Scottish Sanitary Survey Programme

Sanitary Survey Report
Production Area: North Uist 2
SIN: UB 540
July 2011

Cefas

Food Standards Agency
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Buidheann Inbhe-Bìdhe

Report Distribution – North Uist 2

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I. Executive Summary

The North Uist 2 shellfish production area lies in Loch nam Madadh, on the east side of the island of North Uist, in the outer Hebrides. Loch nam Madadh is a complex fjardic sea loch and locally known for its wildlife and conservation interest. A sanitary survey was undertaken in response to the application to classify the site for production of common mussels (*Mytilus* sp).

At the time of survey, no equipment for production of mussels had been put in place on the site, though a creel of mussels had been placed on the proposed site for the purposes of sampling. The proposed site is a long-line aquaculture farm and will eventually comprise 8 long-lines installed on the location of the seabed lease on the eastern side of the loch, south of Loch Portain.

There is relatively little human population in the immediate vicinity of the proposed farm. Of the point sources identified, the largest were located at Lochmaddy. Septic tank discharges to the loch included both public and private septic tank discharges serving homes, a medical centre, a hotel, and a livestock mart, as well as the ferry terminal. These discharges lie 4 km southwest of the proposed farm and contaminant movement around the area is predicted to be low. The discharges at Loch Portain, though smaller, lie much closer to the fishery and therefore may have more impact on faecal indicator bacteria levels at the fishery.

Much of the land in the area is rough moorland and bog, with crofts lining the north shore of Loch Portain and also along the east shore of Loch nam Madadh to the north of Lochmaddy village. Diffuse contamination from livestock is most likely to arise in these areas, and may contribute to background levels of contamination at the fishery. Wildlife species, particularly geese and seals, are likely to contribute to background levels of faecal contamination around the fishery.

Movement of contaminants within Loch nam Madadh is expected to be limited by relatively slow current speeds and the presence of a number of sills and basins within the loch. There is some indication that transport at the surface and at depth may differ markedly in the outer loch and potentially at the fishery. Therefore, different sources may affect contamination levels at the surface than at depth.

As the mussel farm had not yet been established at the time of the survey, and it was not possible to obtain samples representative of contamination levels across the proposed mussel site, a bacteriological survey should be carried out after equipment has been installed in order to evaluate variation in contamination levels in mussels grown on the site. This may be undertaken using bagged shellfish hung at different depths from the longlines to ensure that the survey is complete and an RMP established prior to first harvest.

II. Sampling Plan

PRODUCTION AREA	North Uist 2
SITE NAME	Lochmaddy
SIN	UB 540 969 08
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	Comhairle nan Eilean Siar
AUTHORISED SAMPLER(S)	Samantha Muir
LOCAL AUTHORITY LIAISON OFFICER	Samantha Muir

III. Report

1. General Description

The North Uist 2 shellfish site is located in Loch nam Madadh (Lochmaddy), which is situated on the east coast of the island of North Uist, in the Outer Hebrides. Loch nam Madadh is a complex, fjardic sea loch. Its upper reaches are composed of a number of small lochs and islands. The surrounding area is sparsely populated, except for the village of Lochmaddy and the settlement of Lochportain. As the village and loch have the same name, throughout this report the village will be referred to in the English spelling of Lochmaddy and the loch in the Gaelic spelling as Loch nam Madadh. There are no harbours or marinas in the surrounding area, however there is a ferry terminal south of Lochmaddy.

This survey was undertaken in response to an application submitted to the Food Standards Agency in Scotland for classification of the North Uist 2 site for common mussels.

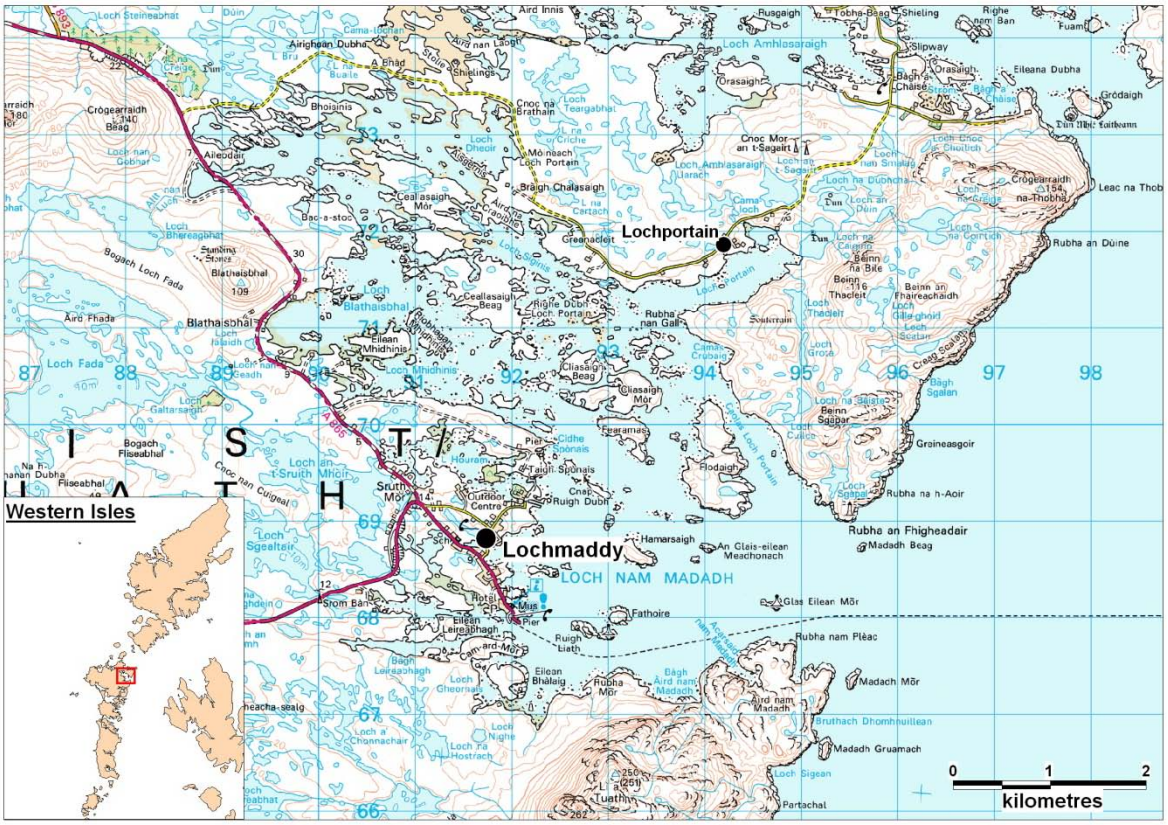

Figure 1.1 Location of Loch nam Madadh

2. Fishery

At the time of shoreline survey, no equipment had yet been installed on site. The harvester identified that he intended to install eight 220 m long lines with 6 m droppers, with an aim to begin harvesting in 2013. A buoy with a creel basket of mussels was set out on the site to allow monthly sampling to commence prior to installation of the longlines. The basket was set at a depth of 14 m and its location is shown mapped in Figure 2.1. A Crown Estate lease was issued for the area, which is identified in Figure 2.1, and the mussel farm is to be situated within the lease area boundaries. The sampling officer identified that as of 19 October 2011, equipment had still not been installed on site.

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Figure 2.1 North 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 Lochmaddy. The last census was undertaken in 2001.

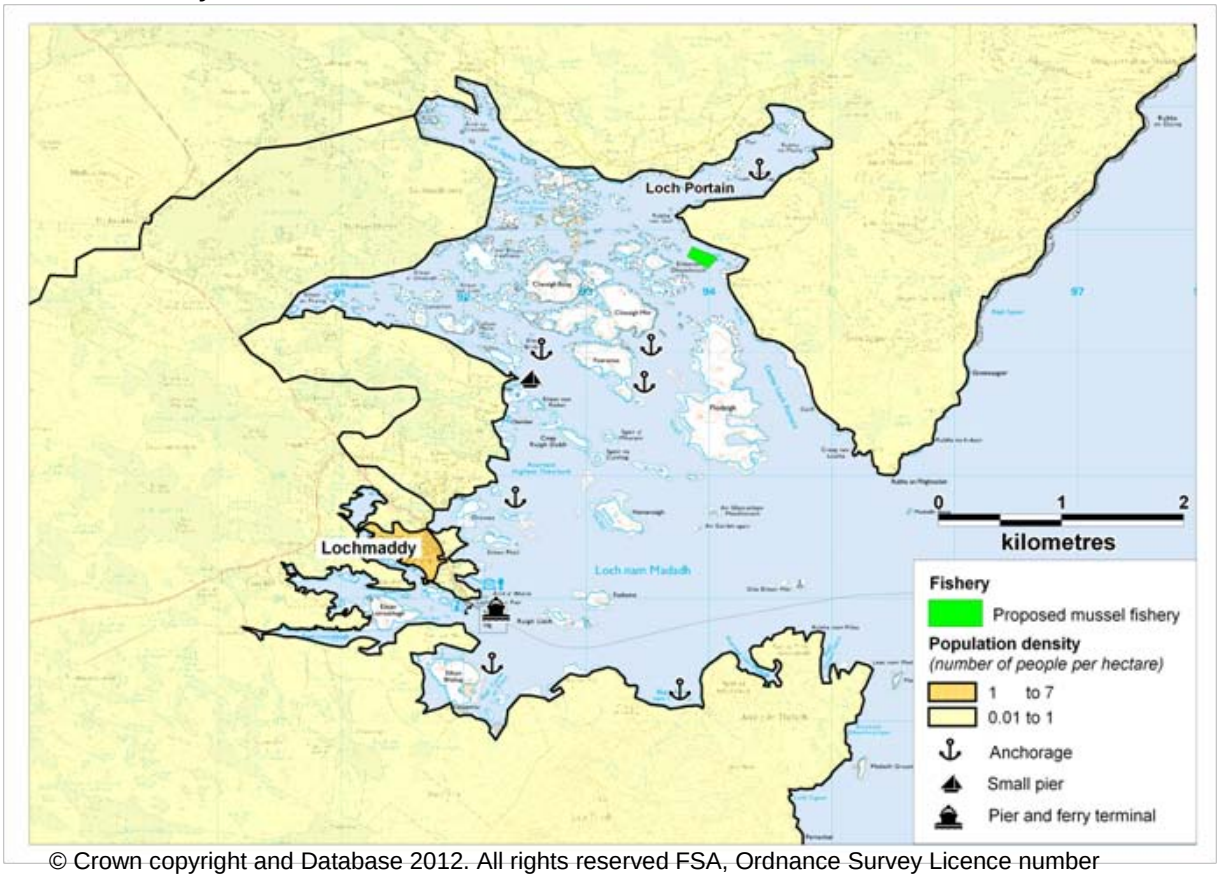

Figure 3.1 Population map of Loch nam Madadh

The population density for the census output areas surrounding Loch nam Madadh is low. The area has two settlements: Lochmaddy, which is the largest centre of population in North Uist, and Lochportain. The population is spread amongst three census output areas, listed in Table 3.1. Despite the large geographic area covered by these three census areas, the majority of the population is located in or near Lochmaddy.

Table 3.1 Census output areas: Loch nam Madadh

Output area	Population
60RJ000031	106
60RJ000032	56
60RJ000033	90
60RJ000034	79
Total	**225**

The ferry terminal at Lochmaddy provides a daily service to Uig and consists of a small pier and a visitor's centre with cafe and public toilets. Visitor accommodation in Lochmaddy is provided for up to 75 people in hotels, B&Bs

and a hostel. In addition, some of the homes in the area are used as self-catering accommodation.

Lochportain is a smaller settlement to the north of the fishery. It lies in a large census output area with other small settlements, therefore only a proportion of the total population of 106 is likely to reside along the north shore of Loch Portain.

Visiting yachts are accommodated in 7 identified anchorages in the wider area of Loch nam Madadh, which are also more likely to be utilised in the summer months.

Based on the visitor accommodation identified in the area, there is the potential for the population around the loch to increase by up to 50% during the summer tourist season and therefore any impacts to water quality from human sources are likely to increase during the summer months.

4. Sewage Discharges

Information on discharges of sewage to the area around Loch nam Madadh was sought from Scottish Water and the Scottish Environment Protection Agency (SEPA). Human sewage discharges are considered to pose a higher risk of contamination with human pathogens than discharges containing solely animal waste. Scottish Water identified community septic tanks and sewage discharges as detailed in Table 4.1.

Table 4.1 Discharges identified by Scottish Water

Consent Ref No.	NGR of discharge	Discharge Name	Discharge Type	Level of Treatment	Consented flow m^3/day	Consented Design PE
CAR/L/1004169	NF 917 687	Lochmaddy 1	Continuous	Septic tank	21	100
CAR/L/1004168	NF 919 683	Lochmaddy 2	Continuous	Septic tank	50	265
CAR/S/1018638	NF 920 680	Lochmaddy 3*	Continuous	Septic tank	not stated	not stated

* Noted as being a small septic tank at pier with 2 houses connected

No sanitary or microbiological data were available for these discharges. All three discharge to sea approximately 3 km southwest of the fishery.

Consents for discharges provided by SEPA are listed in Table 4.2. Two consents were received for marine cage fish farm effluent, however as this contains no faecal indicator bacteria, the consents are not listed in the table below. Their locations are indicated on the map in Figure 4.1 for reference.

Table 4.2 Discharge consents identified by SEPA

No.	Ref No.	NGR of discharge	Discharge Type	Level of Treatment	Consented flow (DWF) m^3/d	Consented/ design PE	Discharges to
1	CAR/S/1018638	NF 9204 6796	STW FE	not stated	1*	27	Lochmaddy
2	CAR/R/1049564	NF 9204 6809	Animal waste STE	Septic tank	-	5	Lochmaddy
3	CAR/R/1049560	NF 9202 6813	Toilet STE	Septic tank	-	5	Lochmaddy
4	CAR/R/1030595	NF 9195 6817	Hotel STE	Septic tank	-	23	Lochmaddy
5	CAR/L/1004168	NF 9191 6834	STE	Septic tank	not given	not given	Lochmaddy
6	CAR/R/1073279	NF 9187 6837	STE	Septic tank	-	5	Lochmaddy
7	CAR/L/1004169	NF 9180 6870	STE	Septic tank	not given	not given	Lochmaddy
8	CAR/R/1059862	NF 9187 6875	STE	Septic tank	-	7	Strom na Fuirneis
9	CAR/R/1059781	NF 9189 6877	STE	Septic tank	-	5	Lochmaddy
10	CAR/R/1049542	NF 9177 6875	STE	Septic tank	-	8	Soakaway
11	CAR/R/1056997	NF 9183 6879	STE	Septic tank	-	5	Strom na Fuirneis
12	CAR/R/1047650	NF 9193 6886	NHS surgery, STE	Septic tank	-	6	Strom na Fuirneis
13	CAR/R/1067751	NF 9187 6901	STE	Septic tank	-	8	Soakaway
14	CAR/R/1049142	NF 9192 6907	STE	Septic tank	-	5	Soakaway
15	CAR/R/1042678	NF 9161 6898	STE	Septic tank	-	5	Soakaway
16	CAR/R/1068513	NF 9157 6900	STE	Septic tank	-	6	Loch an Rubha Iar
17	CAR/R/1042682	NF 9157 6893	STE	Septic tank	-	7	Soakaway
18	CAR/R/1021056	NF 9146 6871	STE	Septic tank	-	5	Soakaway
19	CAR/R/1064706	NF 9135 6884	STE	Septic tank	-	5	Ob nan Stearnain
20	CAR/R/1064679	NF 9124 6891	STE	Septic tank	-	5	Ob nan Stearnain
21	CAR/R/1065226	NF 9130 6894	STE	Septic tank	-	5	Soakaway
22	CAR/R/1064766	NF 9134 6901	STE	Septic tank	-	5	Loch an Rubha Iar
23	CAR/R/1064699	NF 9132 6904	STE	Septic tank	-	5	Loch an Rubha

No.	Ref No.	NGR of discharge	Discharge Type	Level of Treatment	Consented flow (DWF) m^3/d	Consented/ design PE	Discharges to
							Iar
24	CAR/R/1064762	NF 9118 6896	STE	Septic tank	-	5	Ob nan Stearnain
25	CAR/R/1059968	NF 9113 6903	STE	Septic tank	-	5	Soakaway
26	CAR/R/1073245	NF 9080 6868	STE	Septic tank	-	5	Soakaway
27	CAR/R/1078917	NF 9071 6888	STE	Septic tank	-	6	Loch Strumore
28	CAR/R/1059963	NF 9077 6902	STE	Septic tank	-	5	Soakaway
29	CAR/R/1059961	NF 9083 6908	STE	Septic tank	-	5	U/T of Loch Strumore
30	CAR/R/1075208	NF 9095 6909	STE	Septic tank	-	5	Soakaway
31	CAR/R/1073251	NF 9115 6931	STE	Septic tank	-	5	Soakaway
32	CAR/R/1032038	NF 9092 6929	STE	Septic tank	-	5	Soakaway
33	CAR/R/1058211	NF 9090 6943	STE	Septic tank	-	6	Soakaway
34	CAR/R/1057042	NF 9089 6950	STE	Septic tank	-	5	Loch Houram
35	CAR/R/1047922	NF 9077 6946	STE	Septic tank	-	5	Soakaway
36	CAR/R/1051518	NF 9064 6955	STE	Septic tank	-	5	Land
37	CAR/R/1059662	NF 9079 6960	STE	Septic tank	-	5	Loch Houram
38	CAR/R/1047680	NF 9066 6972	STE	Septic tank	-	5	Loch Houram
39	CAR/R/1073260	NF 9209 6974	STE	Septic tank	-	5	Soakaway
40	CAR/R/1056480	NF 9202 7240	STE	Septic tank	-	5	Land
41	CAR/R/1057603	NF 9260 7191	STE	Septic tank	-	15	Soakaway
42	CAR/R/1076160	NF 9280 7169	STE	Septic tank	-	5	Soakaway
43	CAR/R/1042878	NF 9321 7156	STE	Septic tank	-	6	Soakaway
44	CAR/R/1066704	NF 9352 7155	STE	Septic tank	-	5	Soakaway
45	CAR/R/1057102	NF 9371 7145	STE	Septic tank	-	6	Soakaway
46	CAR/R/1048810	NF 9404 7165	STE	Septic tank	-	5	Loch Portain
47	CAR/R/1047644	NF 9416 7181	STE	Septic tank		5	Soakaway
48	CAR/R/1058722	NF 9435 7185	STE	Septic tank		7	Soakaway
49	CAR/R/1056602	NF 9463 7204	STE	Septic tank	-	5	Loch Portain
50	CAR/R/1041646	NF 9464 7212	STE	Septic tank		10	Soakaway

* Mean daily flow (m^3/day)

The first listed consent (CAR/S/1018638) pertains to the Scottish Water septic tank at the ferry pier. No consent details were provided for the other two Scottish Water discharges, however information on consented flow was provided by Scottish Water.

