Scottish Sanitary Survey Report

Sanitary Survey Report
Loch na Cille
AB-617
August 2013

Report Distribution – Loch na Cille

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Partner Organisations

The hydrographic assessment and the shoreline survey and its associated report were undertaken by SRSL, Oban.

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Appendices

I. Executive Summary

A sanitary survey was undertaken at Loch na Cille in response to submission of a standard application for classification of the intertidal sands at Loch na Cille for the harvest of common cockles.

Loch na Cille is a small, shallow inlet at the head of Loch Melfort, located approximately 18 km south of Oban, on the west coast of Scotland.

The fishery is a small bed of common cockles located on the intertidal shore at the head of Loch na Cille. The cockles are harvested by hand raking.

The primary sources of contamination are sewage discharges to the watercourses Abhainn na Cille and its tributaries, and Eas á Choire as well as directly to Loch na Cille. The largest of these is the discharge from Kilmelford WWTW, which discharges to the mouth of Abhainn na Cille, near the north east end of the cockle bed.

The area is largely forested, with agriculture limited to a very small number of farms undertaking extensive cattle and sheep rearing. A large proportion of the accommodation in the area is for tourism, and a significant seasonal variation in the human population is expected. Any overboard discharges from yachts on moorings along the south shore of the loch are likely to lead to increased contamination levels in this vicinity during the summer cruising season.

Contaminants are likely to be carried to the fishery either in freshwater sources or via direct discharge, from where they are predicted to be largely mixed under most conditions. Transport of contaminants from source was predicted to be approximately 0.5 km, and therefore it is expected that sources within this distance of the cockle bed will have the most significant impact on water quality there. Given that the largest sources discharge to Abhainn na Cille, it was recommended that the representative monitoring point (RMP) be established at the northeastern extent of the cockle bed.

The recommended RMP and production area boundaries are presented in tabular form overleaf and graphically in Section 16, Recommendations.

II. Sampling Plan

Production Area	Loch na Cille
Site Name	Loch na Cille Cockles
SIN	AB-617-1204-04
Species	Common cockles
Type of Fishery	Wild, raked
NGR of RMZ	The area bounded by lines drawn from NM 8418 1266 to NM 8419 1246 to NM 8429 1249 to NM 8427 1264 and back to NM 8418 1266
Tolerance (m)	Not applicable
Depth (m)	Not applicable
Method of Sampling	Hand raking
Frequency of Sampling	Monthly
Local Authority	Argyll & Bute Council
Authorised Sampler(s)	Fraser Anderson William MacQuarrie Ewan McDougall Allison Hardie
Recommended Production Area	The area bounded by lines drawn between points NM 8400 1279 and NM 8388 1249 extending to the MHWS

III. Report

1. General Description

Loch na Cille is a small shallow inlet about 500 m wide located southeast of Fearnach Bay at the head of Loch Melfort, approximately 18 km south of Oban.

The village of Kilmelford lies less than 1km to the northeast of the head of Loch na Cille and is the only sizable settlement in the immediate vicinity. Abhainn na Cille and Eas a' Choire flow into the head of the loch, draining a number of freshwater lochs around Kilmelford. An overview map of the area is shown in Figure 1.1.

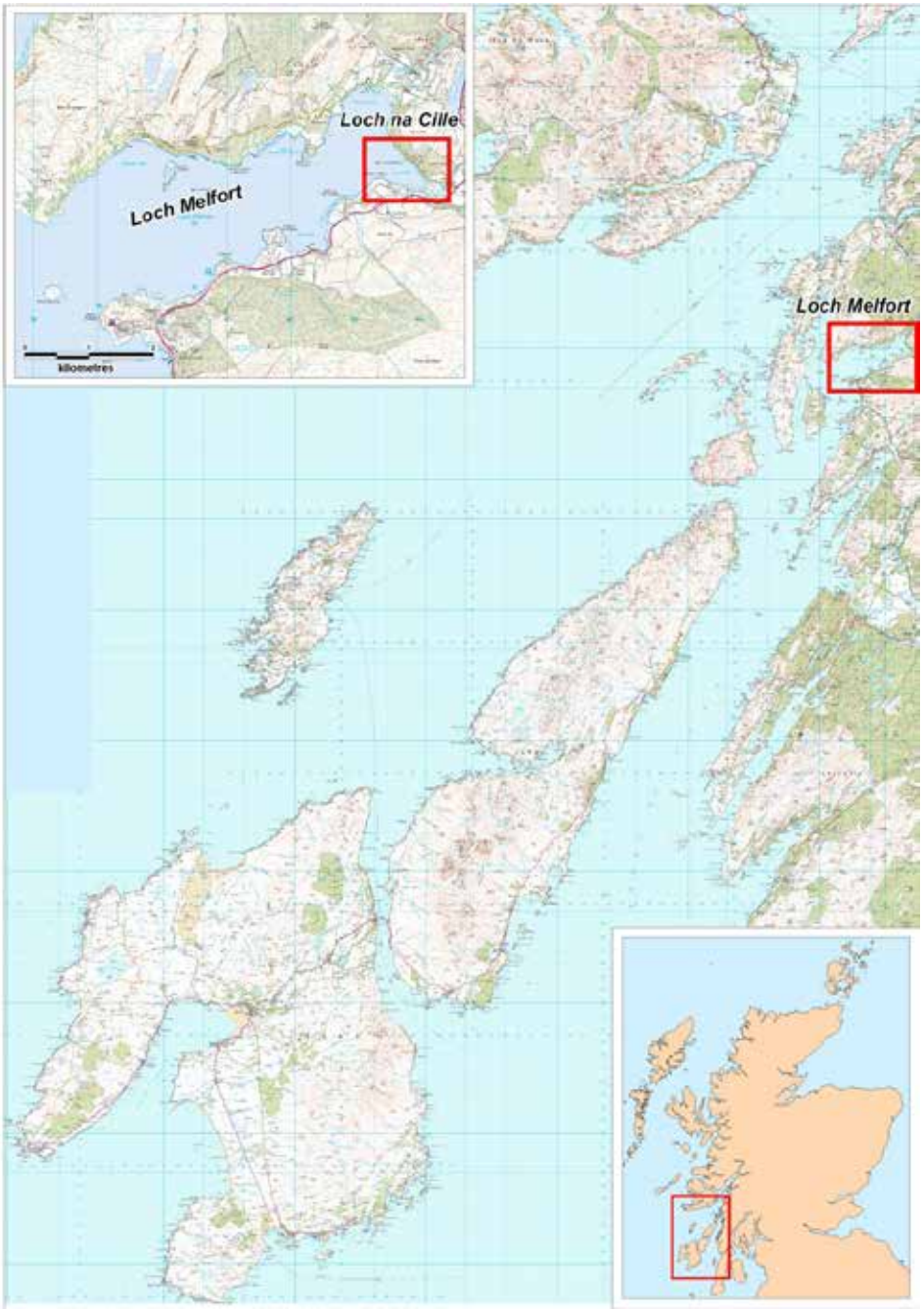

Figure 1.1 Location of survey area

2. Fishery

Loch na Cille falls within the Loch Melfort classified production area, which is currently classified for common mussels only. Standard and fast track applications were submitted in March 2012 for classification of the intertidal sands at the head of Loch na Cille for the harvest of common cockles. The area was given a Fast Track (FT) classification from 26 May - 25 September 2012. Details are presented in Table 2.1. The area identified in the application and the FT sampling point are shown in Figure 2.1

Table 2.1 Loch na Cille cockle fishery

Production area	Site	SIN	Species	FT sampling point	FT boundaries
Loch na Cille	Loch na Cille Cockles	AB-617-1204-04	Common Cockle	NM 8416 1251	Area bounded by lines drawn between points NM 8400 1278 and NM 8388 1250 extending to the MHWS

Harvesting is undertaken by hand raking in the intertidal zone.

