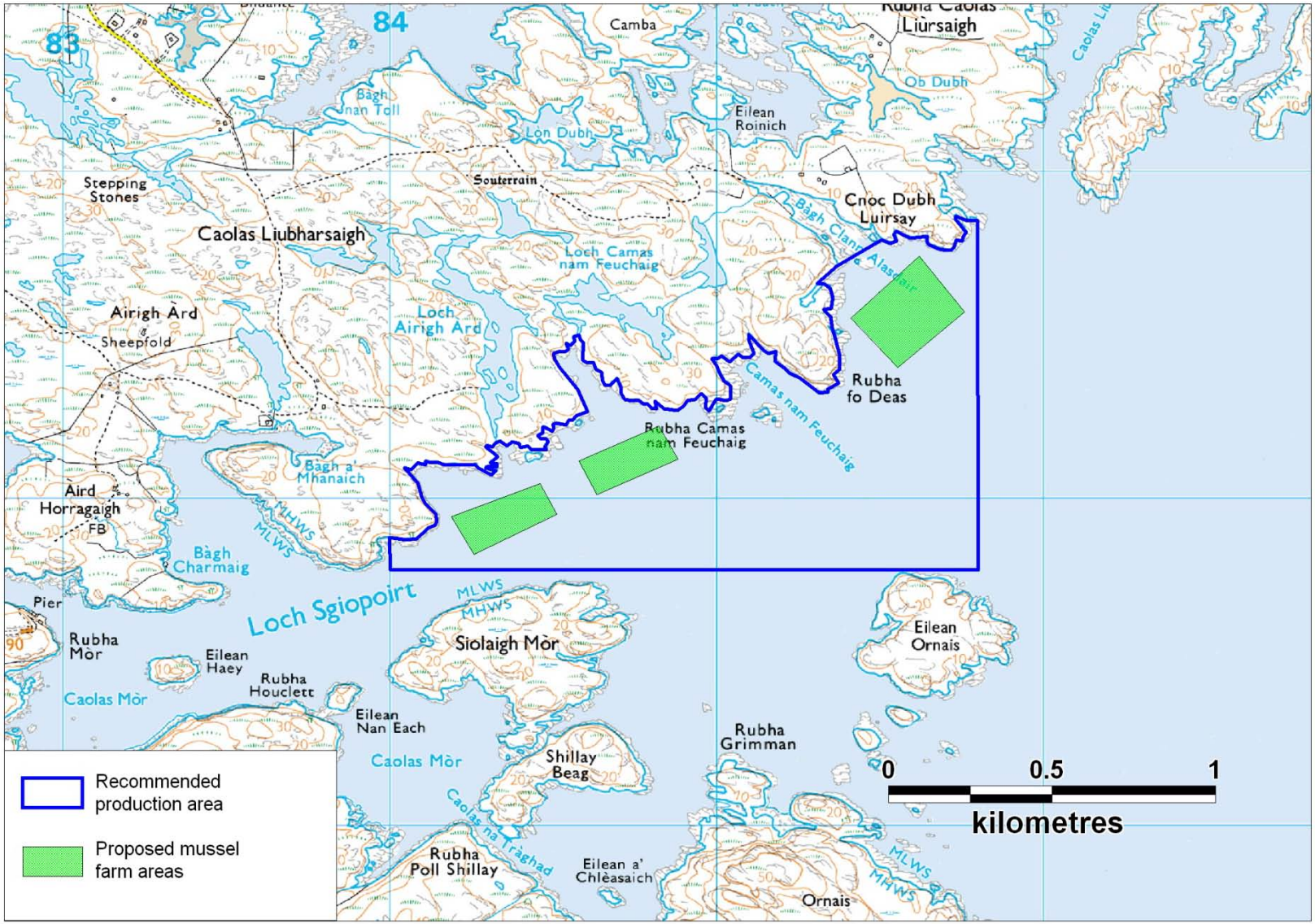

Figure 17.1 Map of recommendations at Loch Skipport

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19. List of Figures and Tables

Appendices

1. **Geology and Soils Assessment Method**
2. **General Information on Wildlife Impacts**
3. **Tables of Typical Faecal Bacteria Concentrations**
4. **Hydrographic Methods**
5. **Shoreline Survey Report**

Geology and Soils Assessment Method

Component soils and their associations were identified using uncoloured soil maps (scale 1:50,000) obtained from the Macaulay Institute. The relevant soils associations and component soils were then investigated to establish basic characteristics. From the maps seven main soil types were identified: 1) humus-iron podzols, 2) brown forest soils, 3) calcareous regosols, brown calcareous regosols, calcareous gleys, 4) peaty gleys, podzols, rankers, 5) non-calcareous gleys, peaty gleys: some humic gleys, peat, 6) organic soils and 7) alluvial soils.

Humus-iron podzols are generally infertile and physically limiting soils for productive use. In terms of drainage, depending on the related soil association they generally have a low surface % runoff, of between 14.5 – 48.4%, indicating that they are generally freely draining.

Brown forest soils are characteristically well drained with their occurrence being restricted to warmer drier climates, and under natural conditions they often form beneath broadleaf woodland. With a very low surface % runoff of between 2 – 29.2%, brown forest soils can be categorised as freely draining (Macaulay Institute, 2007).

Calcareous regosols, brown regosols and calcareous gleys are all characteristically freely draining soils containing free calcium carbonate within their profiles. These soil types have a very low surface % runoff at 14.5%.

Peaty gleys, peaty podzols and peaty rankers contribute to a large percentage of the soil composition of Scotland. They are all characteristically acidic, nutrient deficient and poorly draining. They have a very high surface % runoff of between 48.4 – 60%.

Non-calcareous gleys, peaty gleys and humic gleys are generally developed under conditions of intermittent or permanent water logging. In Scotland, non-calcareous gleys within the Arkaig association are most common and have an average surface % runoff of 48.4%, indicating that they are generally poorly draining.

Organic soils often referred to as peat deposits and are composed of greater than 60% organic matter. Organic soils have a surface % runoff of 25.3% and although low, due to their water logged nature, results in them being poorly draining.

Alluvial soils are confined to principal river valleys and stream channels, with a wide soil textural range and variable drainage. However, the alluvial soils encountered within this region have an average surface % runoff of 44.3%, so it is likely that in this case they would be poorly draining.