Items 2 and 3 in Table 4.2 relate to discharge from the Lochmaddy livestock auction market, which only operates seasonally. A septic tank was installed to treat wash effluent from holding pens, with a separate tank for toilet facilities at the mart. This facility is used primarily during the autumn.

Item 12 relates to a septic tank associated with the NHS surgery, which discharges to a small inlet off Loch nam Madadh at the northern end of Lochmaddy village. This surgery provides dental and GP services to the population of North Uist.

Half of the consents are for discharge to soakaway, a few of which are situated within 20 m of the shore. Given the low elevation and proximity to the mean high water line, these discharges may contribute to background levels of faecal contamination in seawater within the local area. Three discharges to soakaway are located within 1km of the lease area, the nearest of which lies

at MHWS and therefore may affect water quality in the near vicinity. Given the small size of the discharge, any effect is likely to be highly localised.

Sewage infrastructure recorded during the shoreline survey is listed in Table 4.3.

Table 4.3 Discharges and septic tanks observed during shoreline surveys

No.	Date	NGR	Description
1	28/06/2011	NF 92055 67974	Possible location of Scottish Water Lochmaddy No.3 septic tank at ferry terminal. Two concrete structures, that might be related to it, no visible pipes
2	28/06/2011	NF 91934 68278	Taigh Chearsbhagh centre with cafe, shop, toilets. Outfall pipe leading down from centre to shoreline, very little flow
3	28/06/2011	NF 91854 68334	4 pipes leading under road into small bay, no flow visible from any
4	28/06/2011	NF 91917 68400	Location of Scottish Water Lochmaddy No.2 septic tank
5	28/06/2011	NF 91759 68723	Inspection cover and outfall pipe next to wall, probably connected to the Scottish Water Lochmaddy No.1 septic tank on the otherside of the road
6	28/06/2011	NF 91737 68701	Location of Scottish Water Lochmaddy No.1 septic tank , large concrete area with two inspection covers set in it and another on the grass next to it, no outfall pipes
7	28/06/2011	NF 91826 68747	Pipe covered in concrete slabs with pipe leading onto the shoreline, no flow
8	28/06/2011	NF 91825 68746	Broken pipe, no flow

The largest proportion of discharges is associated with the settlement of Lochmaddy. Despite the presence of the public sewerage system, a significant number of properties appear to have private septic tanks. Based on the amount of holiday accommodation present in the area, the peak population in the area during the main summer tourist season is likely to be approximately 350-370. Most of the increase in population, and hence the increase in discharged sewage, will be concentrated around Lochmaddy.

The discharge from the NHS surgery may be more likely to contain human enteric pathogens than the other discharges due to the likelihood of ill people visiting the surgery. As this lies approximately 3 km from the fishery, it is not expected to pose a significant risk to the bacteriological quality of the shellfish.

However, enteric viruses may persist longer than bacteria in the environment and therefore the potential for contamination of the fishery with human viruses, such as norovirus, will depend on water movement around the loch and the fishery.

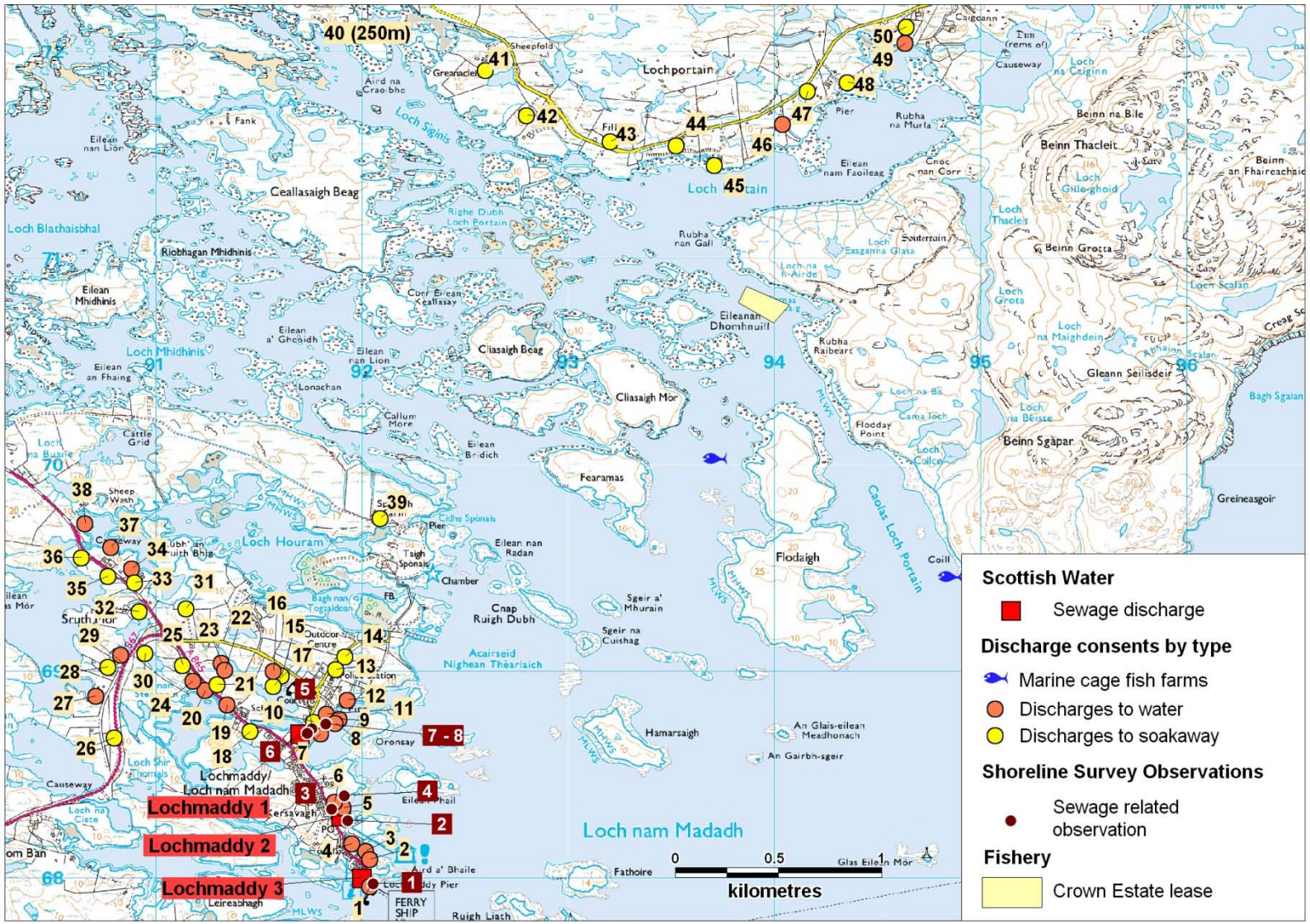

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Figure 4.1 Map of discharges for North Uist 2

5. Geology and Soils

Geology and soil types were assessed following the method described in Appendix 1. A map of the resulting soil drainage classes is shown in Figure 5.1. Areas shaded red and orange indicate poorly draining soils.

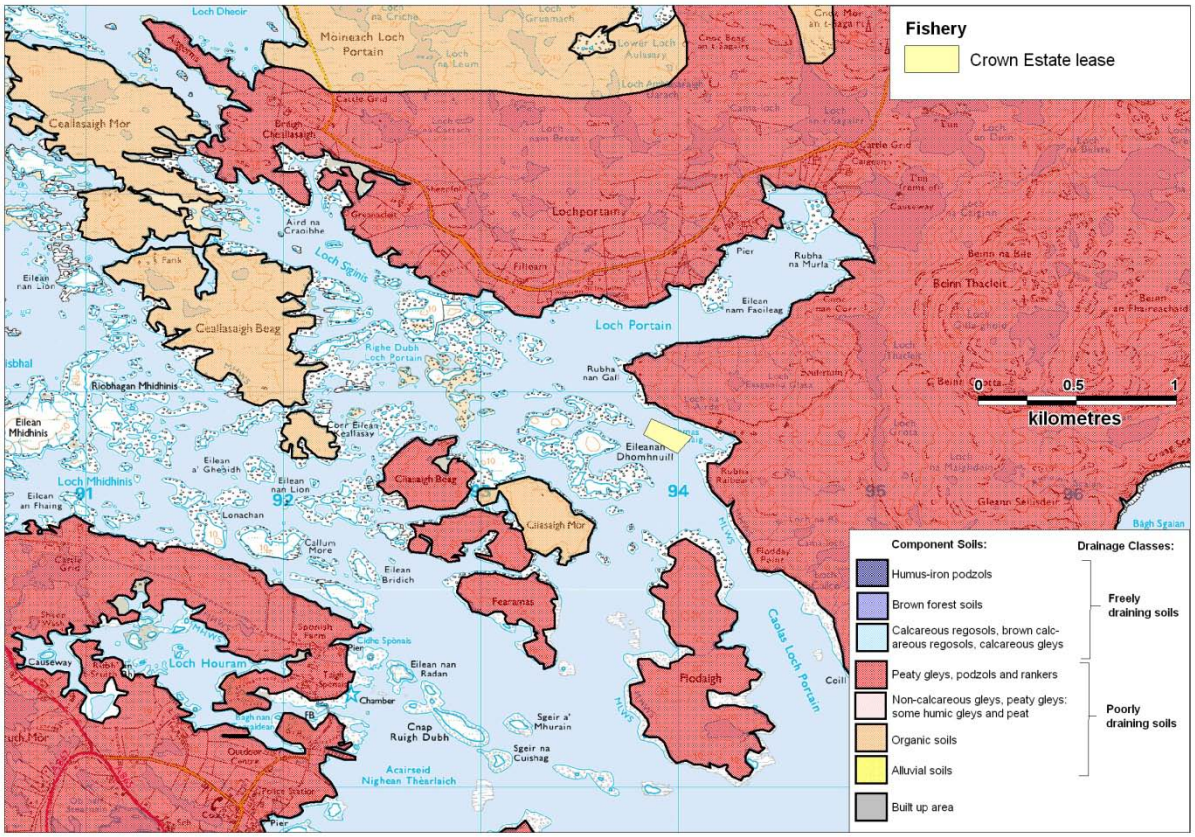

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Figure 5.1 Component soils and drainage classes for Loch nam Madadh

The two types of component soil found in the area are composed primarily of peaty gleys, podzols and rankers and organic soils. Both types of soils are classed as poorly draining. Therefore, the potential for runoff contaminated with *E. coli* from human and/or animal waste is relatively high along the entire coastline of Loch nam Madadh.

6. Land Cover

Land Cover Map 2000 data for Loch nam Madadh is shown in Figure 6.1 below:

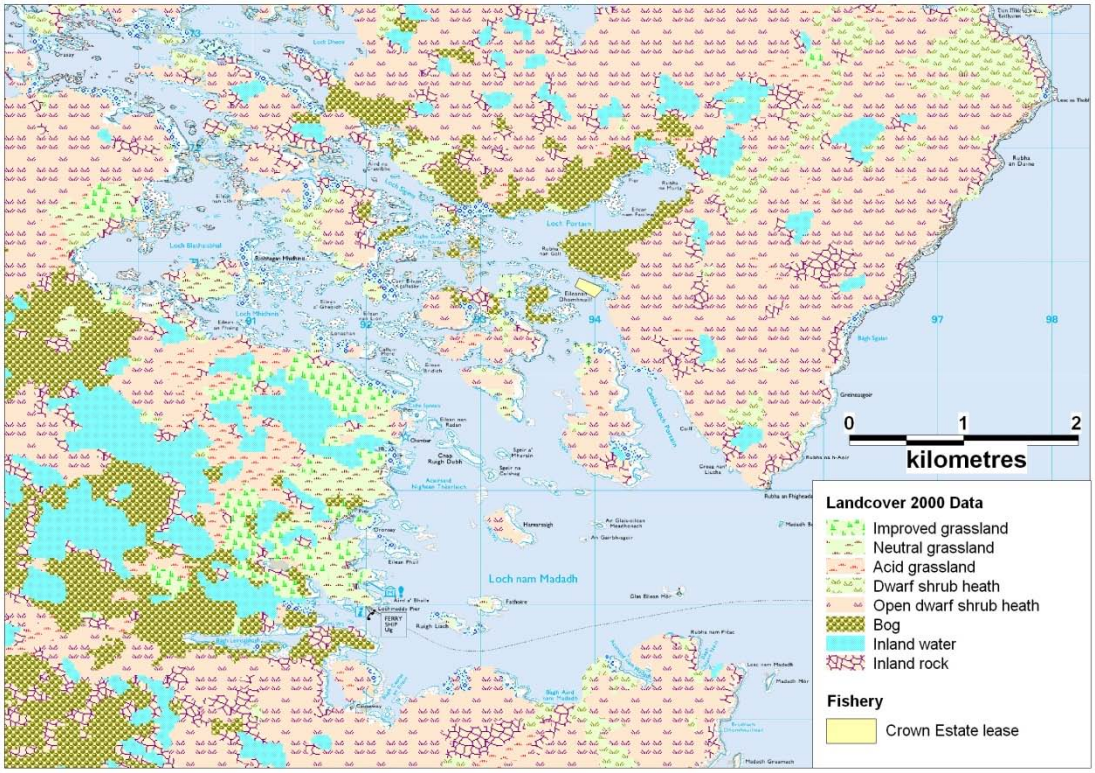

Figure 6.1 LCM2000 class land cover data for Loch nam Madadh

The land immediately adjacent to the fishery and Loch Portain is predominantly classed as bog and open dwarf shrub heath with some areas of supra-littoral rock. Areas of improved grassland and natural (either neutral or acid) grassland are found along the western shore to the southwest of the fishery. Most of the land cover types in the area are likely to be used to some extent for rough grazing.

Faecal indicator organism export coefficients for faecal coliform bacteria have been found to be approximately 8.3×10^8 cfu km^{-2} hr^{-1} for areas of improved grassland and approximately 2.5×10^8 cfu km^{-2} hr^{-1} for rough grazing (Kay et al. 2008). The contributions from all land cover types would be expected to increase significantly after rainfall events, however this effect would be particularly marked from improved grassland areas (roughly 1000-fold) (Kay et al. 2008).