Figure 2.1 shows the estimated cockle bed area which was derived from an outline provided by Fraser Anderson of Argyll and Bute council, as well as the FT cockle area boundaries.

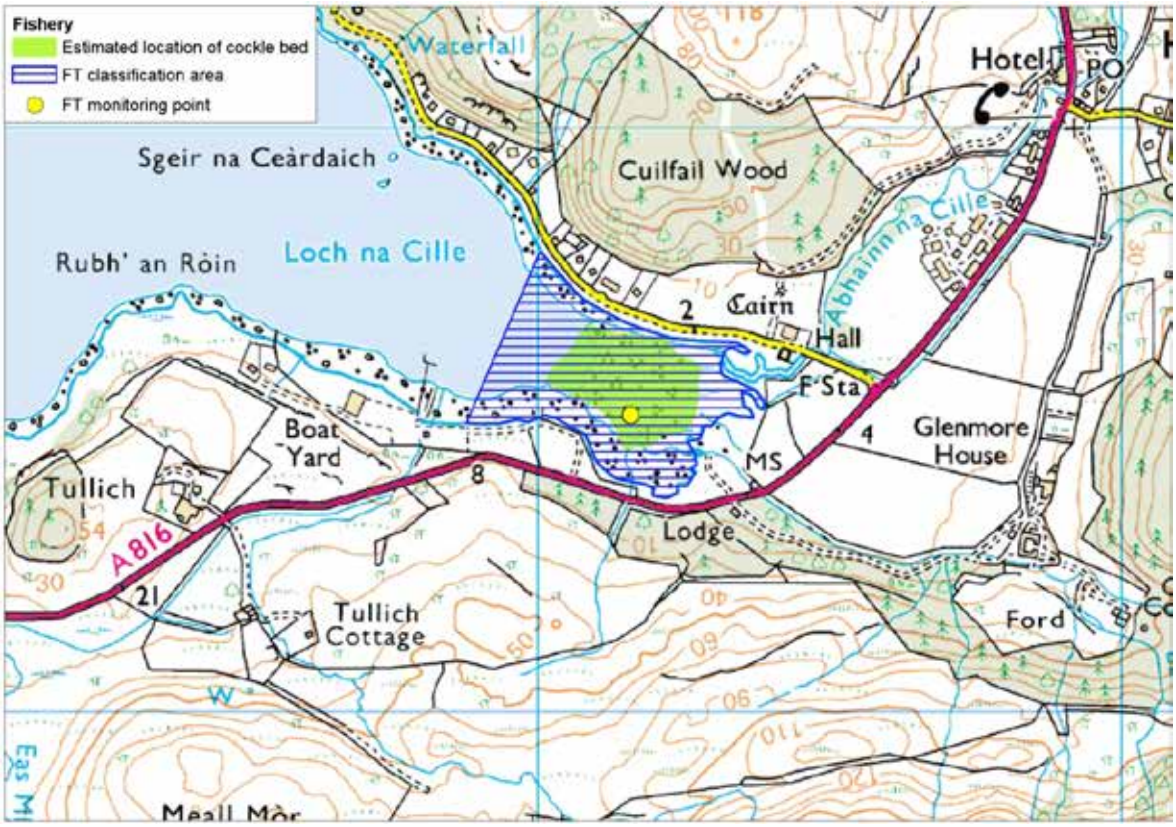

Figure 2.1 Loch na Cille cockle Fishery

3. Human Population

Information was obtained from the General Register Office for Scotland on the population within the census output areas in the vicinity of Loch na Cille. Detailed data from the 2011 census was unavailable at the time of writing this report, therefore data presented below are from the 2001 census. Figure 3.1 presents a map of the census output areas and observations relevant to the distribution of human population in the area of Loch na Cille.

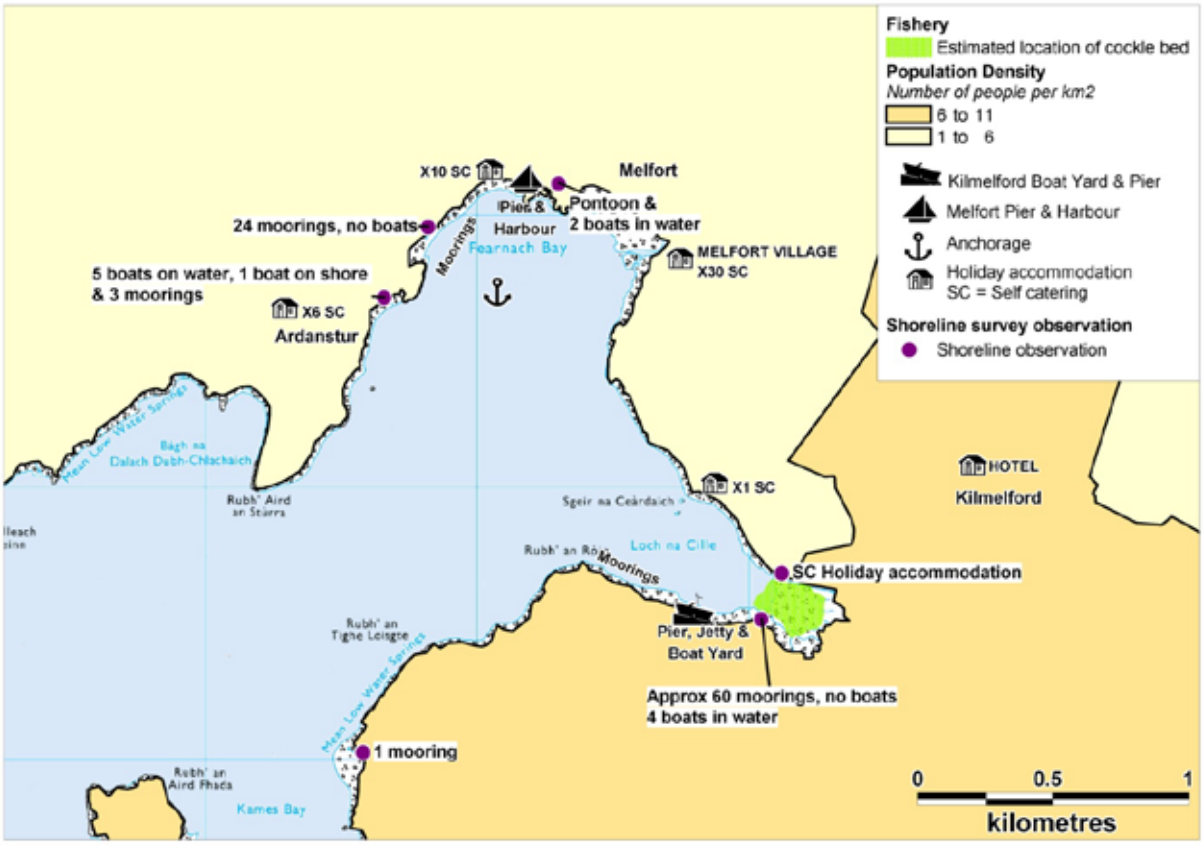

Figure 3.1 Population map of survey area

Population density in the vicinity of the fishery is low. The settlement of Kilmelford is located within 1 km to the east of Loch na Cille and the settlements of Melfort and Ardanstur are located on the shoreline of Fearnach Bay. There is a relatively large amount of holiday accommodation in the area. Melfort Village has approximately 30 self catering holiday cottages, Melfort Harbour has 12 self catering cottages and Ardanstur has 6 self catering cottages. There is a hotel in Kilmelford with 12 double bedrooms and a further self catering cottage on the northern shoreline of Loch na Cille. During the shoreline survey an additional self catering holiday cottage was observed on the north western shoreline of Loch na Cille. Melfort Village is open year-round, with highest rents charged for July and August and Christmas week, which is when demand is presumed to be highest.