These component soils were classed broadly into two groups based on whether they are freely or poorly draining. Drainage classes were created based on information obtained from the both the Macaulay Institute website

and personal communication with Dr. Alan Lilly. GIS map layers were created for each class with poorly draining classes shaded red, pink or orange and freely draining classes coloured blue or grey. These maps were then used to assess the spatial variation in soil permeability across a survey area and it's potential impact on runoff.

Glossary of Soil Terminology

Calcareous: Containing free calcium carbonate.

Gley: A sticky, bluish-grey subsurface layer of clay developed under intermittent or permanent water logging.

Podzol: Infertile, non-productive soils. Formed in cool, humid climates, generally freely draining.

Rankers: Soils developed over noncalcareous material, usually rock, also called 'topsoil'.

Regosol: coarse-textured, unconsolidated soil lacking distinct horizons. In Scotland, it is formed from either quartzose or shelly sands.

General Information on Wildlife Impacts

Pinnipeds

Two species of pinniped (seals, sea lions, walruses) are commonly found around the coasts of Scotland: These are the European harbour, or common, seal (*Phoca vitulina vitulina*) and the grey seal (*Halichoerus grypus*). Both species can be found along the west coast of Scotland.

Common seal surveys are conducted every 5 years and an estimate of minimum numbers is available through Scottish Natural Heritage.

According to the Scottish Executive, in 2001 there were approximately 119,000 grey seals in Scottish waters, the majority of which were found in breeding colonies in Orkney and the Outer Hebrides.

Adult Grey seals weigh 150-220 kg and adult common seals 50-170kg. They are estimated to consume between 4 and 8% of their body weight per day in fish, squid, molluscs and crustaceans. No estimates of the volume of seal faeces passed per day were available, though it is reasonable to assume that what is ingested and not assimilated in the gut must also pass. Assuming 6% of a median body weight for harbour seals of 110kg, that would equate to 6.6kg consumed per day and probably very nearly that defecated.

The concentration of *E. coli* and other faecal indicator bacteria contained in seal faeces has been reported as being similar to that found in raw sewage, with counts showing up to 1.21×10^4 CFU (colony forming units) *E. coli* per gram dry weight of faeces (Lisle *et al* 2004).

Both bacterial and viral pathogens affecting humans and livestock have been found in wild and captive seals. *Salmonella* and *Campylobacter* spp., some of which were antibiotic-resistant, were isolated from juvenile Northern elephant seals (*Mirounga angustirostris*) with *Salmonella* found in 36.9% of animals stranded on the California coast (Stoddard et al 2005). *Salmonella* and *Campylobacter* are both enteric pathogens that can cause acute illness in humans and it is postulated that the elephant seals were picking up resistant bacteria from exposure to human sewage waste.

One of the *Salmonella* species isolated from the elephant seals, *Salmonella typhimurium*, is carried by a number of animal species and has been isolated from cattle, pigs, sheep, poultry, ducks, geese and game birds in England and Wales. Serovar DT104, also associated with a wide variety of animal species, can cause severe disease in humans and is multi-drug resistant (Poppe et al 1998).

Cetaceans

As mammals, whales and dolphins would be expected to have resident populations of *E. coli* and other faecal indicator bacteria in the gut. Little is known about the concentration of indicator bacteria in whale or dolphin

faeces, in large part because the animals are widely dispersed and sample collection difficult.

A variety of cetacean species are routinely observed around the west coast of Scotland. Where possible, information regarding recent sightings or surveys is gathered for the production area. As whales and dolphins are broadly free ranging, this is not usually possible to such fine detail. Most survey data is supplied by the Hebridean Whale and Dolphin Trust or the Shetland Sea Mammal Group and applies to very broad areas of the coastal seas.

It is reasonable to expect that whales would not routinely affect shellfisheries located in shallow coastal areas. It is more likely that dolphins and harbour porpoises would be found in or near fisheries due to their smaller physical size and the larger numbers of sightings near the coast.

Birds

Seabird populations were surveyed all over Britain as part of the SeaBird 2000 census. These counts are investigated using GIS to give the numbers observed within a 5 km radius of the production area. This gives a rough idea of how many birds may be present either on nests or feeding near the shellfish farm or bed.

Further information is gathered where available related to shorebird surveys at local bird reserves when present. Surveys of overwintering geese are queried to see whether significant populations may be resident in the area for part of the year. In many areas, at least some geese may be present year round. The most common species of goose observed during shoreline surveys has been the Greylag goose. Geese can be found grazing on grassy areas adjacent to the shoreline during the day and leave substantial faecal deposits. Geese and ducks can deposit large amounts of faeces in the water, on docks and on the shoreline.

A study conducted on both gulls and geese in the northeast United States found that Canada geese (*Branta canadiensis*) contributed approximately 1.28×10^5 faecal coliforms (FC) per faecal deposit and ring-billed gulls (*Larus delawarensis*) approximately 1.77×10^8 FC per faecal deposit to a local reservoir (Alderisio and DeLuca, 1999). An earlier study found that geese averaged from 5.23 to 18.79 defecations per hour while feeding, though it did not specify how many hours per day they typically feed (Bedard and Gauthier, 1986).

Waterfowl can be a significant source of pathogens as well as indicator organisms. Gulls frequently feed in human waste bins and it is likely that they carry some human pathogens.

Deer

Deer are present throughout much of Scotland in significant numbers. The Deer Commission of Scotland (DCS) conducts counts and undertakes culls of deer in areas that have large deer populations.

Four species of deer are routinely recorded in Scotland, with Red deer (*Cervus elaphus*) being the most numerous, followed by Roe deer (*Capreolus capreolus*), Sika deer (*Cervus nippon*) and Fallow deer (*Dama dama*).

Accurate counts of populations are not available, though estimates of the total populations are >200,000 Roe deer, >350,000 Red deer, < 8,000 Fallow deer and an unknown number of Sika deer. Where Sika deer and Red deer populations overlap, the two species interbreed further complicating counts.

Deer will be present particularly in wooded areas where the habitat is best suited for them. Deer, like cattle and other ruminants, shed *E. coli*, *Salmonella* and other potentially pathogenic bacteria via their faeces.

Other

The European Otter (*Lutra lutra*) is present around Scotland with some areas hosting populations of international significance. Coastal otters tend to be more active during the day, feeding on bottom-dwelling fish and crustaceans among the seaweed found on rocky inshore areas. An otter will occupy a home range extending along 4-5km of coastline, though these ranges may sometimes overlap (Scottish Natural Heritage website). Otters primarily forage within the 10 m depth contour and feed on a variety of fish, crustaceans and shellfish (Paul Harvey, Shetland Sea Mammal Group, personal communication).