Although not identified specifically in the land cover data, the settlement of Lochmaddy would constitute a developed area though the extent of its coverage is very low relative to the remainder of the area around it. Therefore the potential for the highest contribution of faecal coliform bacteria attributable to land cover type is greatest along the western shore in and around the settlement of Lochmaddy, where there are both developed areas and improved grassland and lower for the area of bog adjacent to the fishery.

7. Farm Animals

Agricultural census data to parish level was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for North 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. The data for horses and ponies presented below represents the summation of numbers provided for the categories 'Horses used in Agriculture' and 'Other horses and ponies'. A further livestock category, 'Livestock other', has not been considered here.

Table 7.1 Livestock numbers in North Uist parish 2009 - 2010

	North Uist 431 km^2			
	2009		2010	
	Holdings	Numbers	Holdings	Numbers
Pigs	*	*	*	*
Poultry	49	649	46	624
Cattle	80	2117	88	2252
Sheep	227	23256	207	23723
Deer	0	0	*	*
Horses and ponies	8	37	5	28

Sheep and cattle are the predominant livestock animals kept on North Uist. 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.

The Lochmaddy livestock mart is located south of Lochmaddy village and handled 770 cattle and 7,000 sheep in 2009/10 (CnES, 2010). It serves Uist, Benbecula, and South Harris and therefore would draw livestock from across a wider region than that adjacent to the fishery. Washings from the livestock pens goes to septic tank and this is addressed specifically in Section 4.

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.

Observations during the shoreline survey of sheep along the north shore of Loch Portain are consistent with the use of the area for crofting. Animals are likely to be present in the area for much of the year. A small number of sheep

were observed on moorland to the south of the proposed mussel farm. No cattle were observed during the survey, and no livestock were observed at Lochmaddy, although land cover data and OS mapping shows areas likely to be in agricultural use. Livestock counts taken during the shoreline survey relate only to the time of the site visit on 28-29 June, 2011 and are dependent upon the observer's viewpoint.

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

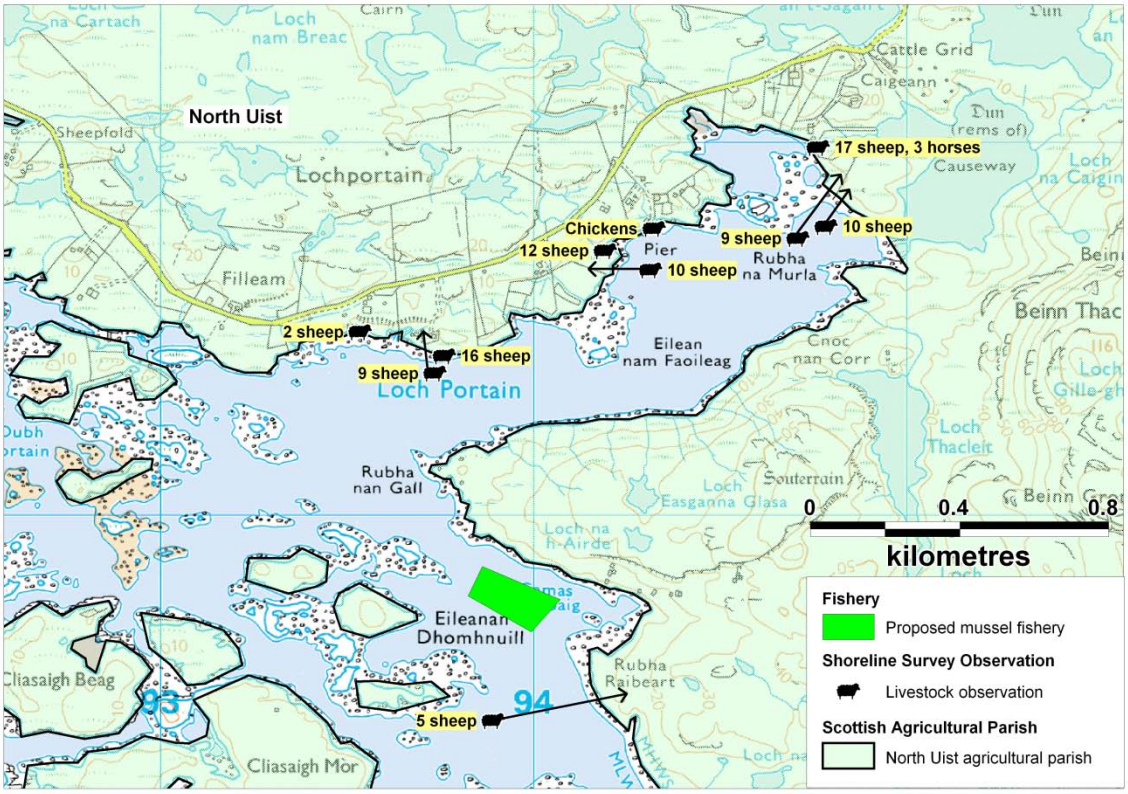

Figure 7.1 Livestock observations at Loch nam Madadh

Overall, the risk of faecal contamination to the fishery from livestock sources is greatest along the north shore of Loch Portain. Although no livestock were seen at Lochmaddy during the shoreline survey, there is an active livestock mart there and livestock may be kept on land to the north of the village. However, contamination arising from these sources is a greater distance from the fishery and therefore any impact to the proposed mussel farm would be dependent upon the circulation of contaminants within the loch.

8. Wildlife

Wildlife may also contribute to faecal contamination observed at fisheries. General information on the impacts of wildlife species can be found in Appendix 2. Lochmaddy (Loch nam Madadh) is a designated Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI) due to its littoral and sublittoral habitats and to the presence of European otters (*Lutra lutra*).

Seals

Both grey seals (*Halichoerus grypus*) and common or harbour seals (*Phoca vitulina vitulina*) are recorded in the Outer Hebrides, and Loch nam Madadh has been identified as an important haul out area for common seals. Scottish Government have identified 11 km of coastline in the upper reaches of Loch nam Madadh as a potential for designation as a protected haulout area **(Scottish Government 2011). No specific counts were available for inclusion in** this report, however according to the information provided in the map for Loch nam Madadh (Annex D, Site 33) the number of animals present in Loch nam Madadh may number in the low hundreds. The identified haul out area is located a few kilometres to the northwest of the mussel farm; however seals are likely to forage around much of the loch and so may be present around the mussel lines at times. Therefore, seals are likely to contribute to background levels of faecal contamination within the loch. Any direct deposition of faeces to the fishery is likely to be intermittent and unpredictable. No seals were observed during the shoreline survey.

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 nam Madadh. However, the typical population densities of coastal otters are low and their impacts on the shellfishery are expected to be very minor. No otters were seen during the shoreline survey.

Birds

Seabirds

Seabird 2000 data has been provided for a 5 km radius of North Uist 2.

Table 8.1 Seabird counts within 5km of the site.

Common name	Species	Count	Method
Arctic Tern	*Sterna paradisaea*	125	Occupied territory or nests
Northern Fulmar	*Fulmarus glacialis*	174	Occupied sites
Herring Gull	*Larus argentatus*	210	Occupied territory or nests
Common Gull	*Larus canus*	111	Occupied territory or nests
Black Guillemot	*Cepphus grylle*	105	Individuals on land
Great Black-backed Gull	*Larus marinus*	8	Occupied territory or nests
Lesser Black-backed Gull	*Larus fuscus*	32	Occupied nests or sites
Black-headed Gull	*Larus ridibundus*	62	Occupied territory or nests
Common tern	*Sterna hirundo*	204	Occupied nests/territory
European Shag	*Phalacrocorax aristotelis*	15	Occupied nests
Arctic skua	*Stercorarius parasiticus*	5	Occupied territory

The numbers presented in Table 8.1 represent a minimum number of birds as many of the counts refer to nests or territories, which are likely to relate to pairs and offspring and therefore more than one individual. The majority of these are gull species, at least some of which may be present in the area throughout the year. Although no large populations of seabirds were recorded during the shoreline survey, a significant number were identified in the Seabird 2000 data as breeding on an island to approximately 300m west of the proposed mussel farm. Depending on current movements, guano deposited on or around the nest sites could potentially lead to localised increases in contamination after rainfall. Additionally, droppings may be deposited directly at the fishery as adult birds fly to and from the nests. Any impact from this is likely to be higher when birds are nesting, roughly between May and September.

Geese

Greylag geese are resident in the Uists and are routinely surveyed by Scottish Natural Heritage and the Royal Society for Protection of Birds. Census figures for 2008 (the most recent available) give a total of just under 6000 birds, the majority of which are found along the western shore of North Uist (Mitchell, *et al*. 2010). Distribution data provided in the report show a population of roughly 100 birds in the Loch Portain area, suggesting that the animals sighted during the shoreline survey (also 100) represent a significant portion of the local population.

Migratory geese are also present in area during the winter, though no information was found on the numbers of birds likely to be present in the area around the fishery.

Deer

Although no deer were seen during the shoreline survey, there are deer in many parts of the island so it is likely that they may be present around Loch nam Madadh. 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). Visit Hebrides 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).

Other

Although one rabbit was recorded during the shoreline survey, it is likely that many more are present in the area. However, rabbit faeces are not known to carry significant concentrations of *E. coli* and therefore are unlikely to contribute to contamination levels found within the loch.

Dolphins and other whale species are not considered likely to be present in the loch due to the shallow depths.

Summary

A variety of wildlife species are known to be present in the area and may contribute to background levels of faecal contamination present in the waters of Loch nam Madadh. Geese and seabirds are likely to be near the fishery during the breeding season, and therefore may contribute either directly or indirectly (through runoff from nesting areas) during the nesting season.

Seals are likely to be present in the area and are likely to contribute to background levels of contamination within the loch throughout the year. However, their haul out is some distance from the fishery, and any direct impact is likely to be fleeting and unpredictable.

Deer may be present in the area, and any impacts to the fisheries from this source are likely to be highest near the outlet of streams and burns along the shore.

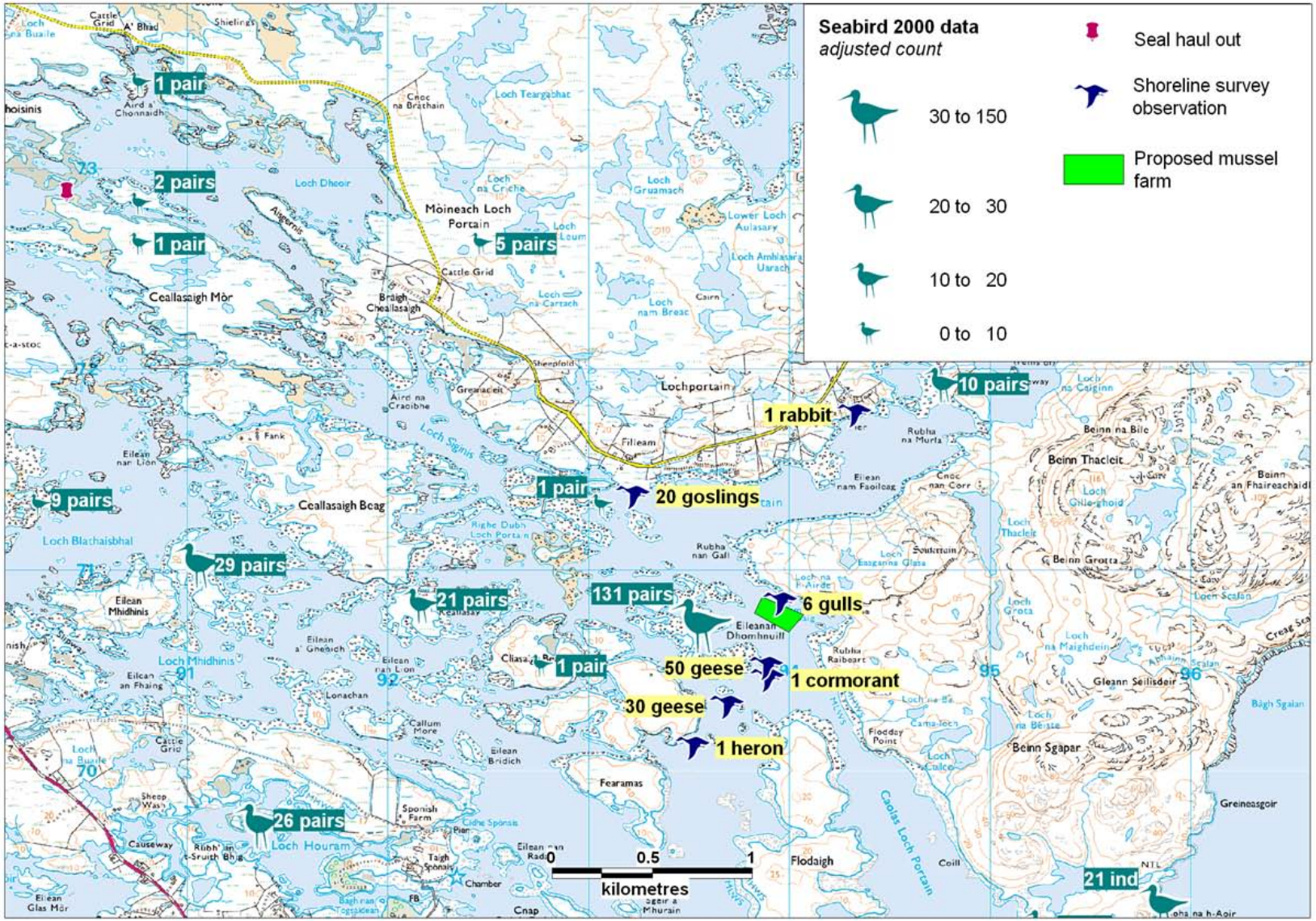

Figure 8.1 Map of wildlife present around North Uist 2

9. Meteorological data

The nearest weather station for which nearly complete rainfall records were available is located at Harris: Quidnish, approximately 22 km to the north-east. Rainfall data was available for 2003-2010 inclusive, and the data set was complete except for one day in October 2008. Recent rainfall data was not available for a rainfall station that had been located at North Uist: Clachan Na Luib as this closed in February 2007. The nearest weather station for which wind data was available is located at Benbecula, about 20 km to the south-west of Lochmaddy. Data for the stations was purchased from the Meteorological Office. 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 and how they may affect the bacterial quality of shellfish at North Uist 2.

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 *.

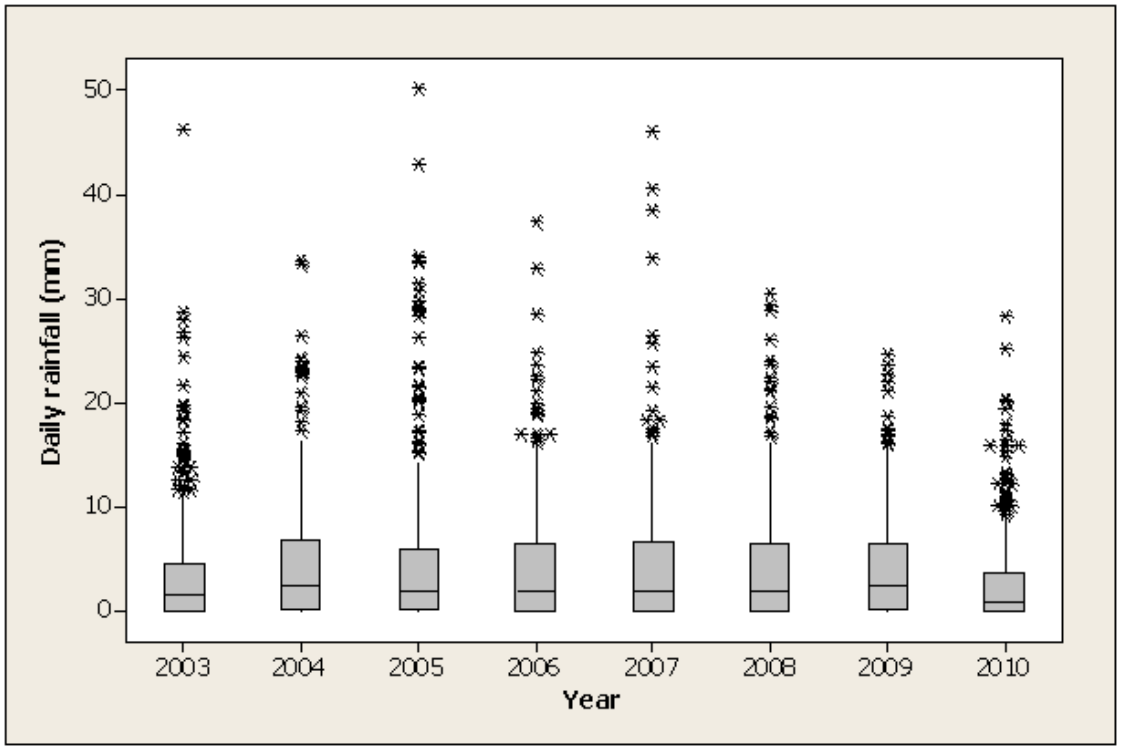

Figure 9.1 Box plot of daily rainfall values by year at Harris: Quidnish, 2003-2010

Figure 9.1 shows that most years showed a similar pattern but that 2010 was drier than the other years. High rainfall events, >30 mm in 24 hours, occurred in all years except 2009 and 2010.