South of Loch na Cille is Kilmelford boat yard and pier. The boatyard provides repairs and services including showers and toilets, summer moorings (including 55 heavy-duty swinging moorings and 6 alongside berths) and winter boat storage (Kilmelford Yacht Haven, 2012). During the shoreline survey approximately 60 moorings were observed, none of which had boats on and 4 boats were observed in the water. Melfort Harbour, in Fearnach Bay, has 21 secure, heavy duty swing moorings and a floating dock. Facilities at the Harbour include showers, toilets and dry dinghy storage (http://www.mellowmelfort.com/moorings.html). During the shoreline survey a pontoon and 2 boats were observed at this location. There is also an anchorage south of Melfort Harbour and additional moorings east of Fearnach Bay (approximately 24 moorings were counted during the shoreline survey) and east of Loch na Cille. During the shoreline survey, 6 boats and 3 moorings were observed west of Ardanstur.

Due to abundant holiday accommodation in the area, it is expected that the population in the area will increase significantly during the summer holiday months. Any overboard discharges from boats using the moorings and/or anchorages could have a significant impact on water quality in Loch na Cille and Fearnach Bay and these are considered most likely during the summer months.

Impacts from human sources to the water quality of the shellfish bed are likely to be seasonal, peaking during the summer months and over Christmas week, when visitor numbers are expected to be highest.

4. Sewage Discharges

Information on sewage discharges to the area around Loch na Cille was sought from Scottish Water and the Scottish Environment Protection Agency (SEPA). Data requested included the name, location, type, size (in either flow or population equivalent), level of treatment, sanitary or bacteriological data, spill frequency, discharge destination (to land or to waterbody), any available dispersion or dilution modelling studies, and whether improvements were in work or planned. All reported grid references were restated to the nearest 10 m for the purposes of presentation in the tables below.

These datasets were cross-validated and then also compared with the shellfish growing water report for Loch Melfort. When data did not match, further details were sought from one or both of the data providers to ensure accuracy.

Scottish Water identified 5 continuous and intermittent discharges for the area (Table 4.1). Those that discharge to Loch na Cille, to Loch Melfort within 3 km of the production area, or to watercourses discharging within or near the production area are considered of greatest significance to the fishery due to the small size of the catchment.

Table 4.1 Scottish Water discharges, Loch na Cille area

Consent Ref No.	NGR	Discharge Name	Discharge Type	Level of Treatment	Flow (m^3/day)	PE	Notes
CAR/L/1021959	NM 8445 1259	Kilmelford WWTW FE	Continuous	Secondary	59	-	
	NM 8451 1259	Kilmelford WWTW CSO	Intermittent	6 mm screen	-	-	
	NM 8449 1258	Kilmelford WWTW EO1	Intermittent	12 mm screen	-	-	
	NM 8449 1259	Kilmelford WWTW EO2	Intermittent	-	-	-	
-	NM 8484 1300	Cuilfail Cotts	Continuous	Septic tank	-	17	discharge from 6 houses

- Data not provided, ST=Septic Tank, PS=pumping station, CSO=combined sewage overflow

Scottish Water do not collect bacteriological quality or spill frequency data for these discharges. Where given, flow or population equivalent data have been included in the tables. The discharges listed in Table 4.1 are mapped in Figure 4.1.

All of the discharges listed above are within the Kilmelford area. The reported locations for Kilmelford WWTW EO1 and EO2 lie within 10 m of one another, suggesting they either have adjacent outlets, or utilise the same outlet. All Kilmelford WWTW outfalls discharge to the head of Loch na Cille, directly into the production area.

The only other Scottish Water asset in the area is the discharge for Cuilfail Cotts SEP FE which discharges to the Abhainn na Cille, which in turn feeds directly into

the production area. Scottish Water was unable to provide a CAR number and SEPA had no discharge consent which corroborated directly, although CAR/R/1038778 (Cuil Lodge), which plots within 60 m of the Scottish Water discharge, has a similar name and is assumed by SEPA to be the same discharge.

Both SEPA and the Shellfish Growing Waters Report (SGW), which is compiled by SEPA, have Glebe Housing development septic tank (CAR/L/1021959) listed as a discharge which the SGW lists as a Scottish Water asset. When queried with Scottish Water it was noted that this septic tank has been incorporated into Kilmelford WWTW (CAR/L/1021959) and SW confirmed that it is an abandoned asset with no flow through it. Therefore it has been removed from the dataset.

Scottish Water identified there were no plans for future improvement of the community discharges in this area.[1]

SEPA provided information on a large number (79) of consented discharges within 3 km of the cockle bed. A subset of 38 were situated within the area mapped in Figure 4.1. For the Kilmelford WWTW discharges, a copy of the consent licence was provided by SEPA and data relating to the continuous and intermittent discharges covered by the licence was extracted from it.

Table 4.2 presents a summary of the SEPA discharge data for the mapped area.

Table 4.2 Summary of discharge consents identified by SEPA*

Type	Number of consents
Associated with public sewerage network	4
Private discharges to water	26
Private discharges to land or soakaway	8
Fish Farms/Hatcheries	3

* for the area mapped in Figure 4.1

Discharges identified by SEPA within the mapped area in Figure 4.1 are listed in Table 4.3. As mentioned before Scottish Water had no licence number for Cuilfail Cotts and when queried SEPA have assumed it is the same as CAR/R/1038778, Cuil Lodge. The PEs given for these differ slightly.

Dry Weather Flow data for Kilmelford WWTW was provided by both SEPA and Scottish Water and were found to be different. For the purpose of this assessment the larger value will be used.

Kilmelford water treatment works (WTW) is located on the Abhainn na Cille and supplies potable water to Kilmelford serving a population of just under 100 (Black, 2011). The filters are purged by backwash on a weekly basis.

[1]. Subsequent to the draft consultation, SEPA identified that SW had applied for a CAR variation to extend the Kilmelford WWTW outfall into Loch Melfort and away from Abhainn na Cille.

One marine cage fish farm (MCFF) and a freshwater hatchery are located in, or discharge to, Kames Bay approximately 2 km from the production area. A further MCFF was identified east of Eliean Coltair, near the north shore of Loch Melfort.

Table 4.3 Discharge consents near Loch na Cille (SEPA)