Otters leave faeces (also known as spraint) along the shoreline or along streams, which may be washed into the water during periods of rain.

References:

Alderisio, K.A. and N. DeLuca (1999). Seasonal enumeration of fecal coliform bacteria from the feces of Ring-billed gulls (*Larus delawarensis*) and Canada geese (*Branta canadensis*). *Applied and Environmental Microbiology*, 65:5628-5630.

Bedard, J. and Gauthier, G. (1986) Assessment of faecal output in geese. *Journal of Applied Ecology*, 23:77-90.

Lisle, J.T., Smith, J.J., Edwards, D.D., andd McFeters, G.A. (2004). Occurrence of microbial indicators and *Clostridium perfringens* in wastewater, water column samples, sediments, drinking water and Weddell Seal feces collected at McMurdo Station, Antarctica. *Applied and Environmental Microbiology*, 70:7269-7276.

Scottish Natural Heritage. http://www.snh.org.uk/publications/on-line/wildlife/otters/biology.asp. Accessed October 2007.

Tables of Typical Faecal Bacteria Concentrations

Summary of faecal coliform concentrations (cfu 100ml-1) for different treatment levels and individual types of sewage-related effluents under different flow conditions: geometric means (GMs), 95% confidence intervals (Cis), and results of t-tests comparing base- and high-flow GMs for each group and type.

Indicator organism	Base-flow conditions				High-flow conditions			
Treatment levels and specific types: Faecal coliforms	n^c	Geometric mean	Lower 95% CI	Upper 95% CI	n^c	Geometric mean	Lower 95% CI	Upper 95% CI
Untreated	252	1.7×10^{7} * (+)	1.4×10^{7}	2.0×10^{7}	282	2.8×10^{6} * (-)	2.3×10^{6}	3.2×10^{6}
Crude sewage discharges	252	1.7×10^{7} * (+)	1.4×10^{7}	2.0×10^{7}	79	3.5×10^{6} * (-)	2.6×10^{6}	4.7×10^{6}
Storm sewage overflows					203	2.5×10^{6}	2.0×10^{6}	2.9×10^{6}
Primary	127	1.0×10^{7} * (+)	8.4×10^{6}	1.3×10^{7}	14	4.6×10^{6} (-)	2.1×10^{6}	1.0×10^{7}
Primary settled sewage	60	1.8×10^{7}	1.4×10^{7}	2.1×10^{7}	8	5.7×10^{6}		
Stored settled sewage	25	5.6×10^{6}	3.2×10^{6}	9.7×10^{6}	1	8.0×10^{5}		
Settled septic tank	42	7.2×10^{6}	4.4×10^{6}	1.1×10^{7}	5	4.8×10^{6}		
Secondary	864	3.3×10^{5} * (-)	2.9×10^{5}	3.7×10^{5}	184	5.0×10^{5} * (+)	3.7×10^{5}	6.8×10^{5}
Trickling filter	477	4.3×10^{5}	3.6×10^{5}	5.0×10^{5}	76	5.5×10^{5}	3.8×10^{5}	8.0×10^{5}
Activated sludge	261	2.8×10^{5} * (-)	2.2×10^{5}	3.5×10^{5}	93	5.1×10^{5} * (+)	3.1×10^{5}	8.5×10^{5}
Oxidation ditch	35	2.0×10^{5}	1.1×10^{5}	3.7×10^{5}	5	5.6×10^{5}		
Trickling/sand filter	11	2.1×10^{5}	9.0×10^{4}	6.0×10^{5}	8	1.3×10^{5}		
Rotating biological contactor	80	1.6×10^{5}	1.1×10^{5}	2.3×10^{5}	2	6.7×10^{5}		
Tertiary	179	1.3×10^{3}	7.5×10^{2}	2.2×10^{3}	8	9.1×10^{2}		
Reedbed/grass plot	71	1.3×10^{4}	5.4×10^{3}	3.4×10^{4}	2	1.5×10^{4}		
Ultraviolet disinfection	108	2.8×10^{2}	1.7×10^{2}	4.4×10^{2}	6	3.6×10^{2}		

Source: Kay, D. et al (2008) Faecal indicator organism concentrations in sewage and treated effluents. *Water Research* 42, 442-454.

Comparison of faecal indicator concentrations (average numbers/g wet weight) excreted in the faeces of warm-blooded animals

Animal	Faecal coliforms (FC) number	Excretion (g/day)	FC Load (numbers /day)
Chicken	1,300,000	182	2.3×10^{8}
Cow	230,000	23,600	5.4×10^{9}
Duck	33,000,000	336	1.1×10^{10}
Horse	12,600	20,000	2.5×10^{8}
Pig	3,300,000	2,700	8.9×10^{8}
Sheep	16,000,000	1,130	1.8×10^{10}
Turkey	290,000	448	1.3×10^{8}
Human	13,000,000	150	1.9×10^{9}

Source: Adapted from Geldreich 1978 by Ashbolt et al in World Health Organisation (WHO) Guidelines, Standards and Health. 2001. Ed. by Fewtrell and Bartram. IWA Publishing, London.

Hydrographic Methods

The new EU regulations require an appreciation of the hydrography and currents within a region classified for shellfish production with the aim to "determine the characteristics of the circulation of pollution, appreciating current patterns, bathymetry and the tidal cycle." This document outlines the methodology used by Cefas to fulfil the requirements of the sanitary survey procedure with regard to hydrographic evaluation of shellfish production areas. It is written as far as possible to be understandable by someone who is not an expert in oceanography or computer modelling. A glossary at the end of the document defines commonly used hydrographic terms e.g. tidal excursion, residual flow, spring-neap cycle etc.

The hydrography at most sites will be assessed on the basis of bathymetry and tidal flow software only. Selected sites will be assessed in more detail using either: 1) a hydrodynamic model, or 2) an extended consideration of sources, available field studies and expert assessment. This document will consider the more basic hydrographic processes and describes the common methodology applied to all sites.

<u>Background processes</u>

Currents in estuarine and coastal waters are generally driven by one of three mechanisms: 1) Tides, 2) Winds, 3) Density differences.

Tidal flows often dominate water movement over the short term (approximately 12 hours) and move material over the length of the *tidal excursion*. Tides move water back and forth over the tidal period often leading to only a small net movement over the 12 hours tidal cycle. This small net movement is partly associated with the *tidal residual* flow and over a period of days gives rise to persistent movement in a preferred direction. The direction will depend on a number of factors including the bathymetry and direction of propagation of the main tidal wave.