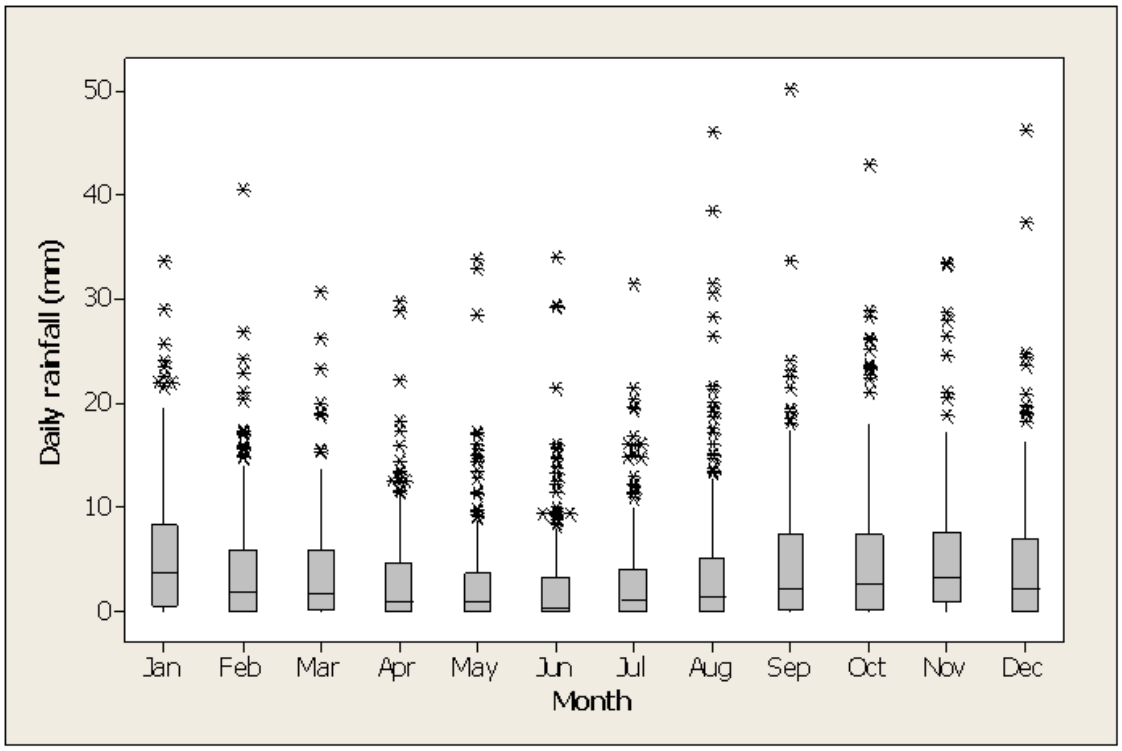

Figure 9.2 Box plot of daily rainfall values by month at Harris: Quidnish, 2003-2010

Weather was wettest in the period from August to January. More extreme rainfall events (in which over 30mm fell in a day) occurred during all months except April: the more extreme events occurred from August to February. For the period considered here (2003-2010), 42% of days experienced rainfall less than 1 mm, and 12% of days experienced rainfall of 10 mm or more.

The potential for increased run-off is therefore highest in late summer, 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.

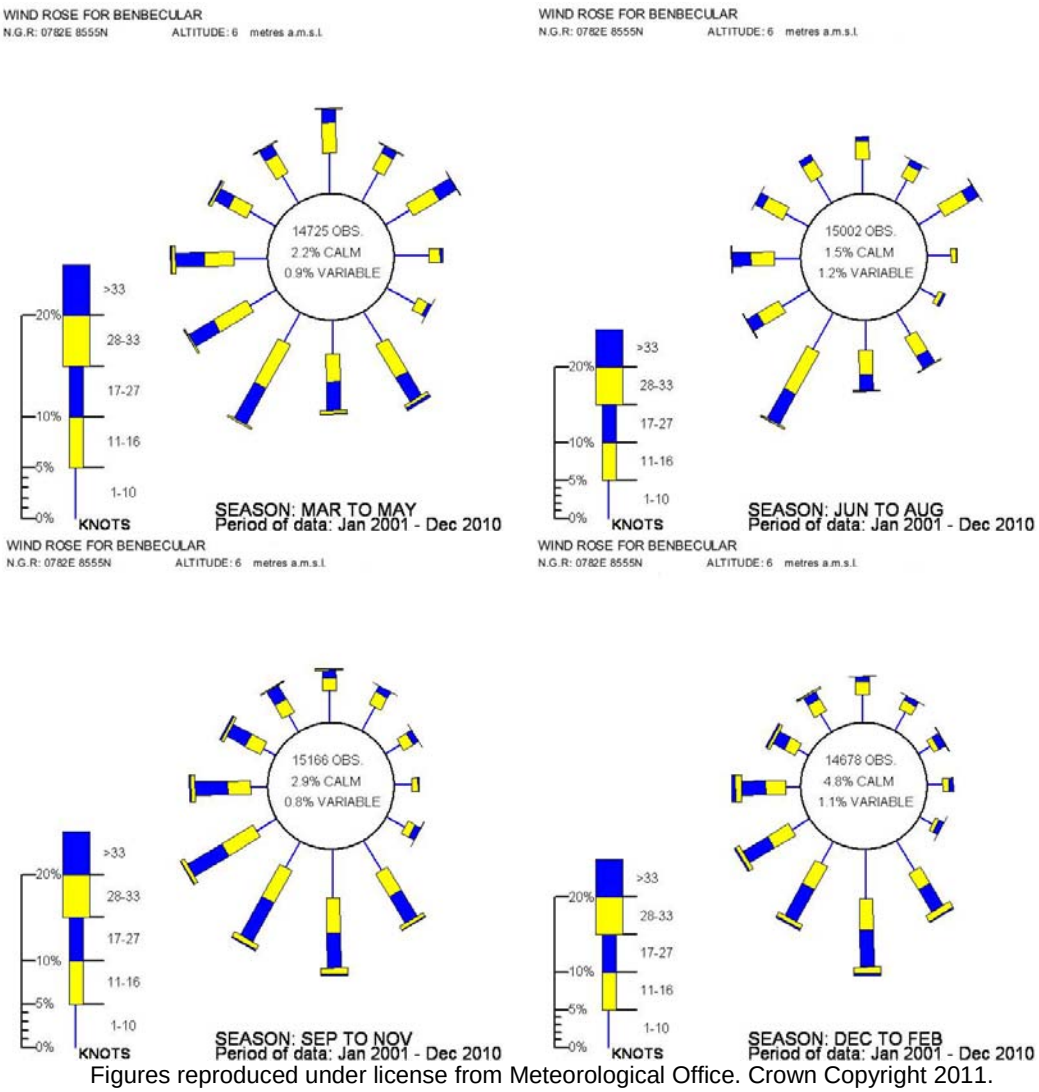

Figure 9.3 Seasonal wind roses for Benbecula

Loch nam Madadh is a large expanse of water and the land surrounding much of it is relatively low and will not provide much protection from, or cause deviation to, prevailing winds. In specific locations, the islands may modify the wind at sea level. The channel between Flodaigh and Fearamas/Cliasaigh Mòr is open to the south-west and so winds from that direction will blow up towards the fishery. 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 pattern of surface currents at Loch nam Madadh, particularly those from the northwest or south. Strong winds may 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.

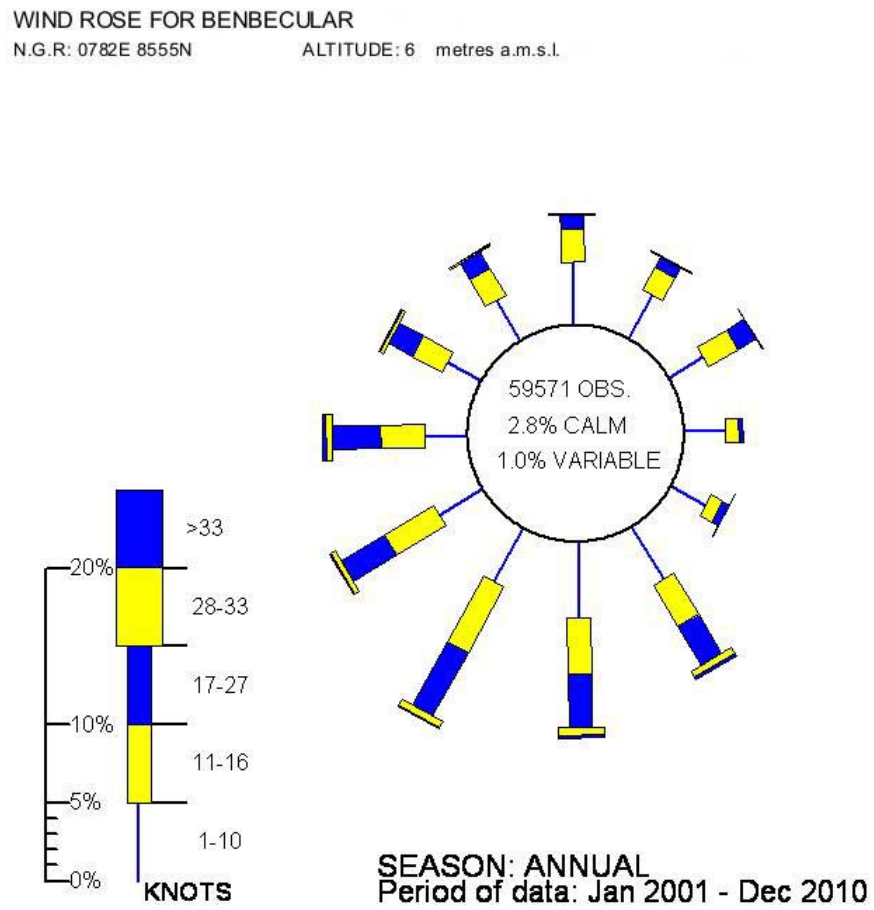

Figure 9.4 Annual wind rose for Benbecula

10. Current and historical classification status

Loch nam Madadh 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 the basket at North Uist 2 was initiated in 2011. All shellfish samples taken at North Uist 2 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 nam Madadh, and all samples were received by the testing laboratory within 24 hours of collection. Two 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

Table 11.1 Summary of historical sampling and results

Number	Collection date	NGR	*E. coli*
1	05/04/2011	NF 9196 6839	330
2	31/05/2011	NF 9447 7175	<20
3	28/06/2011	NF 9471 7160	230
4	19/07/2011	NF 9438 7178	70
5	02/08/2011	NF 9438 7178	70
6	19/09/2011	NF 9438 7178	<20

Sample number one was recorded at the shoreline near Lochmaddy. The remaining samples were reported from locations from the upper reaches of Loch Portain. In actuality, the sampling officer reported that all monitoring samples were collected from a sampling bag hung from the pier at Lochportain. 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 Lochportain pier. Therefore spatial variation in the results has not been considered further.

None of the samples submitted to date have been submitted directly from the site of the proposed mussel farm (with the exception of that taken during the shoreline survey and reported in Section 14).

12. Designated Waters Data

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

13. River Flow

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

The streams were listed in Table 13.1 were observed during the shoreline survey. Where possible, these were measured and sampled. The locations, together with the calculated loadings, are shown in Figure 13.1. There had been heavy rain two days prior to the survey. The first day of the survey was dry while some showers occurred on the second day.

Table 13.1 Watercourse loadings for Loch nam Madadh

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 93359 71452	Stream	0.40	0.40	0.081	1120	100	$1.1x10^9$
2	NF 94138 71563	Stream	0.20	0.08	0.130	180	300	$5.4x10^8$
3	NF 94192 71708	Dry stream	Dry at time of survey					N/A
4	NF 94344 71773	Stream	0.50	0.04	0.061	105	3700	$3.9x10^9$
5	NF 94763 71985	Stream, very little flow	Not measured or sampled					N/A
6	NF 95010 71726	Fresh water draining from inland loch	1.00	0.12	0.111	1150	<100	$<1.2x10^9$
7	NF 95010 71725	Stream, very little flow	Not measured or sampled					N/A
8	NF 94875 71647	Stream, little flow	Not measured or sampled					N/A
9	NF 94897 71557	Stream	0.30	0.21	0.128	700	<100	$<7x10^8$

The observed streams were all located on the northern and eastern shores of Loch Portain. The southern shore of that area was not accessible by foot and so the streams shown on the southern shore in Figure 13.1 could not be observed. No streams were observed from the boat on the shore in the vicinity of the proposed mussel fishery.

The loadings given in Table 13.1 are relatively low, and some streams that were dry or had very low flows were recorded, despite the heavy rain that occurred two days prior to the survey. This implies that run-off is only significant for a short time after a rainfall event. 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.

The streams that were measured and sampled during the shoreline survey therefore only represent a proportion of the *E. coli* loading from freshwater sources that are likely to enter that water body. The streams around the shores of Loch Portain will potentially represent the most significant sources of freshwater-borne contamination of the fishery. There is a single watercourse identified on the map approximately 0.5 km south of the fishery, running from Loch na Bà. Two additional small streams are identified further

south (approximately 1 km from the fishery; not shown in Figure 13.1). These could also contribute to the contamination at the fishery, depending on currents. However, the loadings of the other streams that were measured would suggest that their contribution would be small, unless specific additional sources of contamination occur at the southern locations.