No	Licence	NGR	Description	Treatment	PE	Discharge to	Note
1	CAR/R/1039684	NM 8173 1191	Ardbeithe	Septic tank	6	Loch Melfort	
2	CAR/R/1039196	NM 8169 1187	Tigh An Rudha	Septic tank	5	Loch Melfort	
3	CAR/R/1039729	NM 8156 1178	Kames Lodge	Septic tank	6	Loch Melfort	
4	CAR/R/1038097	NM 8166 1171	Craiglea	Septic tank	5	Loch Melfort	
5	CAR/R/1037727	NM 8161 1169	Craigaol	Septic tank	5	Loch Melfort	
6	CAR/R/1039161	NM 8164 1163	Laroch	Septic tank	5	Loch Melfort	
7	CAR/R/1039159	NM 8163 1159	Craig Na Lynn	Septic tank	5	Loch Melfort	
8	CAR/R/1037640	NM 8157 1156	Tulloch Beag	Septic tank	6	Loch Melfort	
9	CAR/R/1037445	NM 8172 1129	Kames Fish Farm	Septic tank	5	Soakaway	
10	CAR/R/1037444	NM 8175 1118	Kames Beag	Septic tank	5	Soakaway	
11	CAR/S/1098154	NM 8199 1124	Plot C Conisby STW	-	26	Soakaway	
12	CAR/R/1108584	NM 8191 1148	Kames	Septic tank	6	Eas an Sgriodain	
13	CAR/R/1037446	NM 8223 1161	The Pier	Septic tank	5	Kames Bay	
14	CAR/R/1039974	NM 8344 1233	Tullich Farm	Septic tank	6	Soakaway	
15	CAR/R/1038432	NM 8353 1267	Ardrowan & Tigh Na Bata	Septic tank	10	Loch na Cille	
16	CAR/R/1041585	NM 8373 1262	Workshop, Kilmelford Yacht Haven	Septic tank	30	Loch na Cille	
17	CAR/R/1041583	NM 8379 1257	Chalet 1, Kilmelford Yacht Haven	Septic tank	5	Loch na Cille	
18	CAR/R/1036697	NM 8392 1251	Camusdarach STW	-	6	Loch na Cille	
19	CAR/R/1064791	NM 8406 1269	Coille Dharaich	Septic tank	6	Loch na Cille	
20	CAR/R/1037797	NM 8399 1277	Seaview	Septic tank	5	Loch Melfort	
21	CAR/R/1039644	NM 8399 1296	Achnacille and Allt-Na-Crioch	Septic tank	12	Land	
22	CAR/R/1037498	NM 8406 1277	Lochend	Septic tank	5	Soakaway	
23	CAR/R/1013536	NM 8417 1272	Kinloch, Degnish Road	Septic tank	5	Land	
24	CAR/L/1021959	NM 8445 1259	Kilmelford WWTW EO2	<12mm screen	na	Abhainn na Cille	4 hrs storage
25	CAR/L/1021959	NM 8445 1258	Kilmelford WWTW EO1	<12mm screen	na	Abhainn na Cille	3.3 hrs storage
26	CAR/L/1021959	NM 8445 1259	Kilmelford WWTW CSO	<6mm screen	na	Abhainn na Cille	
27	CAR/L/1021959	NM 8445 1259	Kilmelford WWTW FE	secondary	164	Abhainn na Cille	connected PE 112
28	CAR/R/1076812	NM 8498 1212	Glen Cottage	Septic tank	5	Eas á Choire	
29	CAR/R/1038782	NM 8480 1278	Glenmore House	Septic tank	25	Eas na Caillich	
30	CAR/R/1038778	NM 8487 1306	Cuil Lodge + 3	Septic tank	22	Abhainn na Cille	

No	Licence	NGR	Description	Treatment	PE	Discharge to	Note
31	CAR/R/1077967	NM 8503 1328	Glenbeg	Septic tank	5	Abhainn na Cille	
32	CAR/S/1026274	NM 8521 1362	Kilmelford WTW	Filter backwash	na	Abhainn na Cille	
33	CAR/R/1104101	NM 8416 1455	Hazlewood Cottage	Septic tank	5	River Oude	
34	CAR/R/1018019	NM 8407 1443	Kilmelford Hydro Power Station	Septic tank	5	River Oude	
35	CAR/L/1000244	NM 8401 1431	Melfort Leisure Club STW	-	1	River Oude	
36	CAR/S/1013937	NM 8326 1406	New restaurant STW, Melfort Pier and Harbour	-	32	Fearnach Bay	
37	CAR/R/1015362	NM 8301 1415	Glenfearnoch Estate Cottage STW	-	8	Coastal waters	
38	CAR/R/1071929	NM 8299 1437	Primrose Cottage, Glenfearnach Estate	Septic tank	5	Soakaway	

- Not given; na Not applicable

The flow data provided for Melfort Leisure Club (No. 35, Table 4.3) was given as 1 for DWF, MDF, and PE. A query was raised with SEPA, however no response had been received by the time of writing this report. This is considered likely to be a large discharge associated with Melfort Village holiday complex, and therefore the value of 1 is considered to be invalid.

Most of the private discharges are located on either side of Loch na Cille or on the headland of Rubh'an Aird Fhada and have a PE between 5 and 12. Two of the largest discharges, Glenmore House (No. 29, Table 4.3) and Kilmelford Yacht Haven (No. 17, Table 4.3), with PE of 25 and 30 respectively, discharge into Loch na Cille. Another large septic tank, located at Melfort Pier and Harbour (No. 36, Table 4.3), with a PE of 32 lies within 2 km of the production area.

Four discharges to land are located away from watercourses and MHWS so are considered unlikely to have an impact on the production area.

Eleven observations relating to sewerage infrastructure and discharges were made during the shoreline survey are listed in Table 4.4. Observations were mainly located on the shore of Loch na Cille.

Table 4.4 Discharges and septic tanks observed during the shoreline survey

No	Date	NGR	Description
1	26/03/2013	NM 8312 1415	Concrete structure on shore next to road with Melfort Village Pier Houses behind. Small burn runs under road and next to concrete structure. Smell of sewage
2	26/03/2013	NM 8412 1269	Metal pipe cast in concrete. Not flowing. 'Pebble Beach View' house behind shore.
3	27/03/2013	NM 8350 1267	Cast iron outflow pipe. Diameter - 10 cm. Tide above outflow so no sample taken. No obvious discharge.
4	27/03/2013	NM 8353 1266	Outflow pipe (plastic) with discharge. 10 cm diameter.

No	Date	NGR	Description
5	27/03/2013	NM 8358 1262	10 cm diameter plastic pipe on shore from house. No discharge.
6	27/03/2013	NM 8372 1257	Discharge from Melfort boatyard. Strong smell.
7	27/03/2013	NM 8374 1258	Plastic pipe 10 cm diameter. No outflow.
8	27/03/2013	NM 8388 1250	Plastic outflow pipe - 10 cm diameter. Very strong smelling discharge.
9	27/03/2013	NM 8391 1250	Plastic outflow pipe, 10 cm diameter, no outflow.
10	27/03/2013	NM 8450 1260	Sewage plant.
11	27/03/2013	NM 8444 1258	Discharge from sewage plant (Kilmelford waste water discharge). Brown water.

Samples were taken of discharge effluent where possible, but not all pipes were flowing during the time of the survey. Of those discharges where samples were taken some could be considered to be moderate to high values

The discharge identified in observation 1 did not correlate directly with any SEPA or Scottish Water discharge. A water sample collected from this source returned as result of <1000 *E. coli* cfu/100 ml.

Observation 4 appears to relate to SEPA discharge 15 (Table 4.4). It was not possible to sample the discharge directly due to the state of the tide and due to the close proximity of other discharges (Observation 3) a sea water sample was taken. This returned a high result of 300 *E. coli* cfu/100 ml. While the water quality at this location may have been influenced by other potential faecal sources in the area, the nearby discharge pipes are assumed to be the main source of contamination in this sample.

Observation 6 appears to correlate with No. 16 in Table 4.3. The discharge was noted as smelling strongly, but a water sample yielded a result of <1000 *E. coli* cfu/100 ml.

Observation 8, which did not correlate directly with any SEPA or Scottish Water discharges, was found to be significantly contaminated. The discharge was noted as smelling strongly, and a water sample taken from the outflow returned a result of 6.7×10^4 *E. coli* cfu/100 ml.

Observation 11, which relates to Kilmelford WWTW, returned a high result of 2.7×10^6 *E. coli* cfu/100ml which is more typical of primary treated sewage rather than the secondary treatment at this works. A local man encountered during the shoreline survey stated that there had been problems with the works and a strong smell of sewage came down the river at times.

It was not clear in some cases whether an observed flow related to an outfall, an overflow or a flow to a watercourse. If there was any doubt, the observation was included in Table 4.4. Therefore, not all observations given there may relate to sewage discharges.