Wind and density driven current also lead to persistent movement of water and are particular important in regions of relatively low tidal velocities characteristic of many of the water bodies in Scottish waters. Whilst tidal flows generally move material in more or less the same direction at all depths, wind and density driven flows often move material in different directions at the surface and at the bed. Typical vertical profiles are depicted in Figure 1. However, it should be understood that in a given water body, movement will often be the sum of all three processes.

In sea lochs, mechanisms such as "wind rows" can transport sources of contamination at the edge of the loch to production areas further offshore. Wind rows are generated by winds directed along the main length of the loch. An illustration of the waters movements generated in this way is given in Figure 2. As can be seen the water circulates in a series of cell that draw material across the loch at right angles to the wind direction. This is a particularly common situation for lochs with high land on either side as these tend to act as a steering mechanism to align winds along the water body.

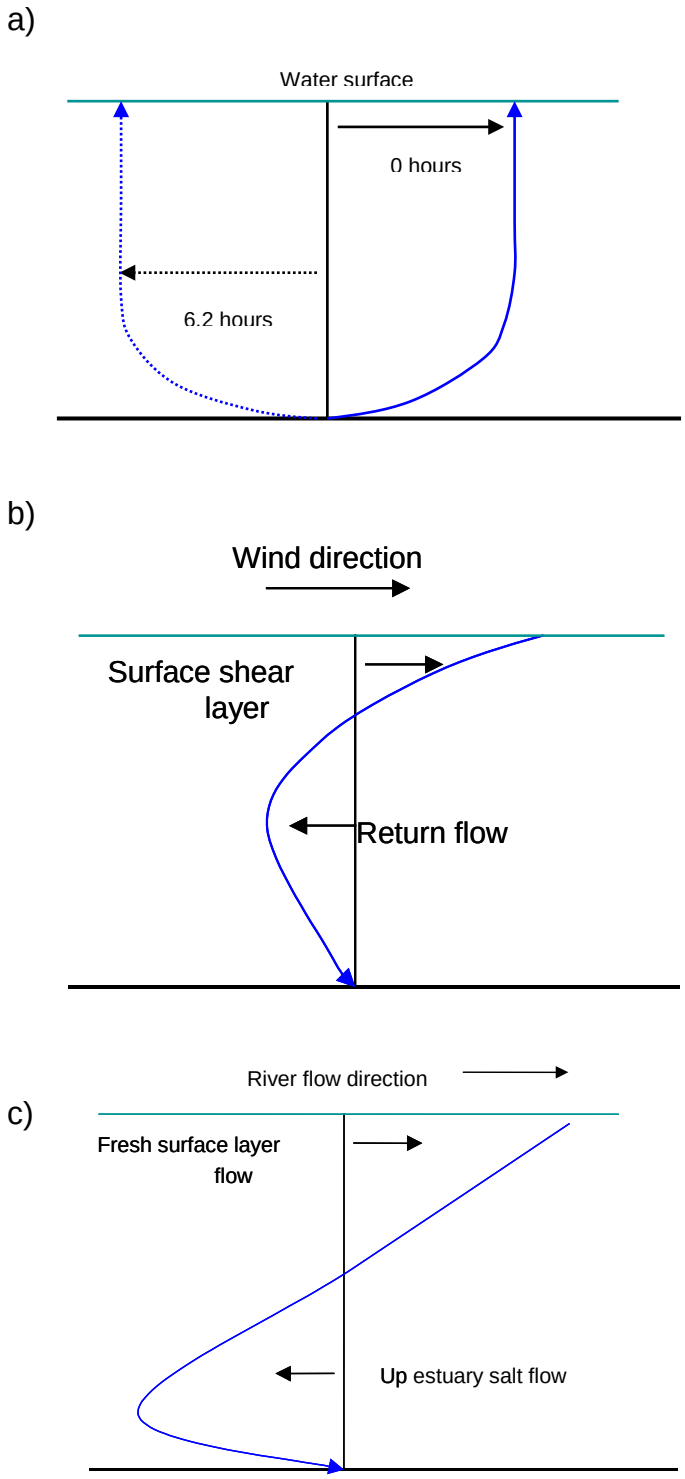

Figure 1. Typical vertical profiles for water currents. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction over a period of 6.2 hours. b) wind driven current profile, c) density driven current profile.

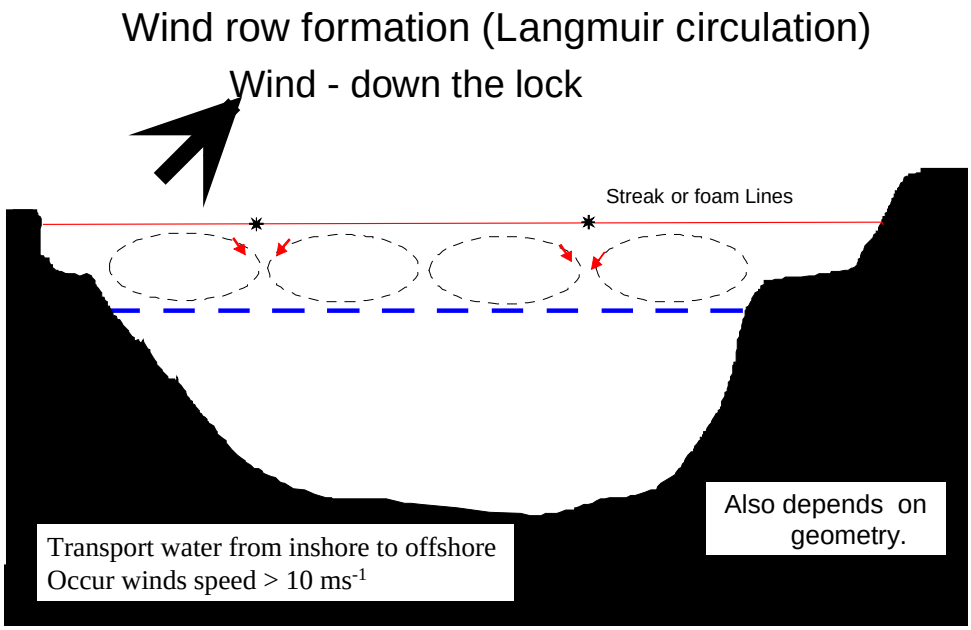

Figure 2. Schematic of wind driven 'wind row' currents. The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

Non-modelling Assessment

In this approach the assessment requires a certain amount of expert judgment and subjectivity enters in. For all production areas, the following general guidelines are used:

1. Near-shore flows will generally align parallel to the shore.
2. Tidal flows are bi-directional, thus sources on either side of a production area are potentially polluting.
3. For tidal flows, the tidal excursion gives an idea of the likely main 'region of influence' around an identified pollutant source.
4. Wind driven flows can drive material from any direction depending on the wind direction. Wind driven current speeds are usually at a maximum when the wind direction is aligned with the principle axis of the loch.
5. Density driven flows generally have a preferred direction.
6. Material will be drawn out in the direction of current, often forming long thin 'plumes'.