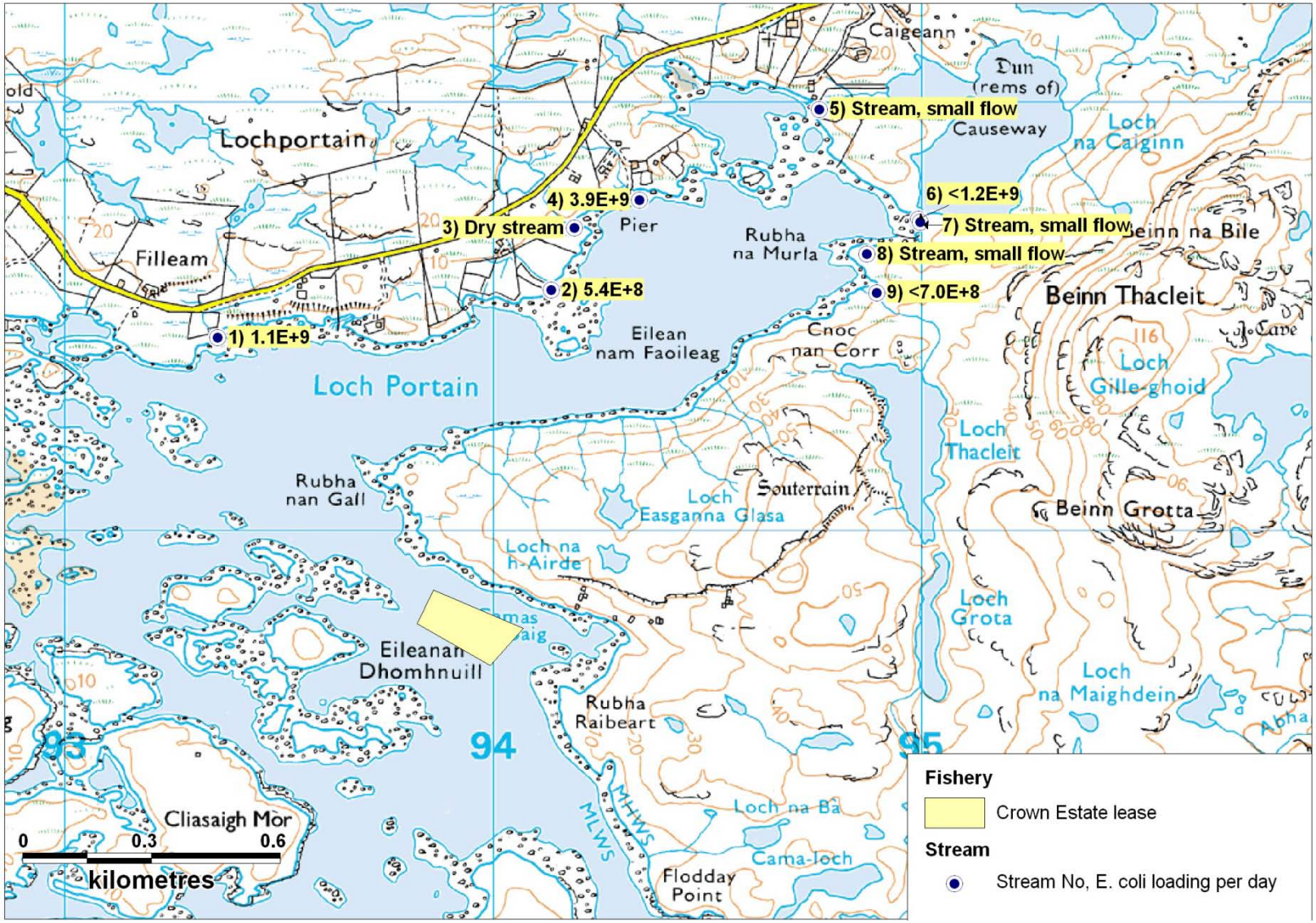

Figure 13.1 Map of river/stream loadings at North Uist 2

14. Bathymetry and Hydrodynamics

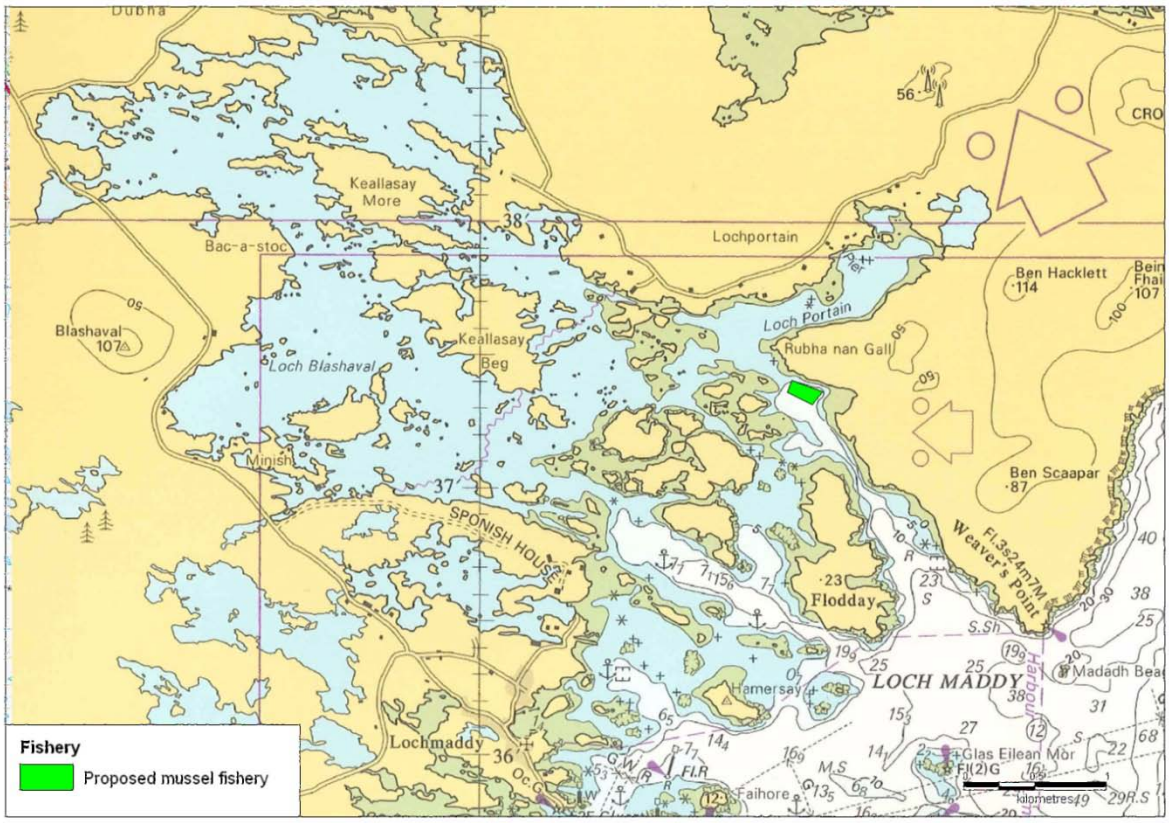

Figure 14.1 Bathymetry at Loch nam Madadh

Loch nam Madadh is a complex fjardic loch with several basins and a large number of islands. Most of the loch is relatively shallow (< 5m deep) with the deepest areas occurring towards the mouth of the loch. There is a channel between the island of Flodday and the mainland of North Uist and the proposed mussel farm is located at the northern end of this. The depth indicated on the chart for that part of the channel is between 5 and 10 m (see Figure 14.1). However, the depth of a mussel sample taken at the lines during the shoreline survey was recorded as 16 m.

Lewis (1957) identified that, while the loch is only 5 miles long by 2.5 miles wide, the branches, inlets and islands means that the length of shoreline is somewhere between 200 and 300 miles. He also noted that branches of the sea loch communicate with a system of brackish-water lochs with the outflows of the latter running across the mud-flats at low tide. This action produced a wide range of salinities within the loch.

14.1 Tidal Curve and Description

The two tidal curves below are for Lochmaddy, on the southern side of the loch. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 BST on 28/06/11 and the second is for seven days beginning 00.00 BST on 05/07/11. 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.

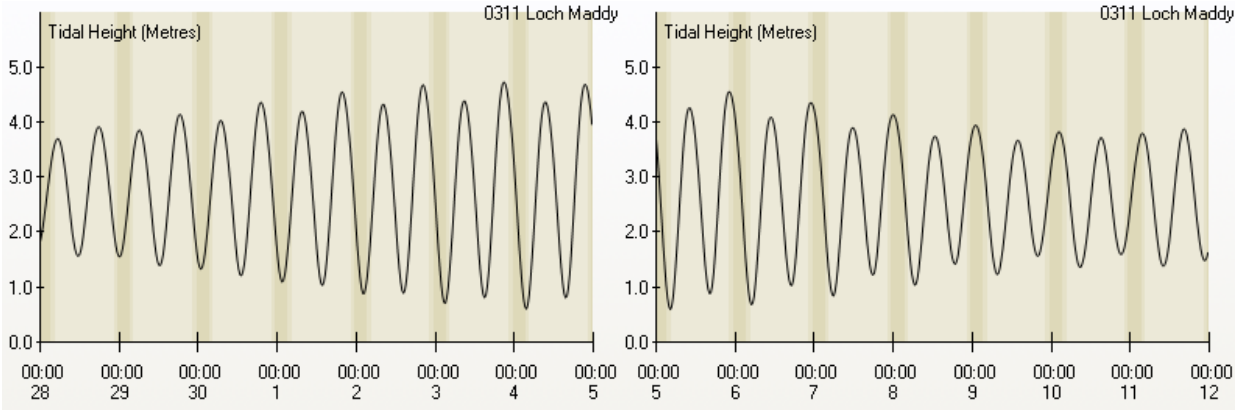

Figure 14.2 Tidal curves for Lochmaddy

The following is the summary description for Lochmaddy from TotalTide:

0311 Lochmaddy is a Secondary Non-Harmonic port. The tide type is Semi-Diurnal.

HAT	5.7 m
MHWS	4.8 m
MHWN	3.6 m
MLWN	1.9 m
MLWS	0.7 m
LAT	0.0 m

Predicted heights are in metres above chart datum. The average tidal range at spring tide is 4.1 m and at neap tide 1.7 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 nam Madadh. SEPA provided current study information for a location within the loch. Summary information on the site is given in Table 14.1 and the position is 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 period, are shown in Figure 14.4.

Table 14.1 Survey periods for the current meter study

Location	NGR	Survey period
Caolas Loch Portain	NF 9476 8694	23/11/10 – 8/12/10

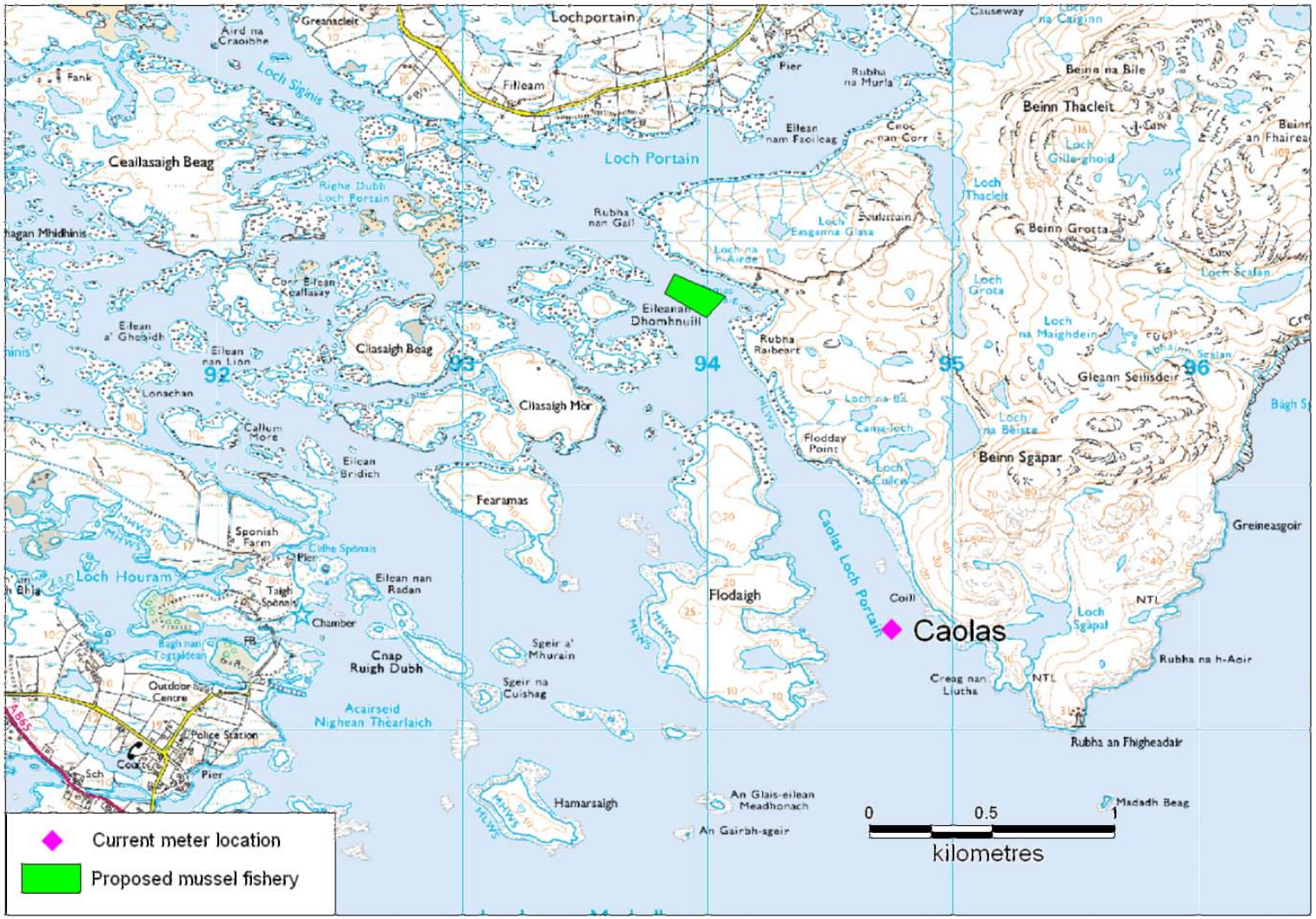

Figure 14.3 Current meter location

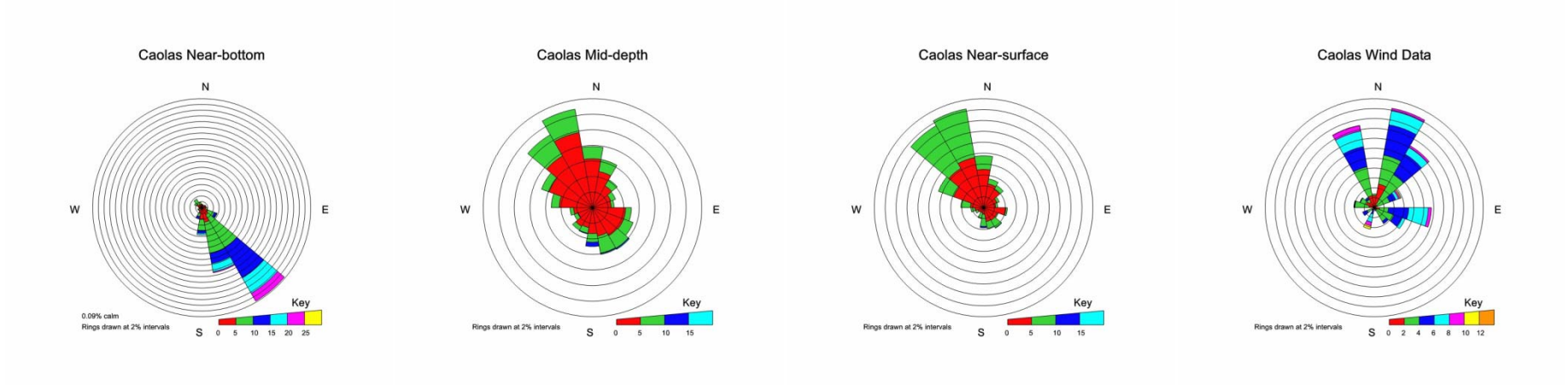

Figure 14.4 Current and wind plots for the Caolas current meter study

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.

The currents recorded at near-bottom were strongly directional, flowing in a south-easterly direction along the channel over all states of tide. Current speeds were low to moderate with a median speed of 8.4 cm/s (0.08 m/s; 0.16 knots) and a maximum speed of 26.7 cm/s (0.27 m/s; 0.52 knots). Currents at mid-depth and near-surface were weaker and more variable in direction: currents tended to flow in a north-westerly to north-north-westerly direction for most of the time, although currents flowing in the opposite direction, when they did occur, were stronger for some of the time. The median current speed near the surface was 4.2 cm/s (0.04 m/s; 0.08 knots) and the maximum current speed was 16.3 cm/s (0.16 m/s; 0.32 knots). The differences in current directions could have been due to one, or both, of two causes. There could be a permanent vertically differentiated flow with outgoing currents in the channel predominating at depth and incoming currents predominating nearer the surface. However, as the flow measurements pertained to a two week period during winter, it is difficult to draw conclusions about current movement over a broader period of time. Seasonal variation in both thermo- and halocline regimes may occur in fjordic/fjardic systems. Two salinity profiles recorded during the shoreline survey showed less than 0.1 ppt difference in salinity between sub-surface and 10 m, indicating no stratification over that range of depths. Alternatively, the effect may have been due to the winds that occurred during the study period. A plot of near-surface current direction versus wind speed and direction did not show a marked association between current and wind (see Figure 14.5).