Overall, the production area is subject to contamination from septic tanks discharging to sea around the shores of Loch na Cille, as well as those discharge to watercourses Abhainn na Cille, Eas na Caillich and Eas á Choire all of which discharge to the head of the loch in close proximity to the cockle bed. Significant contamination is likely to come from the Kilmelford WWTW discharge due to its proximity to the bed. However, it should be noted that the combined PE of all the other sewage sources to Loch na Cille and its tributaries is slightly higher than the connected PE reported for the Kilmelford WWTW and therefore these other sources are also likely have a significant impact on water quality at the fishery. There is further the possibility of some contamination associated with more distant sources located within Loch Melfort.

Sewage=Related Acronyms

WWTW/STW	Wastewater (Sewage) treatment works	LSO	Long sea outfall
CSO	Combined sewer overflow	SSO	Settled storm overflow
EO	Emergency overflow	PE	Population equivalent
SPS/PS	Sewage pumping station	DWF	Dry weather flow
FE	Final effluent	ST	Septic tank
MDF	Mean daily flow	WTW	Water Treatment Works (potable)

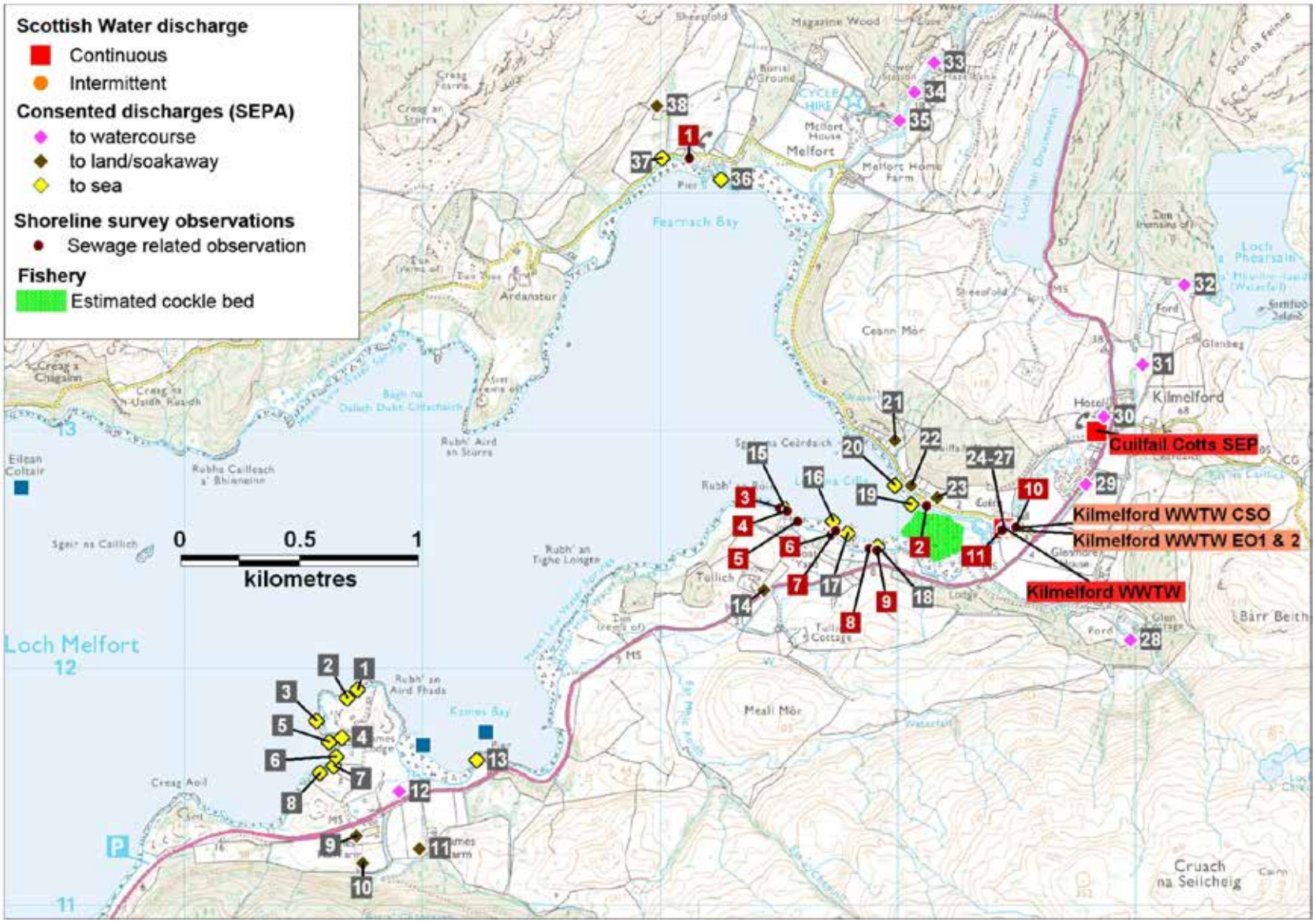

Figure 4.1 Map of discharges for Loch na Cille

5. Agriculture

Information on the spatial distribution of animals on land adjacent to or near the fishery can provide an indication of the potential amount of organic pollution from livestock entering the shellfish production area. Agricultural census data to parish level was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the Kilninver and Kilmelford parish. Reported livestock populations for the parish in 2012 are listed in Table 5.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data. Any entries which relate to less than five holdings, or where two or fewer holdings account for 85% or more of the information, are replaced with an asterisk.

Table 5.1 Livestock numbers in agricultural parishes along the Loch na Cille coastline 2012

	Kilninver & Kilmelford	
	131 km^2	
	Holdings	Numbers
Pigs	*	*
Poultry	16	442
Cattle	24	1,366
Sheep	36	16,184
Other horses and ponies	10	48

The Kilninver and Kilmelford parish covers a large area, encompassing a total land area of over 131 km^2 (shown in the inset of Figure 5.1). The numbers of pigs were not reported due to the small number of holdings. Relatively small numbers of poultry and horses and ponies were reported. Numbers of cattle and sheep were relatively high, although as no spatial data of the location of the holdings is available it is not possible to estimate the potential impact of these to Loch na Cille.

The SEPA Loch Melfort Shellfish Growing Waters report (2011) identifies that there are two known farms within the area that run extensive beef and sheep production systems. Two farms are noted on the OS map: Kames Farm, to the southwest of the Loch na Cille and Melfort Home Farm at the head of Fearnach Bay to the north of Loch na Cille. However, no further information was found on these farms.

An additional significant source of spatially relevant information on livestock population in the area was the shoreline survey (see Appendix 5) which only relates to the time of the site visit on 26th March 2013 (see Table 5.1). Observations made during the survey are dependent upon the viewpoint of the observer some animals may have been obscured by the terrain. The spatial distribution of livestock observed and noted during the shoreline survey is illustrated in Figure 5.1.

During the shoreline survey only 4 sheep were observed in a field on the west shoreline of Fearnach Bay (see Figure 5.1). However, sheep and cattle were observed in the fields surrounding the greater Loch Melfort area whilst travelling to the site.