Many Scottish shellfish production areas occur within sea lochs. These are fjord-like water bodies consisting of one or more basins, deepened by glacial activity and having relatively shallow sills that control the mixing and flushing processes. The sills are often regions of relatively high currents, while the basins are much more tranquil often containing higher density water trapped below a fresh lower density surface layer. Tidal mixing primarily occurs at the sills.

The catalogue of Scottish Sea Loch produced by the SMBA is used to quantify sills, volume fluxes and likely flow velocities. Because the flow is so constrained by the rapidly varying bathymetry, care has to be used in the extrapolation of direct measurements of current flow. Mean flow velocities can

be estimated at the sills by using estimates of the sill area and the volume change through a tidal cycle. This in turn can be used to estimate the maximum distance travelled in a tidal cycle in the sill area. Away from the sill area, tidal velocities are general low and transport events are dominated by wind or density effects. Sea Lochs generally have a surface layer of fresher water; the extent of this depends on freshwater input, sill depth and quantity of mixing.

In addition to movement of particles by currents, dilution is also an important consideration. Dilution reduces the effect of an individual point source although at the expense of potentially contaminating a larger area. Thus class A production areas can be achieved in water bodies with significant faecal coliform inputs if no transport pathway exists and little mixing can occur. Conversely a poor classification might occur where high mixing causes high and permanent background concentrations arising from many weak diffuse sources.

References

European Commission 1996. Report on the equivalence of EU and US legislation for the Sanitary Production of Live Bivalve Molluscs for Human Consumption. EU Scientific Veterinary Committee Working Group on Faecal Coliforms in Shellfish, August 1996.

Glossary

The following technical terms may appear in the hydrographic assessment.

Bathymetry. The underwater topography given as depths relative to some fixed reference level e.g. mean sea level.

Hydrography. Study of the movement of water in navigable waters e.g. along coasts, rivers, lochs, estuaries.

Tidal period. The dominant tide around the UK is the twice daily one generated by the moon. It has a period of 12.42 hours. For near shore so-called rectilinear tidal currents then roughly speaking water will flow one way for 6.2 hours then back the other way for 6.2 hours.

Tidal range. The difference in height between low and high water. Will change over a month.

Tidal excursion. The distance travelled by a particle over one half of a tidal cycle (roughly~6.2 hours). Over the other half of the tidal cycle the particle will move in the opposite direction leading to a small net movement related to the tidal residual. The excursion will be largest at Spring tides.

Tidal residual. For the purposes of these documents it is taken to be the tidal current averaged over a complete tidal cycle. Very roughly it gives an idea of the general speed and direction of travel due to tides for a particle over a period of several days.

Tidal prism. The volume of water brought into an estuary or sea loch during half a tidal cycle. Equal to the difference in estuary/sea loch volume at high and low water.

Spring/Neap Tides. The strongest tides in a month are called spring tides and the weakest are called neap tides. Spring tides occur every 14 days with neaps tides occurring 7 days after springs. Both tidal range and tidal currents are strongest at Spring tides.

Tidal diamonds. The tidal velocities measured and printed on admiralty charts at specific locations are called tidal diamonds.

Wind driven shear/surface layer. The top metre or so of the surface that generally moves in the rough direction of the wind typically at a speed that is a few percent (~3%)of the wind speed.

Return flow. Often a surface flow at the surface is accompanied by a compensating flow in the opposite direction at the bed (see figure 1).

Stratification. The splitting of the water into two layers of different density with the less dense layer on top of the denser one. Due to either temperature or salinity differences or a combination of both.

Shoreline Survey Report

Production Areas:

Production Area	Site	SIN	Species
South Uist 1	Loch Skipport E	UB 537 966 08	Mussels
South Uist 2	Loch Skipport W	UB 538 967 08	Mussels

Harvester: Ralph Thompson, Whiteshore Cockles Ltd
Local Authority: CnES Council
Status: New application

Date Surveyed: 27/06/2011
Surveyed by: Jessica Larkham – Cefas
Samantha Muir - CnES
Existing RMP: NA
Area Surveyed: See Figure 1.

Weather observations
27/06/2011 – Dry, some clouds, wind 13 mph. Heavy rain previous day.

Specific observations made on site are mapped in Figure 1 and listed in Table 1. Water and shellfish samples were collected at sites marked on Figures 2 and 3. Bacteriology results are given in Tables 2 and 3. Salinity profiles are presented in Table 4. Photographs are presented in Figures 4 – 14.

Fishery
There is currently no equipment or stock on any of the sites. The harvester intends to install twelve long lines at Loch Skipport E, ten long lines at Loch Skipport W and eight long lines at Loch Skipport Site 3. There are plans for five of the long lines at Loch Skipport W to be installed before the end of 2011. The long lines will be 220 m in length with 6 m droppers and the harvester aims to begin harvesting in 2013. The harvester has marked the proposed locations of the sites, South Uist 1 and South Uist 2 using a buoy with a creel basket attached with mussels inside to allow monthly sampling. The Loch Skipport W basket is at a depth of 14 m and the Loch Skipport E basket is at a depth of 20 m.

Sewage/Faecal Sources
Human
There are no large settlements in the area surrounding Loch Skipport and no dwellings were observed in the area during the shoreline survey. A single septic tank and connected outfall pipe was observed during the shoreline survey. The outfall pipe led from the Loch Skipport Marine Harvest workshop, into a septic tank which was open at the top and then out the other side. There was no flow coming out of the outfall pipe at the time of the shoreline survey. In addition to the Marine Harvest workshop, there was a small pier with 5 fishing boats moored nearby and an additional outbuilding.