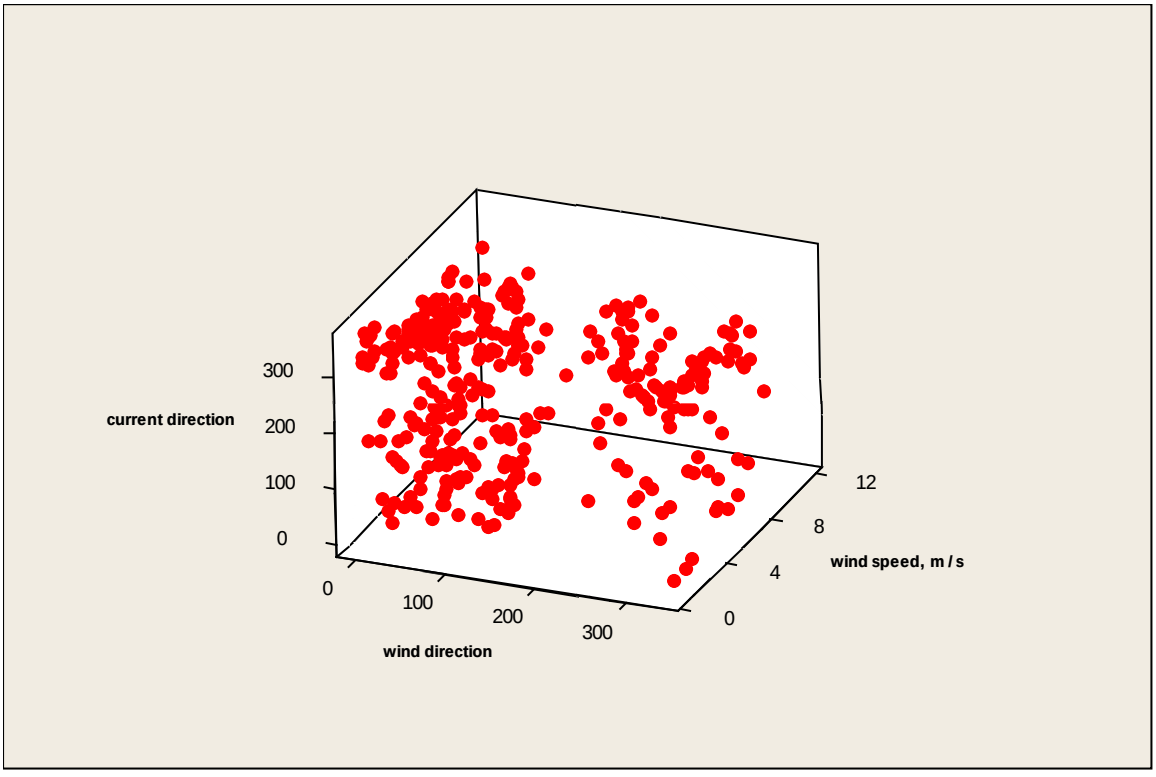

Figure 14.5 Near-surface current direction versus wind speed and direction

At a maximum current speed of 16 cm/s, contamination would be expected to travel a distance of approximately 2.3 km over the course of a tide.

Currents may be similar at the mussel fishery, given that it is in the same channel. However, the distance between the fishery and the current meter location, together with the presence of a number of small islands at channels near the fishery, and Loch Portain to the north-east, may modify the general pattern of flows along the main eastern channel at the northern end.

14.3 Conclusions

Current flows in the area of the fishery are expected to be generally weak and flowing out of the loch at depth and into the loch nearer the surface. The weak currents will mean that transport distances will be low. The upper part of the mussel lines will be exposed to contamination arising in the near vicinity of the fishery towards the outer part of the main channel. The lower ends of the lines will be exposed to contamination arising in the near vicinity of the fishery within the inner loch and Loch Portain, assuming that any contamination with a fresh water element is mixed sufficiently to entrain contamination into the near-bottom current.

15. Shoreline Survey Overview

The shoreline survey was conducted on the 28th and 29th June 2011 under mainly dry and calm weather conditions.

The location of the proposed mussel site was visited on the day of the survey. There was no equipment or stock on the site. The harvester identified that he intended to install eight 220 m long lines with 6 m droppers, with the aim to begin harvesting in 2013. A buoy with a creel basket of mussels was set out to allow monthly sampling. The basket was hung at a depth of 14 m.

There are two centres of population on the coastline adjacent to the loch, Lochmaddy and Lochportain. Lochportain is closest to the fishery, however there are only approximately a dozen dwellings, scattered along the northern shoreline. During the shoreline survey, no outfall pipes were observed leading across the shore from any of the houses suggesting that they may be connected to soakway systems.

At Lochmaddy, the locations of two Scottish Water septic tanks and a possible third were identified. However, none had flowing outfall pipes. A further four outfall pipes were observed, three leading under a road and the fourth leading from the visitors centre. None of the pipes were observed to be flowing at the time.

Livestock were observed grazing along most of the northern shoreline of Loch Portain and animals were able to access the shoreline and watercourses. In total 3 ponies and approximately 85 sheep were observed over the two days. No livestock animals were observed in or around Lochmaddy or on the southern shoreline of Loch Portain.

In total, approximately 70 geese were observed in and around the shoreline of Loch Portain and within close vicinity of the fishery. In addition to the geese, small numbers of several other seabirds were also observed including 1 cormorant, 6 gulls and 1 heron.

Seawater samples taken in the vicinity of the proposed fishery contained no detectable *E. coli*. Salinity profiles taken close to the proposed mussel fishery indicated little or no significant freshwater influence at the time. A seawater sample taken at the far eastern end of Loch Portain contained 5 *E. coli* cfu/100 ml and a salinity of 17.7 ppt, indicating brackish water.

Freshwater samples and discharge measurements were taken at five streams draining into the survey area. The streams were small and drained areas of dense heath and bog land. Samples taken from two streams on the southern shoreline of Loch Portain both had results of <100 *E. coli* cfu/100 ml. The samples taken from three streams on the northern shoreline of Loch Portain had higher results of 100, 300 and 3700 *E. coli* cfu/100 ml. The stream with the highest result originated amongst several dwellings located near the old pier at Lochportain. A mussel sample collected from the sampling creel on the

mussel farm site gave a result of 20 *E. coli* MPN/100 g, indicating little faecal contamination at that location at the time of survey. A shore mussel sample was also collected from the eastern end of Loch Portain gave a result of 40 *E. coli* MPN/100 g, which also indicated low levels of faecal contamination at the time of survey.

Figure 15.1 and Figure 15.2 show summary maps of the most significant findings from the shoreline survey for Loch Portain and the area around Lochmaddy.

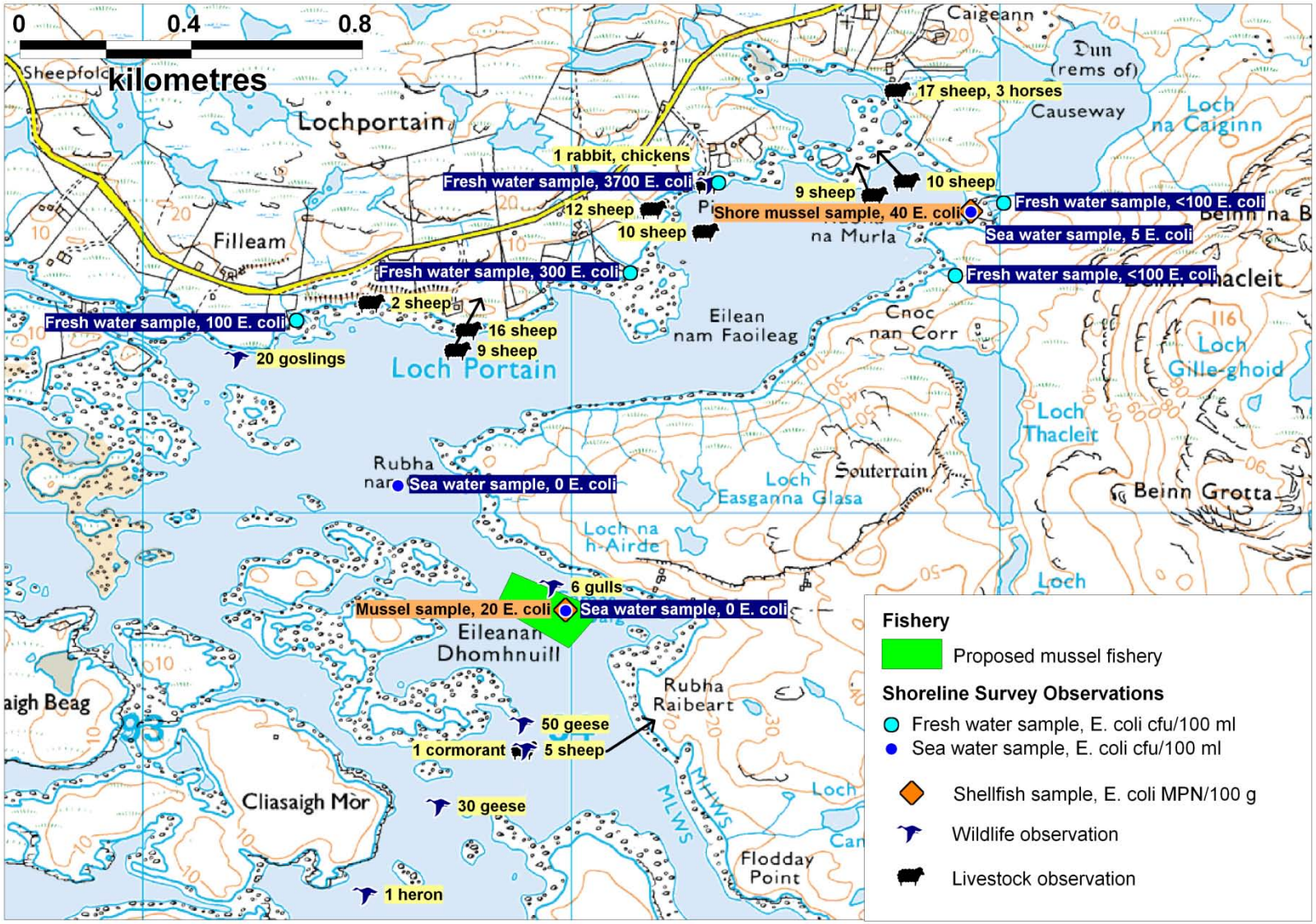

Figure 15.1 Summary of shoreline survey findings for Loch nam Madadh – Loch Portain

Figure 15.2 Summary of shoreline survey findings for Lochmaddy village

16. Overall Assessment

Human sewage impacts

The village of Lochmaddy, which lies just over 3 km to the south-southwest of the North Uist 2 fishery, is the largest source of human sewage to the area. The homes along the north shore of Loch Portain, less than 1 km north of the fishery, are the nearest potential source of human sewage contamination. Two private septic tanks have consented discharges to Loch Portain, though neither of these discharges was seen during the shoreline survey. One of these plots adjacent to a small watercourse, therefore it is likely that the tank discharges to the watercourse. A water sample taken from the watercourse during the shoreline survey was found to contain 300 *E. coli* cfu/100 ml, which indicated only moderate levels of faecal contamination at the time of sampling.

Septic tank discharges at Lochmaddy are sufficiently distant, given the relatively weak predicted current flows, that they are considered unlikely to have a substantial impact on water quality at the mussel farm.

There is potential for faecal contamination from boats using anchorages to the south of the mussel farm site and in Loch Portain, particularly during the summer when visiting yachts are more likely to be present.

Agricultural impacts

Agricultural activity in the area is largely limited to extensive rearing and grazing of livestock. A modest number of sheep were observed during the shoreline survey mainly in the vicinity of crofts at Loch Portain, but also on the shore adjacent to the proposed mussel farm location. Impacts to the fishery are most likely to occur through diffuse runoff from areas where animals are grazed or kept. It is presumed that these animals will graze over a much broader area than that in which they were seen, and that the number of animals observed may be only a proportion of the total present in the area. No livestock were recorded as present on the improved grassland areas around Lochmaddy, though this landcover type is likely to be used for grazing. The land along the north side of Loch Portain, where the majority of livestock was seen, is poorly drained and boggy, therefore the risk of diffuse pollution from livestock faeces is highest along this shore.

There are likely to be more sheep present in spring and summer, when lambs are present and an increase in faecal contamination from this source are likely to occur after heavy rainfall following periods of dry weather.

Wildlife impacts

Of the wildlife species likely to be present in Loch nam Madadh, those most likely to have an impact on water quality at the fishery are gulls and other seabirds, geese and seals. A breeding site for gulls lies 300 metres from the mussel farm, and these and other seabirds are likely to contribute to background levels of faecal contamination in local waters, particularly during

the summer nesting season. These animals may also directly deposit droppings at the mussel fishery by resting on floats. However, until the mussel farm is established, it will not be possible to determine to what extent this will occur.

Approximately 100 resident geese were recorded in the area of the proposed mussel farm. Geese contribute to diffuse source faecal contamination of the area as they deposit droppings on land whilst feeding and are likely to contribute to background levels of contamination at the fishery.

Loch nam Madadh is an important seal haul out area, though the identified haul out areas are located in the upper loch, away from the mussel farm. Seals transiting in and out of the loch and foraging for food may come in close proximity to the farm and in other lochs seals have been observed resting on paired longlines. Impacts from this source may be significant to the fishery, however there is insufficient evidence on which to make a clear determination.

Seasonal variation

Some of the significant potential sources of faecal contamination – people, livestock, seabirds - are likely to be present in greater numbers during the summer months. Although rainfall is greater overall from August to January, rainfall greater than 30 mm, which is more likely to lead to direct runoff from land, was found to have occurred historically at virtually any time of year. Therefore the risk to contamination from diffuse sources is present throughout the year.

As this fishery is not yet established, there is no historical monitoring history on which to assess seasonal variation in *E. coli* concentrations in mussels.

Rivers and streams

Although a number of small streams discharge to the loch in the vicinity of the planned mussel farm, it was only feasible to sample those located along the shore of Loch Portain during the shoreline survey, due to the remote nature of the site.

Results from these samples indicated relatively low loadings of faecal bacteria, although the *E. coli* concentration measured in the stream near the pier was 3700 cfu/100 ml, which indicated significant faecal contamination. Many streams had very small catchments and were dry despite heavy rainfall prior to the survey, therefore runoff may only be significant for a short period of time after a rainfall event in these watercourses. 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.

Most of the potential sources of faecal contamination in the area will be carried via streams, and the most significant of these to the water quality at the proposed fishery discharge to Loch Portain.

Movement of contaminants

Based on data obtained from the fish farm assessment at Caolas Loch Portain, currents in the vicinity of the fishery are expected to be relatively weak, with contamination predicted to travel a maximum of 2.3 km over the course of a tide. Sources arising from Lochmaddy are unlikely to significantly impact the fishery. Sources arising nearer the fishery at Loch Portain and to the south of the site are most likely to affect water quality around the mussel farm.

The likely movement of contaminants is predicted to differ at the surface and at depth. Transport of contaminants near the surface is likely to be from the near vicinity of the fishery and the channel to the south, while transport in deeper waters is likely to be from the north and Loch Portain.

Temporal and geographical patterns of sampling results

Only 6 results were available for analysis. These samples were taken from a location on the fishery and hung at the pier prior to sampling, and therefore cannot clearly be considered representative of contamination at either location. Given the limited monitoring history, and the mixed locations of the shellfish sampled, it is not possible to address geographical patterns amongst the sampling results.

Conclusions

Given that the growing equipment has yet to be installed at the North Uist 2 site, it is unlikely that the mussel farm will be ready for harvest before late 2013. Although a seabed lease area has been established, 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.

The complex nature of the movement of tidal currents in the area suggests that further information would be required to determine where and at what depth a monitoring point would be most protective of public health.

Once the equipment has been installed on the site and there is stock available on the lines for sampling, a bacteriological survey should be undertaken with samples taken from the northern and southern extents of the fishery and also at the top and bottom of the longlines in order to establish the relative importance of sources to the north and south 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 longlines. This could be done 6-12 months prior to planned harvesting 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 established for the farm, and exclude the area of Loch Portain, which may be subject to higher levels of contamination than the mussel farm site itself. The boundaries recommended are NF 9373 7112 to NF 9354 7093 and NF 9354 7093 to NF 9402 7025 and NF 9402 7025 to NF 9425 7043 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.