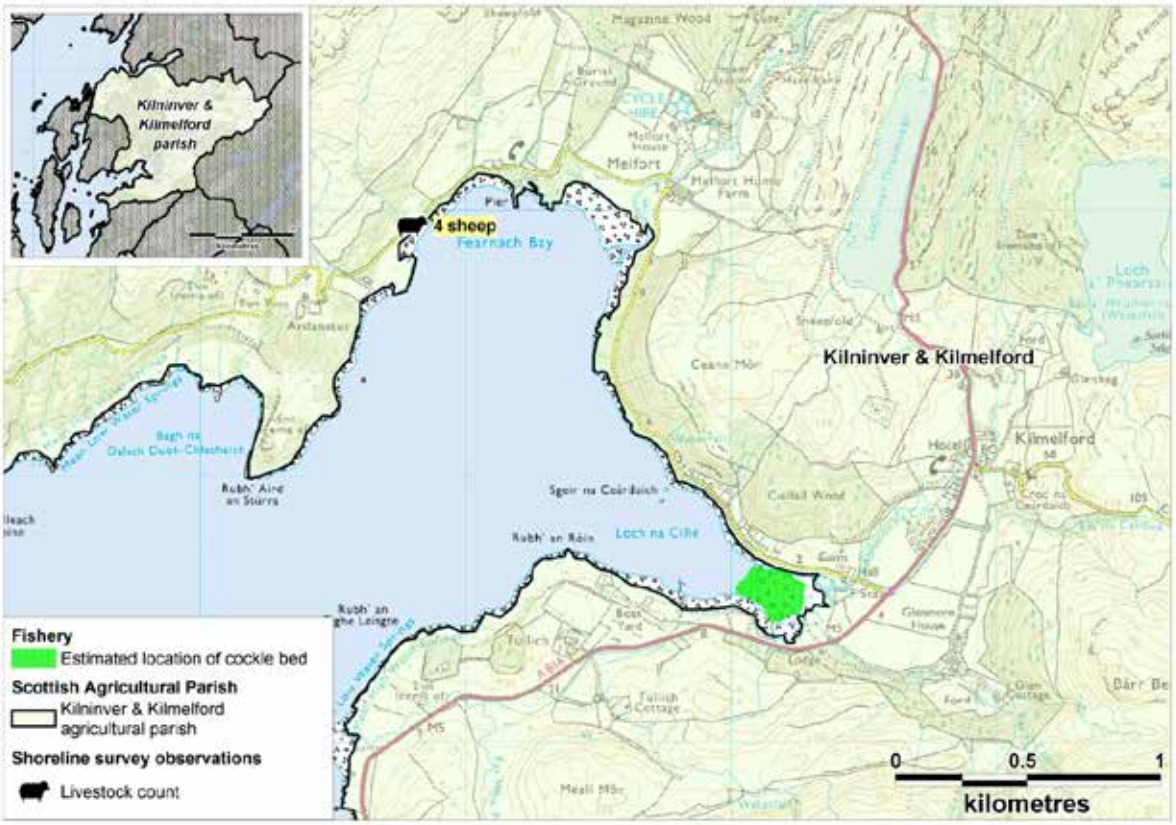

Figure 5.1 Livestock observations at survey area

Therefore, the overall risk from farm animal sources of faecal contamination in the immediate vicinity of Loch na Cille is considered to be low.

6. Wildlife

Pinnipeds

The common/harbour seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*) are commonly found in waters outside Loch na Cille. There is anecdotal evidence that seals frequent Loch Melfort (Loch Melfort Hotel, 2013), in which Loch na Cille is located.

The Scottish Committee on Seals (SCOS) 2011 report showed that < 200 common seals were seen around Loch Melfort and the surrounding Strathclyde area during moulting season surveys undertaken between 2001 and 2006. The report also shows that common seal populations around the west coast of Scotland in the Strathclyde are also relatively stable. There are no reports of grey seal populations around the Strathclyde area. Loch na Cille represents a relatively shallow and a very busy boating area and therefore it is unlikely to be used by seals to forage/haul out. The contamination risk from seals to the fishery is therefore expected to be low. No seals were observed during the shoreline survey.

Cetaceans

Due to the shallow nature of Loch na Cille, it is unlikely that whales or dolphins would be able to enter into the harvest area. However, there are anecdotal accounts of the harbour porpoise (*Phocoena phocoena*) in Loch Melfort (Loch Melfor Hotel & Restaurant, 2013) as well as HWDT sightings of sperm whales and dolphin species including the bottlenose dolphin and the common dolphin in the waters surrounding Loch Melfort (Hebridean Whale and Dolphin Trust, 2013). Risk of contamination from this source is considered to be very low.

Birds

There are no RSPB reserves located within 25 km of Loch na Cille. Seabird 2000 census data (Mitchell *et al*., 2004) was therefore queried for the area within a 5 km radius of Loch na Cille and is summarised in Table 6.1 below and displayed in Figure 6.1. This census undertaken between 1998 and 2002 covered the 25 species of seabird that breed regularly in Britain and Ireland. Counts given relate to pairs of birds.

Table 6.1 Seabird counts within 5 km of Loch na Cille.

Common name	Species	Count	Method
Arctic tern	*Sterna paradisaea*	2	Occupied nests
Common gull	*Larus canus*	32	Occupied nests
Black headed gull	*Larus ridibundus*	200	Occupied nests
Common tern	*Sterna hirundo*	238	Occupied nests
Arctic tern	*Sterna paradisaea*	4	Occupied nests

The larger collection of occupied nests (474) is situated on the small island of Sgeir na Caillich, approximately 2.7 km west of Loch na Cille. Contamination levels are expected to peak in the spring/summer months during the breeding season.

According to the Argyll Bird Club, other significant bird populations around Loch na Cille include Greenland white-fronted geese, barnacle geese and greylag geese (Argyll Bird Club, 2012). Geese were present in low numbers (n=4) during the shoreline survey and were largely associated with the shoreline and adjacent grassland/fields. Goose droppings were also located adjacent to a watercourse to the northwest of the cockle bed. Gulls were seen in larger numbers around the shoreline (approximately 60). Oyster catchers and ducks were also observed to the northeast and southwest shorelines.

Otters

The Eurasian otter (*Lutra lutra*) is now considered to be ubiquitous within Scotland, inhabiting both rural and urban areas. Anecdotal accounts exist of otters in Loch Melfort, but none could be found at the time of compiling this report on otters in Loch na Cille (Loch Melfort Hotel, 2013). During the shoreline survey, one otter was observed in the water on the eastern side of Loch na Cille. Coastal otters will use watercourses for protection, latrines and cleaning and therefore the larger watercourses discharging to Loch na Cille may carry contamination from this source.

Deer

There are no population data or reports available on deer around Loch na Cille. However, there area anecdotal accounts of Red deer on the high grounds surrounding Loch Melfort (Loch Melfort Hotel, 2013). Red deer area known to migrate from higher grounds to sheltered lower grounds in the winter. Areas of woodland along the north shore and to the south and east of the head of the loch may be used by deer, and therefore watercourses draining these areas may carry faecal contamination from deer.

Overall

Species potentially impacting on Loch na Cille include gulls, geese, otters and deer. Little is known about the numbers of these animals inhabiting the area or about their seasonal movements in and out of the area. There will be some deposition of bird droppings immediately onto the cockle bed. Impacts from other forms of wildlife are likely to be higher around watercourses discharging to the area.