Livestock
Large number of sheep droppings, horse manure and pony tracks were observed along most of the western coastline of Loch Skipport. Approximately 6 ponies in total were observed on the western shoreline and approximately 14 sheep in total were observed from the boat on the northern shoreline.

Seasonal Population
There was no tourist accommodation in the area surrounding Loch Skipport. On the day of the shoreline survey, two caravans were observed parked in the area, along with 4 other cars. Large numbers of walkers were present.

Boats/Shipping
There were 5 small fishing boats moored of the pier at the Loch Skipport Marine Harvest boat yard. On site at the Loch Skipport Marine Harvest Fish Farm there was one working boat and a barge which is presumed to stay on site.

Land Use
The land on the western side of Loch Skipport is used in places for livestock grazing.

The land cover surrounding Loch Skipport is predominantly dense heath land and bog land.

Wildlife/Birds
During the shoreline survey, 1 gannet and 7 herons were observed on the western shoreline and 1 otter was observed on the southern shoreline.

Recorded observations apply to the date of survey only. Animal numbers were recorded on the day from the observer's point of view. This does not necessarily equate to total numbers present as natural features may obscure individuals and small groups of animals from view.

Dimensions and flows of watercourses are estimated at the most convenient point of access and not necessarily at the point at which the watercourses enter the sound.