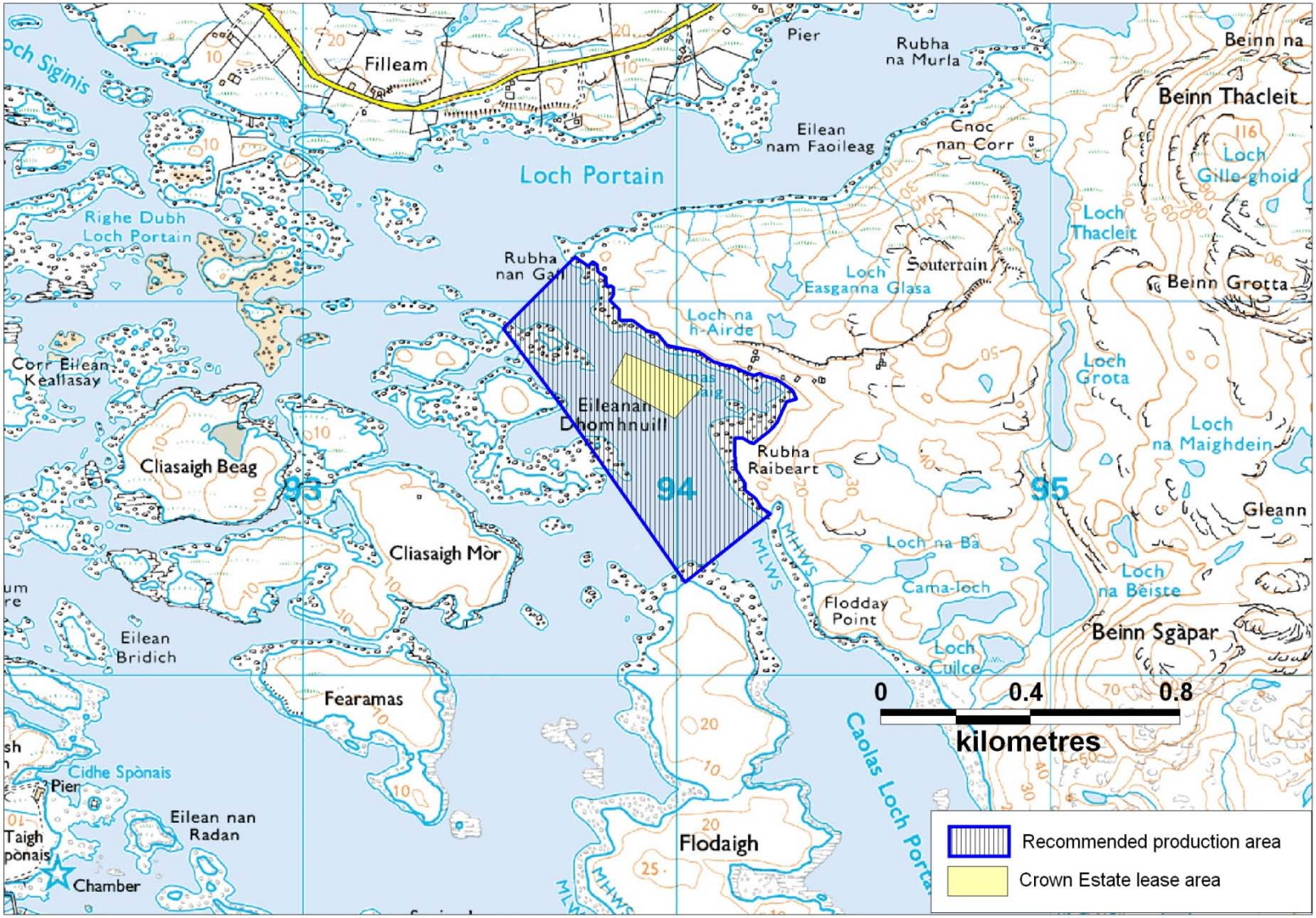

Figure 17.1 Map of recommendations at North Uist 2

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19. List of Figures and Tables

Appendices

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

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.

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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.

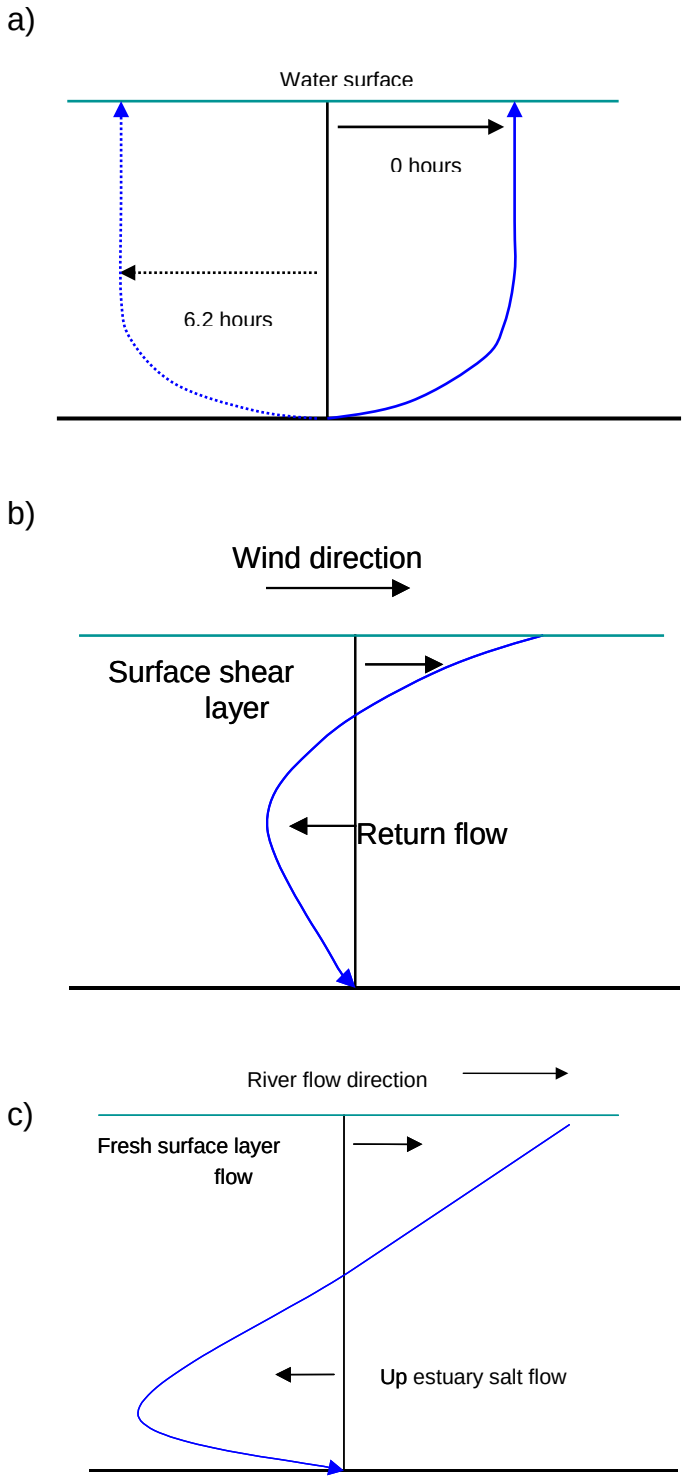

Figure 1. Typical vertical profiles for water currents. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction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

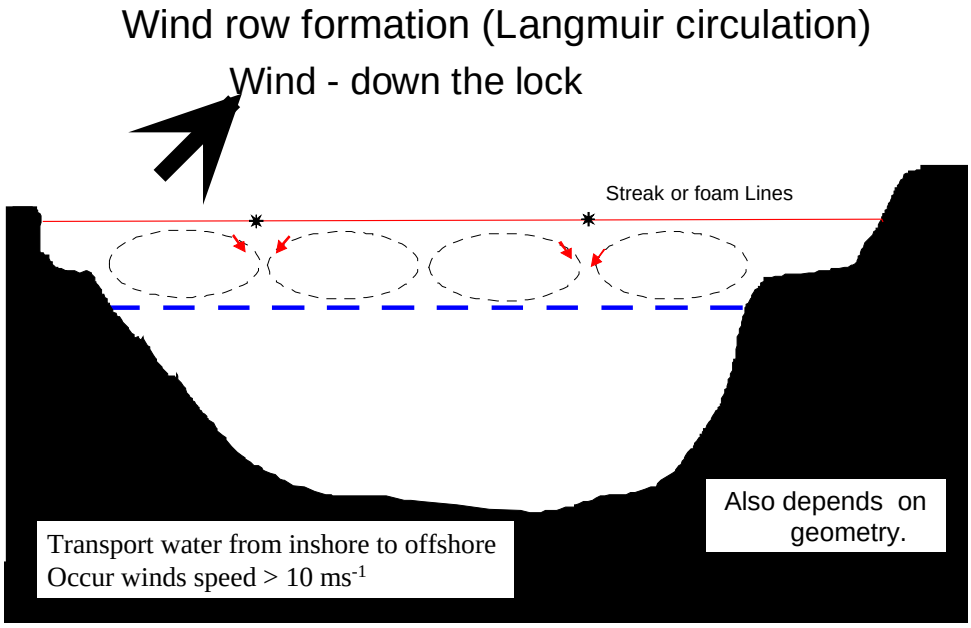

Figure 2. Schematic of wind driven 'wind row' currents. The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

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 area:	North Uist 2
Site name:	Lochmaddy
SIN:	UB 540 969 08
Species:	Common mussels
Harvester:	Ralph Thompson, Whiteshore Cockles Ltd
Local Authority:	CnES Council
Status:	New application
Date Surveyed:	28/06/2011 & 29/06/2011
Surveyed by:	Jessica Larkham – Cefas Samantha Muir - CnES
Existing RMP:	NA
Area Surveyed:	See Figure 1.

Weather
28/06/2011 – Dry, some clouds, wind 14 mph. Heavy rain on 26/06/2011.
29/06/2011 – Light showers midday, some clouds, wind 15 mph. Heavy rain on 26/06/2011.

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 – 20.

Fishery
There is currently no equipment or stock on site. The harvester intends to install twelve 220 m long lines with 8 m droppers, with the aim to begin harvesting in 2013. The harvester has marked the proposed location of the fishery using a buoy with a creel basket attached with mussels inside to allow monthly sampling. The basket is currently at a depth of 14 m.

Sewage/Faecal Sources
Human
There are two areas of population on the coastline adjacent to Lochmaddy. The first is the village of Lochmaddy, located on the west side of the loch and is the largest settlement on North Uist. During the shoreline survey the location of two Scottish Water septic tanks and a possible third were identified. However, none had flowing outfall pipes. A further four outfall pipes were observed, three leading under a road and the fourth leading from the visitors centre. None of the pipes were flowing. There one small pier, the ferry terminal and a slipway in Lochmaddy.

The second area of human population is on the north side of Loch Portain where there are a dozen or so scattered dwellings. No outfall pipes were observed leading from any of the premises on the day of the shoreline survey, indicating that any septic tanks are likely to be connected to soakaways.

Livestock
Over the two days of the shoreline survey a total of 85 sheep were observed scattered along the northern shoreline of Loch Portain. As this total was accumulated over two days and several counts were made by boat, some observations may have been duplicated. Approximately 3 horses were also observed on this stretch of coastline. No livestock or evidence of livestock was observed on the southern shoreline of Loch Portain, which is closest to the fishery.

Seasonal Population
There are two hotels, a youth hostel and two bed and breakfasts, one of which has three self catering apartments attached to it. It is expected that a large number of visitors pass through Lochmaddy when arriving/departing on the daily ferry service to Uig. Other facilities in the village include a post office, petrol station, tourist office and the visitors centre. There is no tourist accommodation along the northern shoreline of Loch Portain. Walkers and cyclists were encountered on many of the roads surrounding the loch.

Boats/Shipping
As previously mentioned there is a daily ferry service from Lochmaddy to Uig. On the day of the shoreline survey there were five boats moored in the loch close to the pier. The slipway in Lochmaddy provides access for Marine Harvest to the Lochmaddy Fish Farm. Two yachts were observed moored in Loch Portain.

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

The land cover surrounding Loch Portain and the rest of Lochmaddy is predominantly dense heath land and bog land, with some areas of grassland.

Wildlife/Birds
During the shoreline survey, 1 cormorant, 6 gulls, 1 heron and approximately 70 geese were observed on the shoreline or in the water in close vicinity to the fishery.

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.

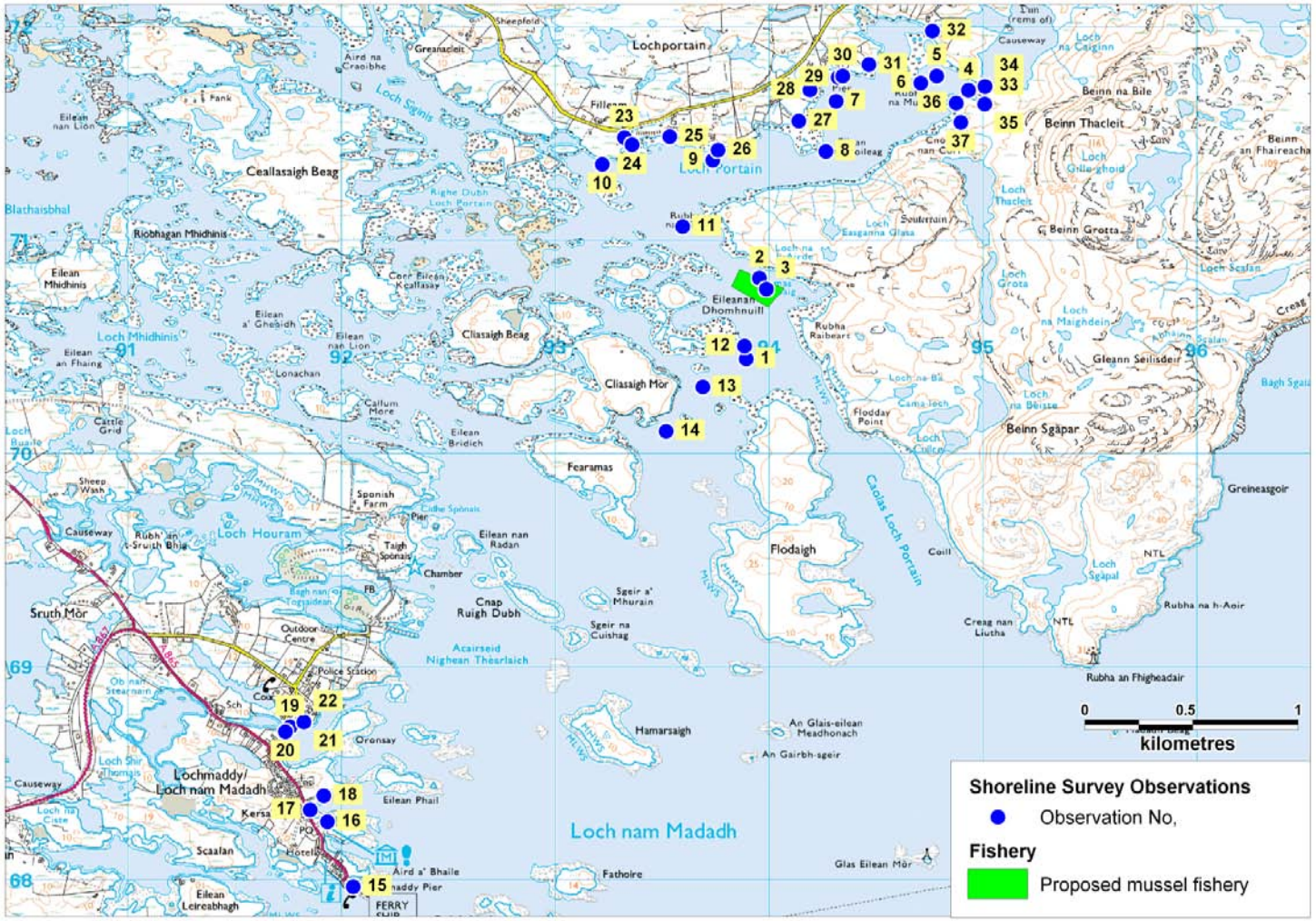

Figure 1. Shoreline Observations

Table 1 Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	28/06/2011	11:26	NF 93892 70447	93892	870447			5 sheep on shoreline, 1 cormorant on buoy
2	28/06/2011	11:28	NF 93955 70827	93955	870827			6 gulls
3	28/06/2011	11:35	NF 93987 70775	93987	870775	Figure 4	LMMUSSEL 1, LMSW1	Location of proposed fishery. Location of mussel sample LMMUSSEL 1, taken from a creel basket hung a 14 m from the end of a buoy. Location of LMSW1 and salinity profile 1
4	28/06/2011	11:53	NF 94933 71706	94933	871706		LMMUSSEL2, LMSW2	Location of shore mussel sample LMMUSSEL 2 and sea water sample LMSW2
5	28/06/2011	11:57	NF 94784 71773	94784	871773			10 sheep on shoreline (N side of Loch Portain)
6	28/06/2011	11:57	NF 94709 71741	94709	871741			9 sheep on shoreline
7	28/06/2011	12:01	NF 94314 71656	94314	871656			10 sheep on shoreline
8	28/06/2011	12:02	NF 94266 71420	94266	871420			1 yacht moored
9	28/06/2011	12:05	NF 93736 71379	93736	871379			9 sheep on shoreline
10	28/06/2011	12:07	NF 93220 71360	93220	871360	Figure 5		20 goslings in the water
11	28/06/2011	12:11	NF 93596 71067	93596	871067		LMSW3	Location of sea water sample LMSW3 and salinity profile 2
12	28/06/2011	12:19	NF 93885 70507	93885	870507			50 geese on the shoreline
13	28/06/2011	12:20	NF 93690 70316	93690	870316			30 geese on the shoreline
14	28/06/2011	12:21	NF 93519 70109	93519	870109			1 heron
15	28/06/2011	13:46	NF 92055 67974	92055	867974	Figure 6		Possible location of Scottish Water Lochmaddy No.3 septic tank at ferry terminal. Two concrete structures, that might be related to it, no visible pipes
16	28/06/2011	13:52	NF 91934 68278	91934	868278	Figure 7		Taigh Chearsbhagh centre with cafe, shop, toilets. Outfall pipe leading down from centre to shoreline, very little flow
17	28/06/2011	13:55	NF 91854 68334	91854	868334	Figures 8 & 9		3 pipes leading under road into small bay, no flow visible from any
18	28/06/2011	13:58	NF 91917 68400	91917	868400	Figure 10		Location of Scottish Water Lochmaddy No.2 septic tank
19	28/06/2011	14:05	NF 91759 68723	91759	868723	Figure 11		Inspection cover and outfall pipe next to wall, probably connected to the Scottish Water Lochmaddy No.1 septic tank on the other side of the road
20	28/06/2011	14:08	NF 91737 68701	91737	868701	Figures 12 & 13		Location of Scottish Water Lochmaddy No.1 septic tank, large concrete area with two inspection covers set in it and