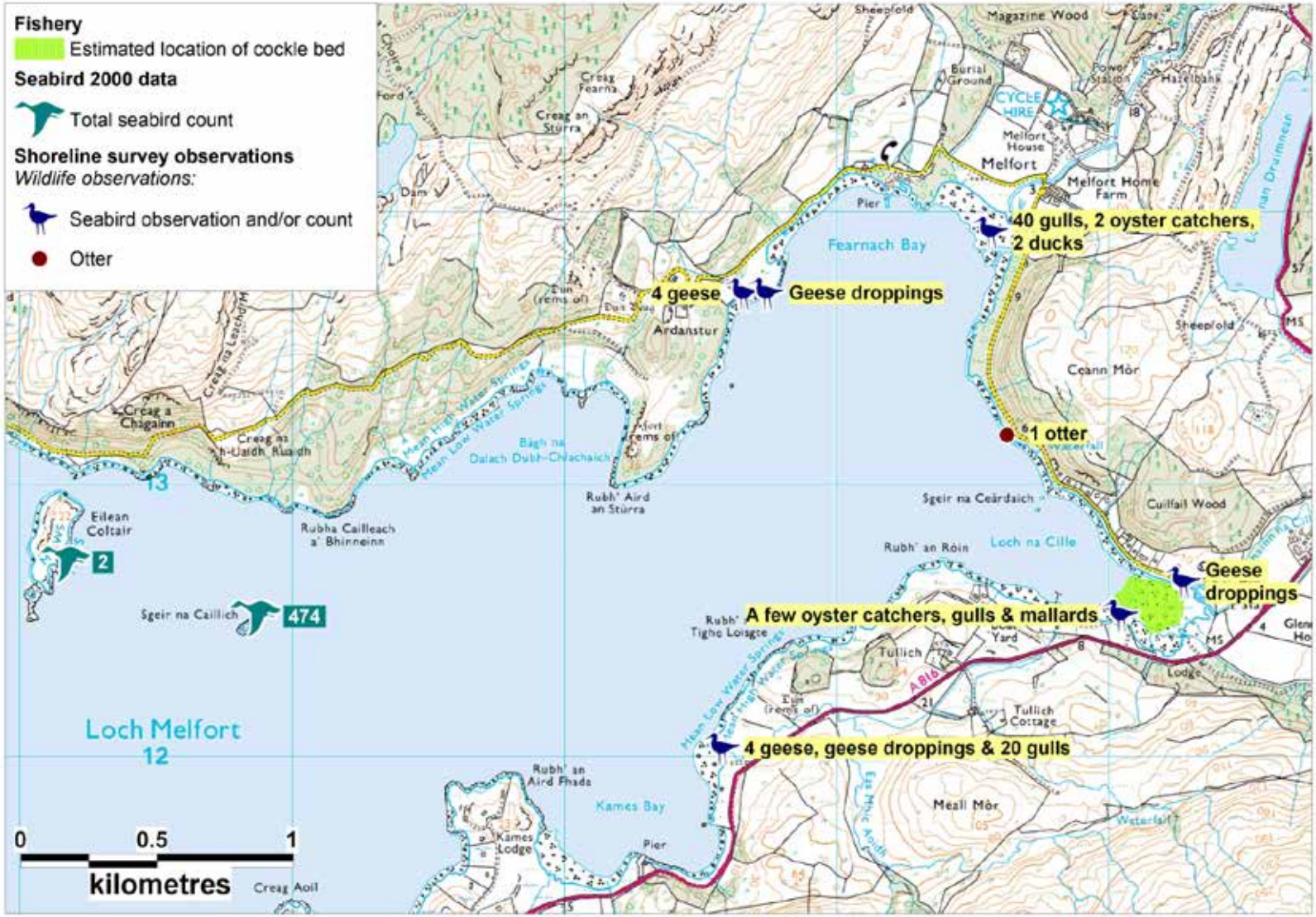

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Figure 6.1 Map of wildlife around Loch na Cille.

7. Land Cover

Land Cover 2007 data for this area was not available at the time of writing this report. The Land Cover Map 2000 data for the area is shown in Figure 7.1 below:

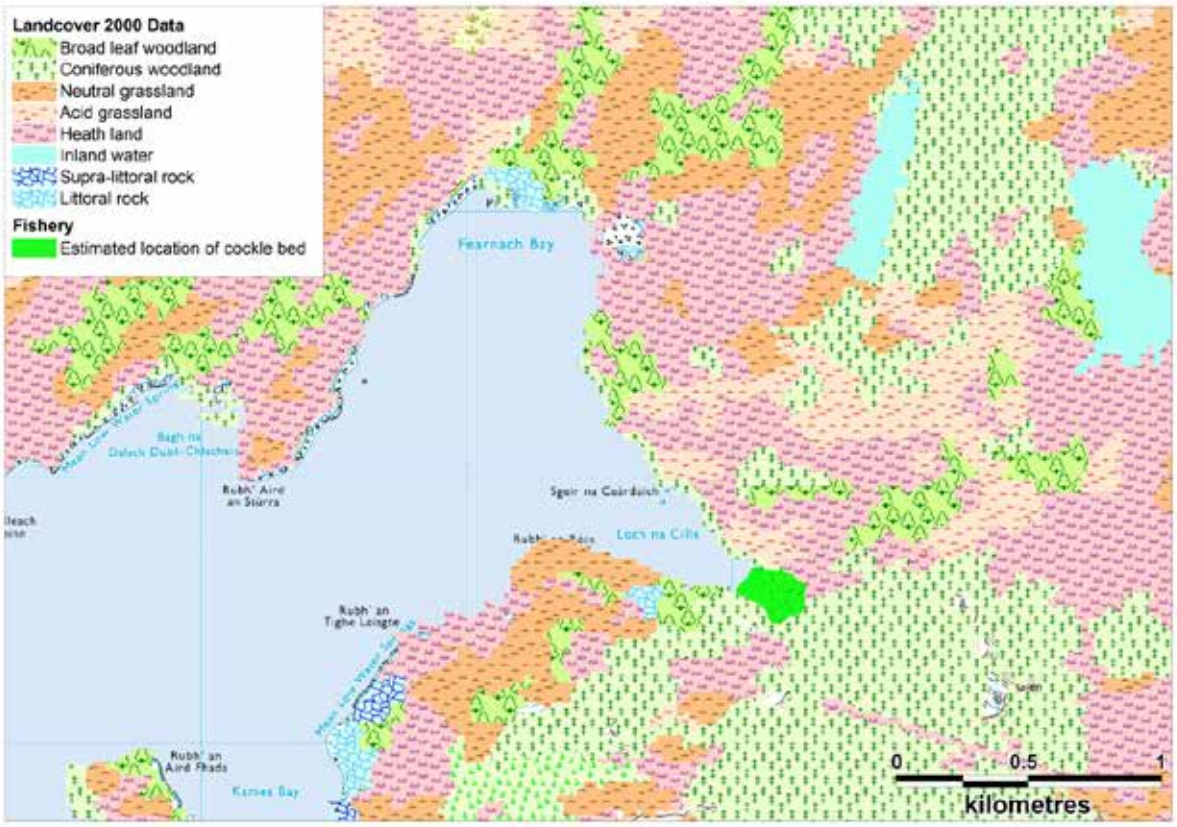

Figure 7.1 LCM2000 class land cover data for Loch na Cille

The immediate shoreline of Loch na Cille is mainly a coniferous woodland with some neutral grassland and broad leaf woodland on the southern shoreline of the loch. An area of improved grassland is shown to the southwest of Loch na Cille. There are no identified areas of suburban or urban development. The SEPA Loch Melfort Growing Waters report (2011) reported that the land cover in the area was predominantly semi-natural woodland, improved pasture and semi-natural grassland.

A brief description of land cover was noted in the shoreline survey report (Appendix 4) The northern shore of Loch na Cille was found to have a mixture of grassland/improved pasture with areas of native woodland adjoining the shoreline, while the southern shore contained a mixture of grassland/improved pasture along with heath and areas of plantation forest/native forest.

The faecal indicator contributions from all land cover types would be expected to increase significantly after rainfall events (Kay, et al., 2008a). Livestock were present in the area at the time of the shoreline survey and any areas utilised for

rough grazing would be expected to contribute significantly to faecal contaminant loading carried in watercourses and overland flow draining the area during rainfall. The risk of faecal contamination based on landcover type is therefore considered to be low.

8. Watercourses

There are no river gauging stations on watercourses discharging to Loch na Cille. Watercourses measured and sampled during the shoreline survey are listed in Table 8.1. These represent the largest freshwater inputs into the survey area. It was noted that in the four to five weeks prior to this survey, the weather had been unseasonably dry, with rainfall well below average. In the 48 hr prior to the survey no precipitation was noted, and no rainfall fell on either of the survey days (26th & 27th March 2013).