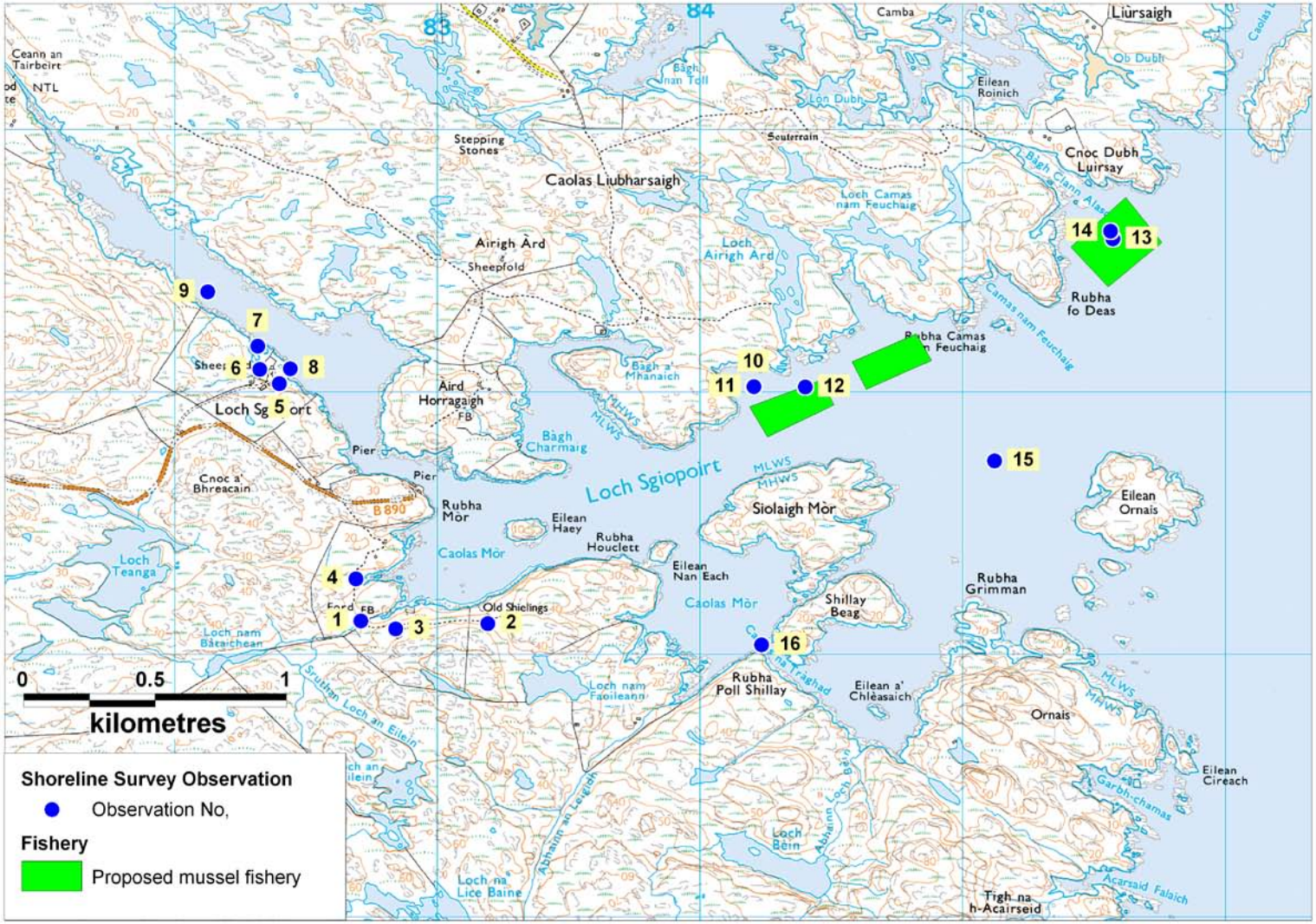

Figure 1. Shoreline Observations

Table 1 Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	27/06/2011	11:14	NF 82709 38132	82709	838132	Figure 4	LSFW1	Stream, W 0.80 m, D 0.18 m, Flow 0.244 m/s, S.D 0.009, location of fresh water sample LSFW1
2	27/06/2011	11:29	NF 83193 38122	83193	838122			Large amount of horse manure on shoreline, 1 gannet
3	27/06/2011	11:34	NF 82842 38102	82842	838102	Figure 5		2 ponies and 1 foal next to derelict outbuilding
4	27/06/2011	11:38	NF 82690 38293	82690	838293	Figure 6	LSFW2	Stream, W 0.38 m, D 0.14 m, Flow 0.045 m/s, S.D 0.037, location of fresh water sample LSFW2
5	27/06/2011	11:57	NF 82399 39036	82399	839036	Figures 7 – 9		Loch Skipport Marine Harvest workshop located next to pier. 5 fishing boats moored off the shoreline.
6	27/06/2011	12:02	NF 82324 39090	82324	839090	Figure 10	LSFW3	Stream, W 0.30 m, D 0.20 m, Flow 0.127 m/s, S.D 0.005, location of fresh water sample LSFW3. Sheep droppings all along the shoreline
7	27/06/2011	12:11	NF 82317 39178	82317	839178		LSSW1	Location of sea water sample LSSW1. Manure on shoreline and next to river sampled previously, many pony tracks
8	27/06/2011	12:19	NF 82440 39093	82440	839093	Figures 11 – 13		Pipe covered in concrete leading from Marine Harvest Workshop to a septic tank with no cover. Outfall pipe leading out other side of septic tank on to the shoreline, no flow
9	27/06/2011	12:43	NF 82126 39385	82126	839385		LSSW2	Location of sea water sample LSSW2. 7 herons on shoreline (3 stationary, 4 flying away), 3 ponies on shoreline
10	27/06/2011	12:55	NF 84204 39024	84204	839024		LSMUSSEL1, LSSW3	Location of proposed fishery - Loch Skipport W. Location of mussel sample LSMUSSEL 1, taken from a creel basket hung a 14 m from the end of a buoy. Location of sea water sample LSSW3
11	27/06/2011	12:57	NF 84206 39024	84206	839024			Location of salinity profile 1
12	27/06/2011	13:05	NF 84401 39023	84401	839023			6 sheep on shoreline
13	27/06/2011	13:10	NF 85573 39587	85573	839587			8 sheep on shoreline
14	27/06/2011	13:11	NF 85564 39616	85564	839616		LSMUSSEL2, LSSW4	Location of proposed fishery - Loch Skipport E. Location of mussel sample LSMUSSEL 2, taken from a creel basket hung a 20 m from the end of a buoy. Location of sea water sample LSSW4 and salinity profile 2
15	27/06/2011	13:22	NF 85122 38742	85122	838742	Figure 14		Location of Marine Harvest Salmon Farm, 1 working boat and 1 barge on site
16	27/06/2011	13:27	NF 84235 38041	84235	838041			1 otter on shoreline

Photographs referenced in the table can be found attached as Figures 4 – 14.

Sampling

Water and shellfish samples were collected at sites marked on the maps in Figures 2 and 3 respectively. Bacteriology results follow in Tables 2 and 3. Samples were transferred to a Biotherm 25 box with ice packs and shipped to Glasgow Scientific Services via air freight on the 28th June for *E. coli* analysis. Samples were received by the laboratory on the same day as shipping. The box temperature on arrival was 4.6˚C, which was within the recommended temperature range of 2-8˚C. The National Reference Laboratory (NRL) undertook a study on the effect of temperature and time of storage on levels of *E. coli* in shellfish and found no significant effect with up to 48 hours' storage at temperatures ≤10˚C.

Samples of seawater were tested for salinity by the laboratory using a salinity meter under controlled conditions. These results are shown in Table 2, given in units of grams salt per litre of water. Note that this is equivalent to ppt.

Table 2. Water sample *E. coli* results

No.	Sample Ref.	Date	Position	Type	*E. coli* (cfu/100 ml)	Salinity (g/L)
1	LSSW1	27/06/2011	NF 82317 39178	Sea water	0	20.9
2	LSSW2	27/06/2011	NF 82126 39385	Sea water	10	20.3
3	LSSW3	27/06/2011	NF 84204 39024	Sea water	0	36.0
4	LSSW4	27/06/2011	NF 85564 39616	Sea water	0	36.5
5	LSFW1	27/06/2011	NF 82709 38132	Fresh water	<100	
6	LSFW2	27/06/2011	NF 82690 38293	Fresh water	<100	
7	LSFW3	27/06/2011	NF 82324 39090	Fresh water	<100	

Table 3. Shellfish sample *E. coli* results

No.	Sample Ref.	Date	Position	Site	Species	Depth (m)	*E. coli* MPN/100 g
1	LSMUSSEL1	27/06/2011	NF 84204 39024	Loch Skipport W	Mussels	14 m	<20
2	LSMUSSEL2	27/06/2011	NF 85564 39616	Loch Skipport E	Mussels	20 m	50

Table 4. Salinity profiles

Profile	Date	Time	Position	Depth (m)	Salinity (ppt)
1	27/06/2011	12:57	NF 84206 39024	<1	34.65
				2	34.7
				4	34.92
				6	34.92
				8	34.94
				10	34.92
2	27/06/2011	13:11	NF 85564 39616	<1	34.92
				2	34.92
				4	34.92
				6	34.92
				8	34.95
				10	34.95