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
								another on the grass next to it, no outfall pipes. Five boats moored in the loch.
21	28/06/2011	14:11	NF 91826 68747	91826	868747	Figures 14 & 15		Pipe covered in concrete slabs with pipe leading onto the shoreline, no flow
22	28/06/2011	14:12	NF 91825 68746	91825	868746	Figure 16		Broken pipe, no flow
23	29/06/2011	11:48	NF 93323 71486	93323	871486			Water mains inspection cover
24	29/06/2011	11:52	NF 93359 71452	93359	871452	Figure 17	LMFW1	Stream, W 0.40 m, D 0.40 m, Flow 0.081 m/s, S.D 0.010, location of fresh water sample LMFW1. Large number of sheep droppings on shoreline and around the stream
25	29/06/2011	12:02	NF 93535 71490	93535	871490			2 sheep
26	29/06/2011	12:08	NF 93761 71426	93761	871426	Figure 18		16 sheep
27	29/06/2011	12:19	NF 94138 71563	94138	871563		LMFW2	Stream, W 0.20 m, D 0.08 m, Flow 0.130 m/s, S.D 0.003, location of fresh water sample LMFW2
28	29/06/2011	12:30	NF 94192 71708	94192	871708			12 sheep, dry stream leading into the bay opposite pier, 1 yacht moored off shoreline
29	29/06/2011	12:34	NF 94323 71767	94323	871767			Old pier, 3 houses behind (1 with chickens), 1 rabbit
30	29/06/2011	12:36	NF 94344 71773	94344	871773	Figure 19	LMFW3	Stream, W 0.50 m, D 0.04 m, Flow 0.061 m/s, S.D 0.002, location of fresh water sample LMFW3
31	29/06/2011	12:48	NF 94466 71827	94466	871827			Field drains, rotting seaweed
32	29/06/2011	13:10	NF 94763 71985	94763	871985			Stream, very little flow. 17 sheep, 3 horses. 1 house inland.
33	29/06/2011	13:18	NF 95010 71726	95010	871726	Figure 20	LMFW4	Fresh water draining from inland loch, W 1.00 m, D 0.12 m, Flow 0.111 m/s, S.D 0.013, location of fresh water sample LMFW4
34	29/06/2011	13:18	NF 95010 71725	95010	871725			Stream, very little flow
35	29/06/2011	13:26	NF 95008 71642	95008	871642			Field drain
36	29/06/2011	13:36	NF 94875 71647	94875	871647			Stream, little flow
37	29/06/2011	13:42	NF 94897 71557	94897	871557		LMFW5	Stream, W 0.30 m, D 0.21 m, Flow 0.128 m/s, S.D 0.011, location of fresh water sample LMFW5

Photographs referenced in the table can be found attached as Figures 4 – 20.

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 29th & 30th June for *E. coli* analysis. Samples were received by the laboratory on the same day as shipping. The box temperatures on arrival varied from 4 and 4.8˚C, which was within the recommended temperature range of 2-8˚C.

Samples of seawater were tested for salinity by the laboratory using a . 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	LMFW1	29/06/2011	NF 93359 71452	Fresh water	100	
2	LMFW2	29/06/2011	NF 94138 71563	Fresh water	300	
3	LMFW3	29/06/2011	NF 94344 71773	Fresh water	3700	
4	LMFW4	29/06/2011	NF 95010 71726	Fresh water	<100	
5	LMFW5	29/06/2011	NF 94897 71557	Fresh water	<100	
6	LMSW1	28/06/2011	NF 93987 70775	Sea water	0	36.5
7	LMSW2	28/06/2011	NF 94933 71706	Sea water	5	17.7
8	LMSW3	28/06/2011	NF 93596 71067	Sea water	0	36.3

Table 3. Shellfish sample *E. coli* results

No.	Sample Ref.	Date	Position	Site	Species	Depth (m)	*E. coli* MPN/100 g
1	LMMUSSEL1	29/06/2011	NF 93987 70775	Lochmaddy	Mussels	14 m	20
2	LMMUSSEL2	29/06/2011	NF 94933 71706	Taken from the shore at Loch Portain	Mussels	<1 m	40

Table 4. Salinity profiles

Profile	Date	Time	Position	Depth (m)	Salinity (ppt)
1	28/06/2011	11:35	NF 93987 70775	<1	34.69
				2	34.69
				4	34.68
				6	34.68
				8	34.68
				10	34.66
2	28/06/2011	12:11	NF 93596 71067	<1	34.69
				2	34.69
				4	34.69
				6	34.7
				8	34.74
				10	34.77

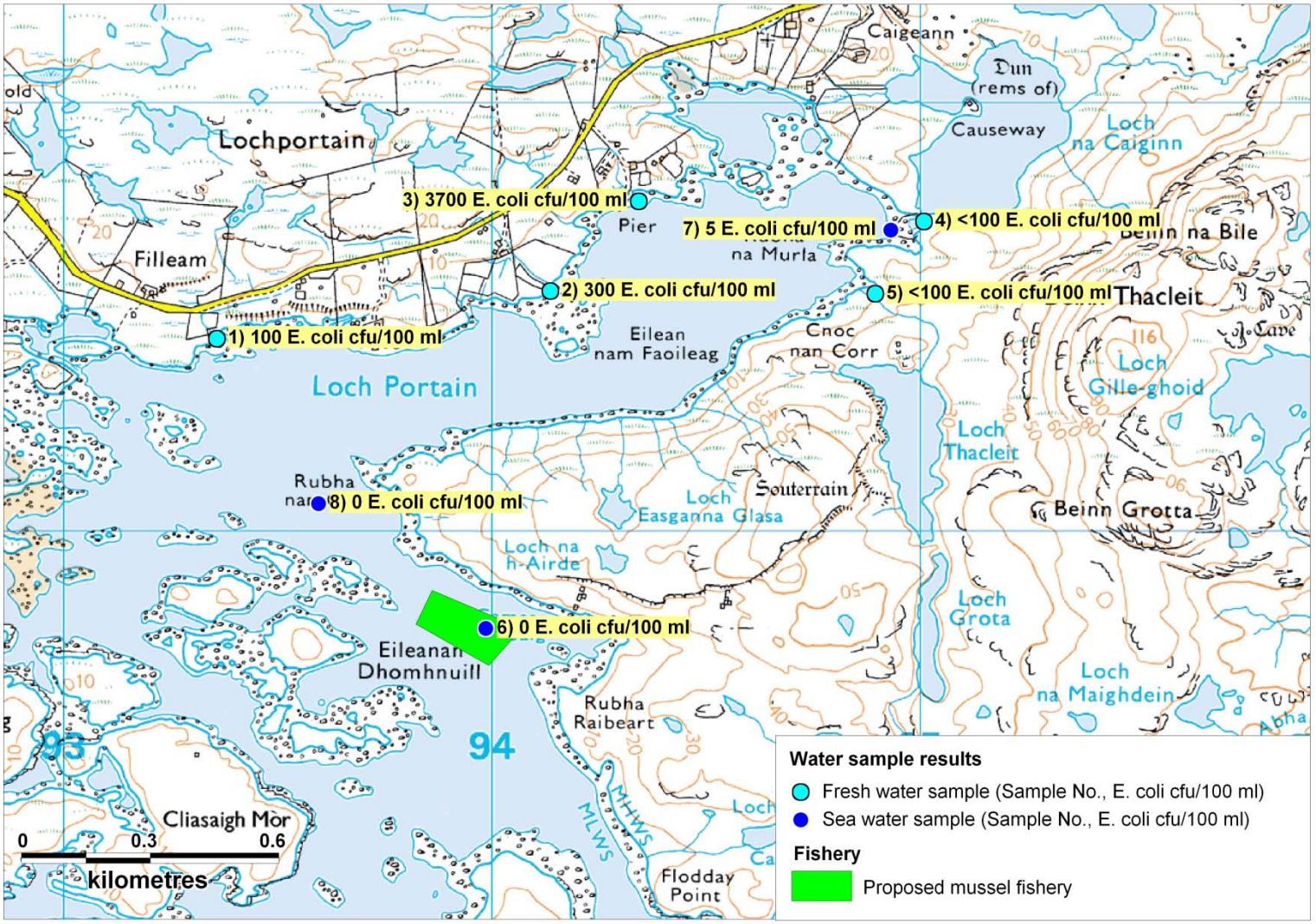

Figure 2. Water sample results

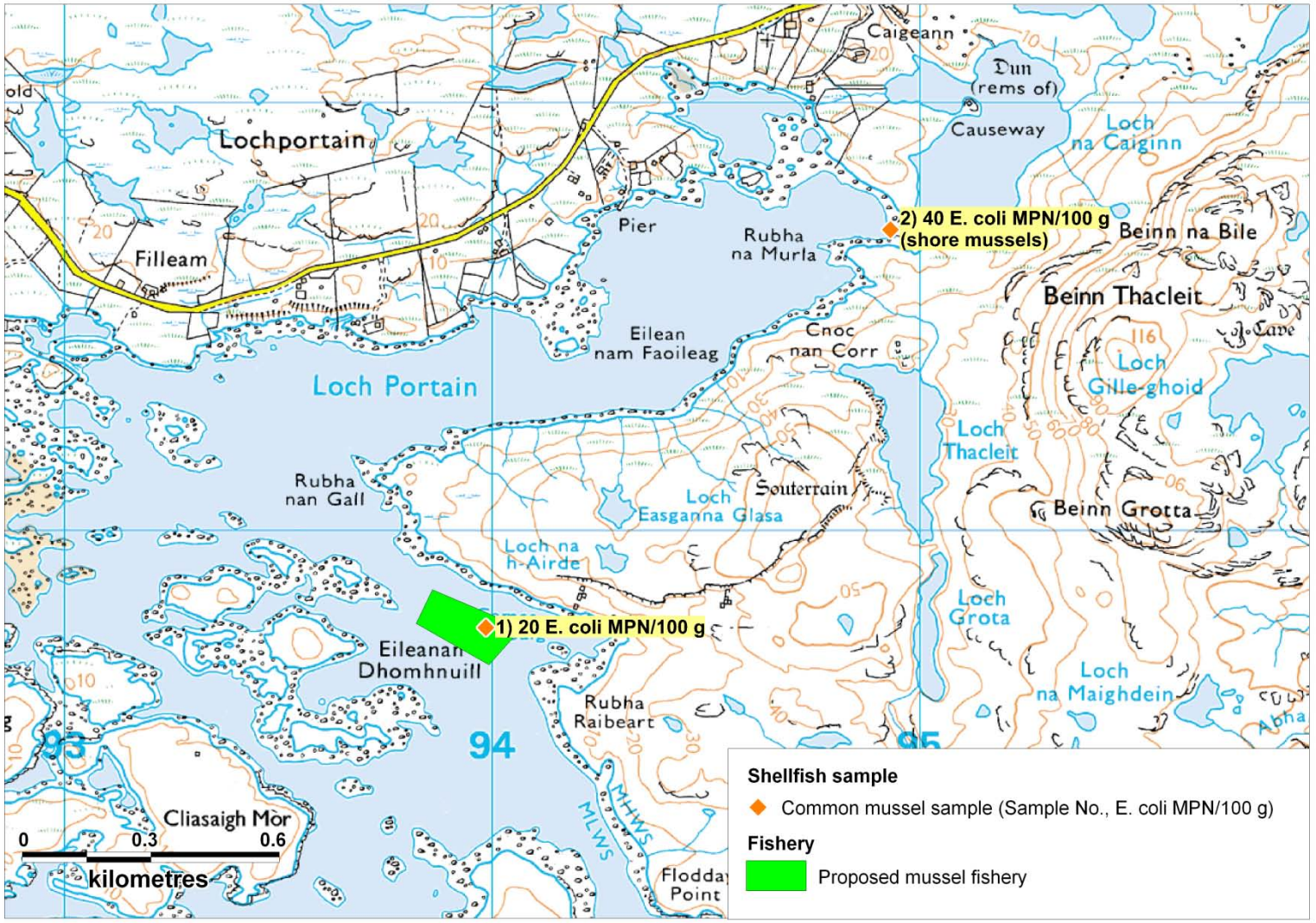

Figure 3. Shellfish sample results

Photographs

Figure 4. Mussel sample 1, LMMUSSEL 1

Figure 5. 20 goslings in water

Figure 6. Possible location of Scottish Water septic tank Lochmaddy No.3

Figure 7. Outfall pipe leading down from visitor's centre, little flow

Figure 8. Pipes leading under road onto shoreline in Lochmaddy

Figure 9. Pipe leading under road onto shoreline in Lochmaddy

Figure 10. Scottish Water Lochmaddy No.2 septic tank

Figure 11. Outfall pipe and inspection cover on opposite side of road to Scottish Water Lochmaddy No. 1 septic tank

Figure 12. Scottish Water Lochmaddy No. 1 septic tank

Figure 13. Scottish Water Lochmaddy No.1 septic tank inspection cover

Figure 14. Outfall pipe covered in concrete slabs

Figure 15. Outfall pipe shown in Figure 14, very little flow

Figure 16. Broken pipe, no flow

Figure 17. Stream, location of fresh water sample LMFW1

Figure 18. Sheep on N shoreline of Loch Portain

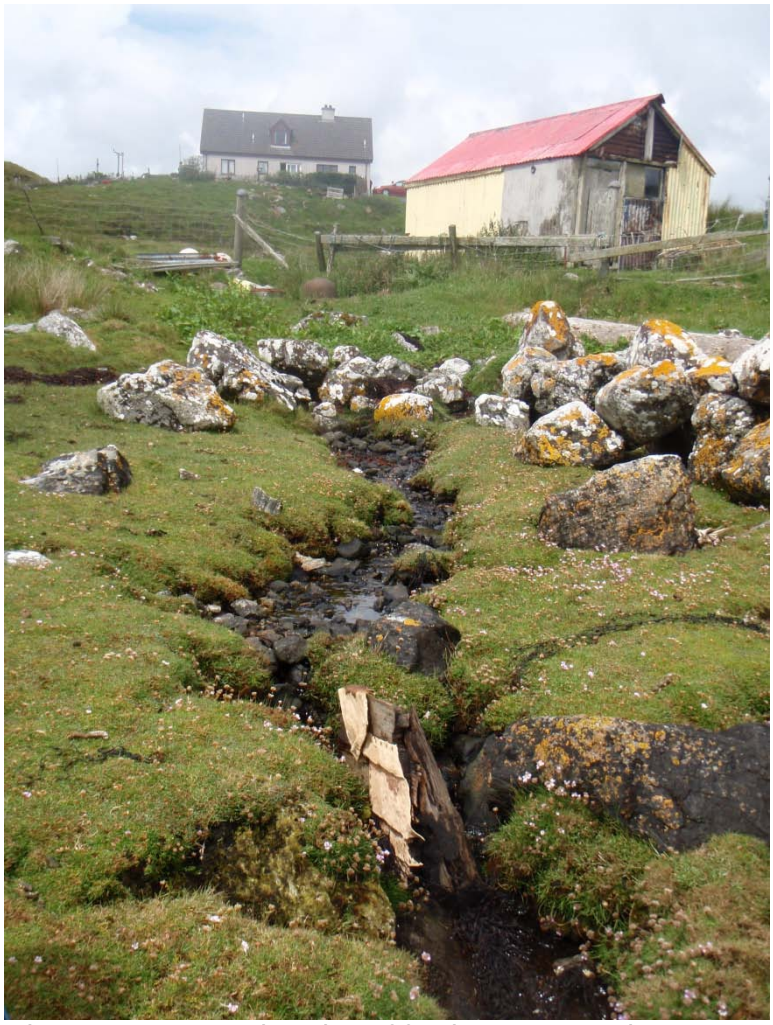

Figure 19. Stream, location of fresh water sample LMFW3

Figure 20. Fresh water draining from inland loch into Loch Portain, location of fresh water sample LMFW4