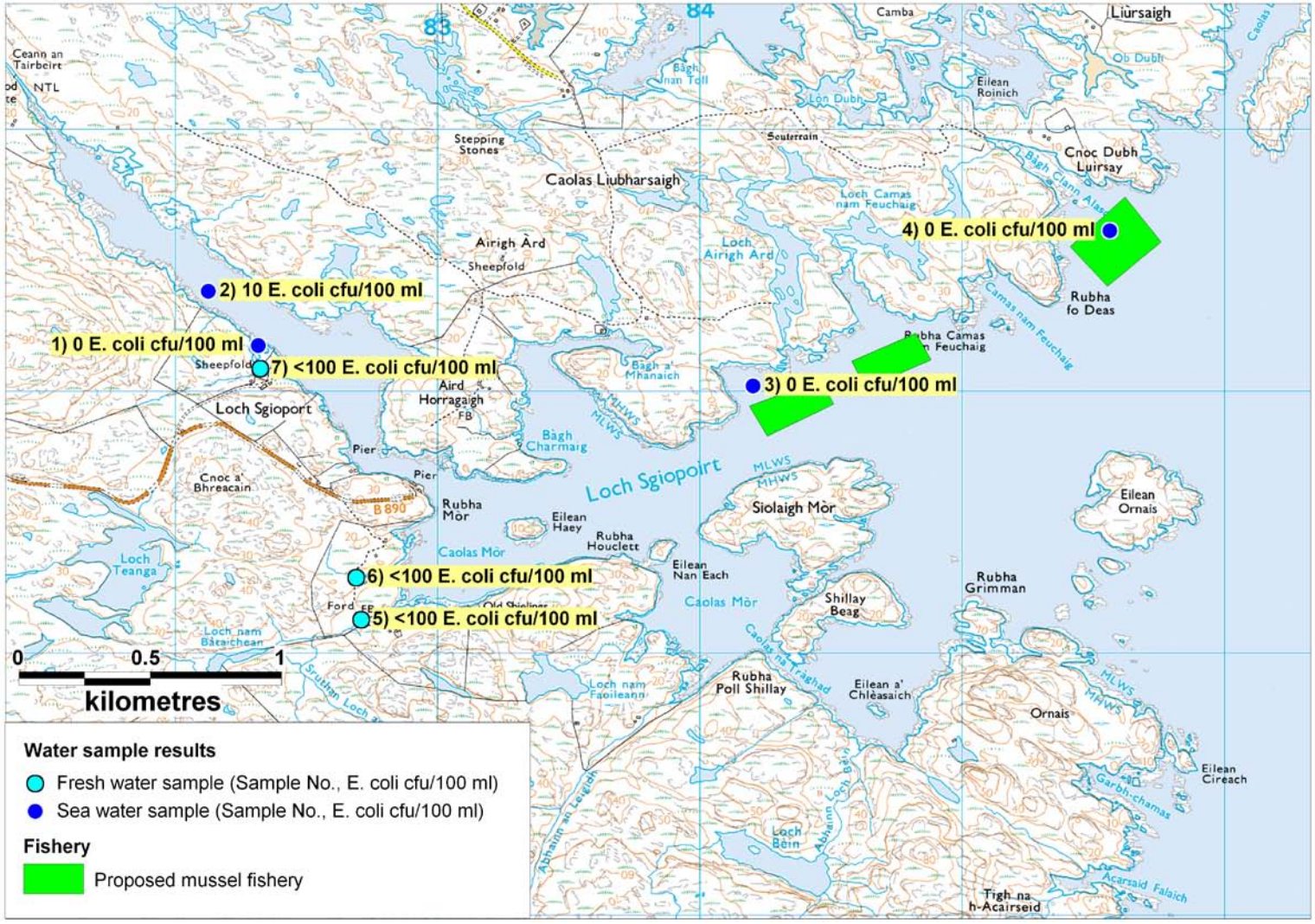

Figure 2. Water sample results

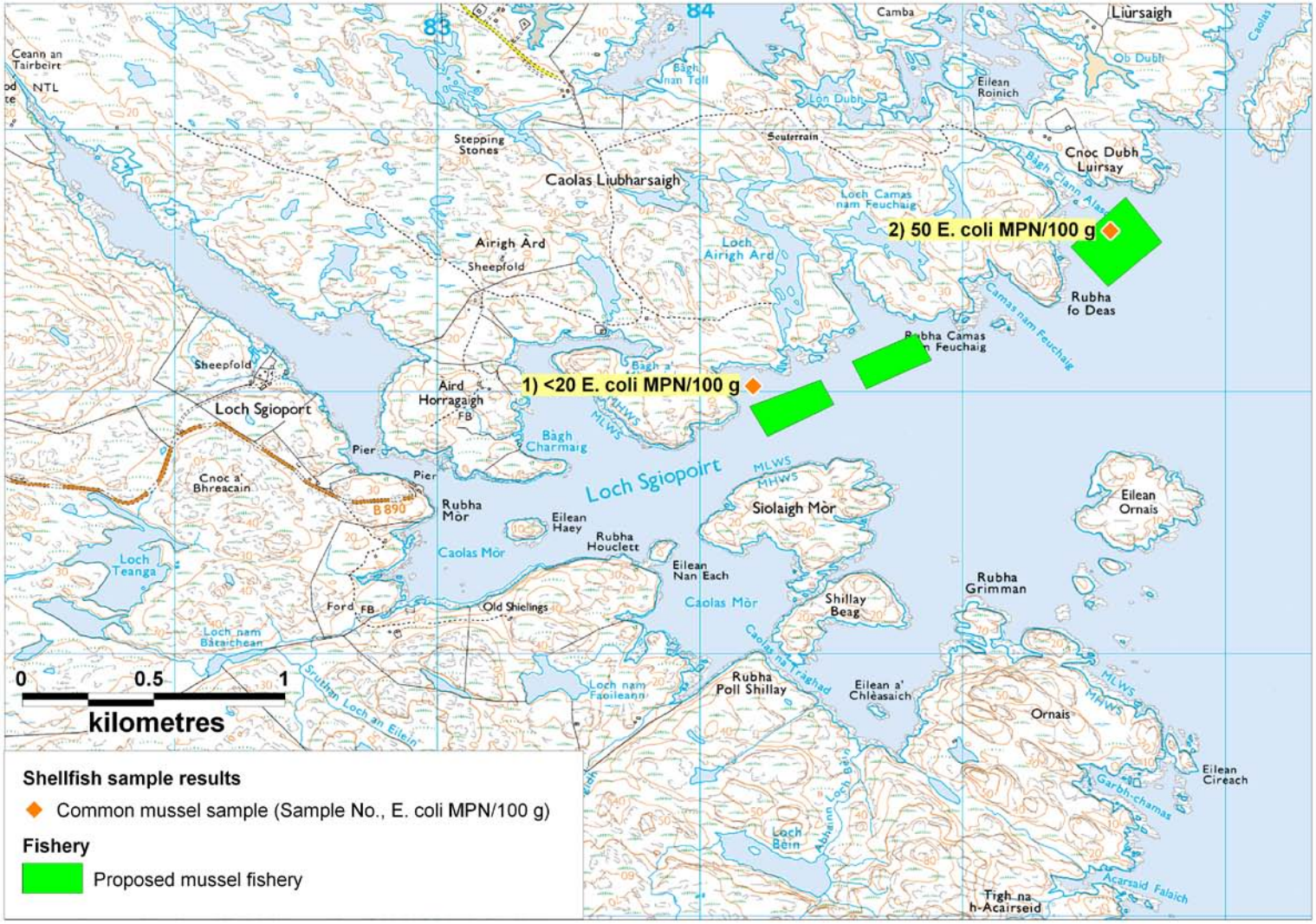

Figure 3. Shellfish sample results

Photographs

Figure 4. Stream, location of fresh water sample LSFW1

Figure 5. Ponies on western shoreline of Loch Skipport

Figure 6. Stream, location of fresh water sample LSFW2

Figure 7. Loch Skipport Marine Harvest workshop

Figure 8. Outbuilding and machinery at Loch Skipport and Marine Harvest boatyard

Figure 9. Fishing boats moored off the pier at Loch Skipport Marine Harvest boatyard

Figure 10. Stream, location of fresh water sample LSFW3

Figure 11. Outfall pipe covered in concrete leading from workshop

Figure 12. Open septic tank leading from workshop

Figure 13. Dry outfall pipe leading from workshop septic tank

Figure 14. Loch Skipport Marine Harvest Fish Farm with working boat on site