Table 8.1 Watercourse loadings for Loch na Cille

No.	NGR	Description	Width (m)	Depth (m)	Flow (m^3/d)	*E. coli* (cfu/ 100 ml)	Loading (*E. coli* per day)
1	NM 8266 1370	Small river	0.75	0.15	430	< 100*	$< 4.3x10^8$
2	NM 8280 1393	Small river	0.58	0.24	1200	< 100*	$< 1.2x10^9$
3	NM 8312 1415	Small burn	0.25	0.02	1100	< 1000*	$< 1.1x10^{10}$
4	NM 8367 1395	River Oude	7.50	0.18	28000	2400	$6.8x10^{11}$
5	NM 8397 1288	Stream	0.25	0.02	560	200	$1.1x10^9$
6	NM 8428 1264	Abhainn na Cille	5.40	0.19	11800	130000	$1.5x10^{13}$
7	NM 8423 1248	Eas a' Choire	1.80	0.06	3500	1200	$4.2x10^{10}$
8	NM 8416 1239	Small stream	0.90	0.15	1500	< 100*	$< 1.5x10^9$
9	NM 8253 1157	Small river	0.55	0.06	240	900	$2.2x10^9$
10	NM 8260 1202	Eas Mhic Aoidh	1.60	0.15	2100	< 100*	$< 2.1x10^9$
11	NM 8383 1251	Stream	1.00	0.05	1100	< 100*	$< 1.1x10^9$

* A nominal assumed value of 100/1000 *E. coli CFU*/100 ml was used to calculate a 'less than' potential loading respectively. NGRs rounded to 10 m, full NGRs can be found in Appendix 1.

Loadings were estimated on the basis of measurements and water sample results from the shoreline survey and are only representative of the conditions on the day of survey. Five watercourses were noted to discharge directly to the head of Loch na Cille, where the cockle bed is located. These were Nos. 5-8 and 11 in Table 8.1. Calculated loadings ranged from $< 1.1x10^9$ to $1.5x10^{13}$ *E. coli*/ day. The estimated loading from Abhainn na Cille represented the highest loading from the 11 watercourses sampled during the shoreline survey.

Four watercourses discharge to Fearnach Bay, approximately 1.5 km NNW of Loch na Cille. Estimated loadings ranged from $< 4.3x10^8$ *E. coli*/ day to $6.8x10^{11}$ *E. coli*/ day (River Oude). The River Oude was the largest source of freshwater to the area mapped in Figure 8.1, although the estimated loading was approximately two logs lower than that of Abhainn na Cille.

Two other watercourses discharging to Kames Bay (No. 9 and 10, Table 8.1) were also sampled. Estimated loadings were relatively low and contamination from these watercourses is considered unlikely to significantly affect water quality at the cockle bed.

Overall, freshwater contamination entering from watercourses 5-8 and 11 will have the largest impact on the Loch na Cille harvest area. Abhainn na Cille represented the highest loading sampled at the time of the shoreline survey and discharges directly to the cockle bed at the head of the loch. Watercourses 1-4 represented relatively moderate levels of contamination, which may impact the harvest area due to their close proximity to Loch na Cille. Due to un-seasonably low levels of rainfall, the current watercourse loadings will under-represent diffuse contamination entering Loch na Cille through freshwater input.

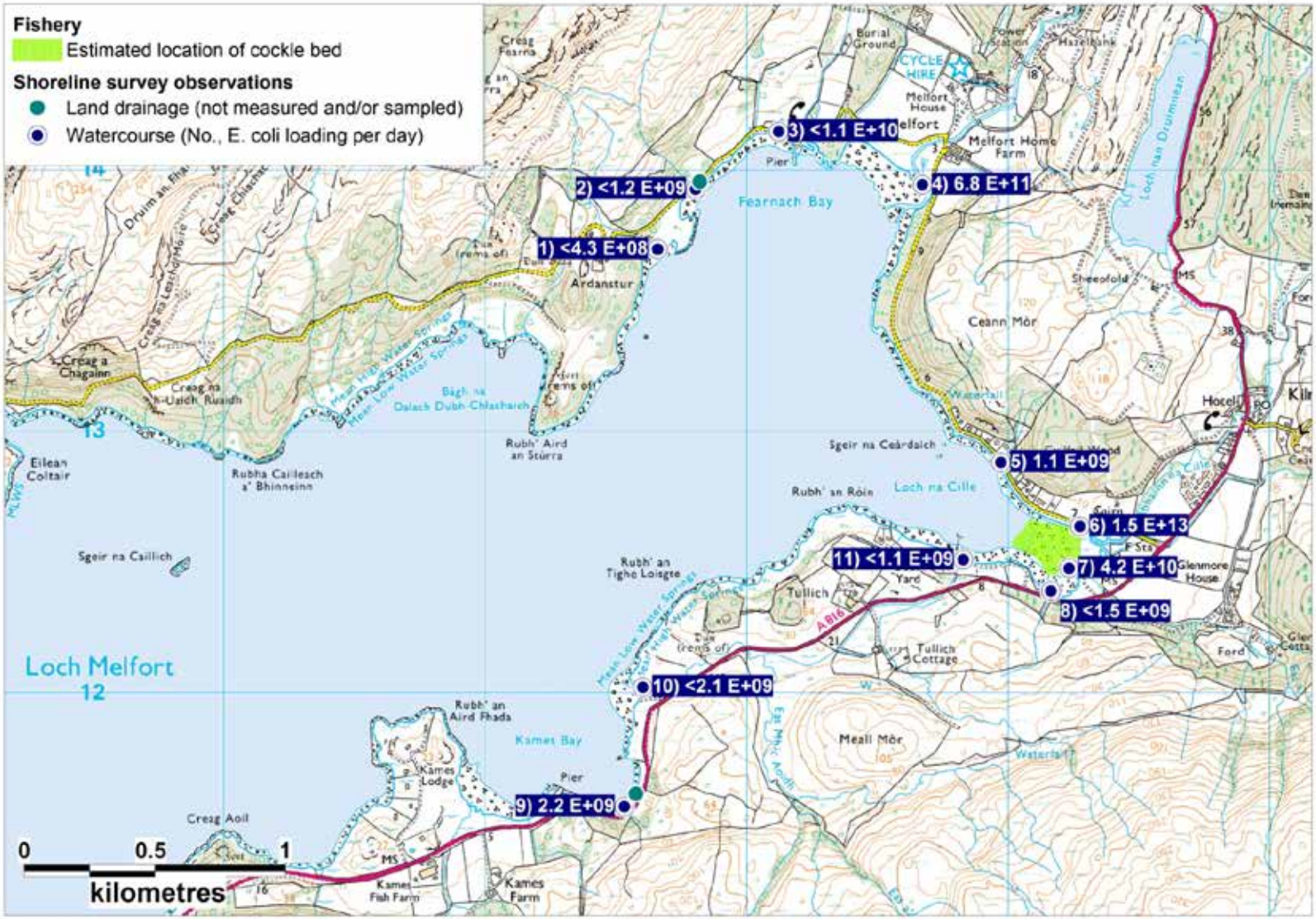

Figure 8.1 Map of watercourse loadings at Loch na Cille

9. Meteorological Data

The nearest weather station for which a near complete rainfall data set was available is located at Lismore: Frackersaig Farm, situated approximately 26 km to the south east of the production area. Rainfall data was available for January 2007 – December 2012. The nearest wind station is also situated in Glasgow, Bishopton, located 80 km south east of the production area. Conditions may differ between this station and the fisheries due to the distances between them. However, this data is still shown as it can be useful in identifying seasonal variation in wind patterns.

Data for these 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 in the context of the bacterial quality of shellfish at Loch na Cille.

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 (Mallin, et al., 2001; Lee & Morgan, 2003). The box and whisker plots in Figures 9.1 and 9.2, present a summary of 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 *.

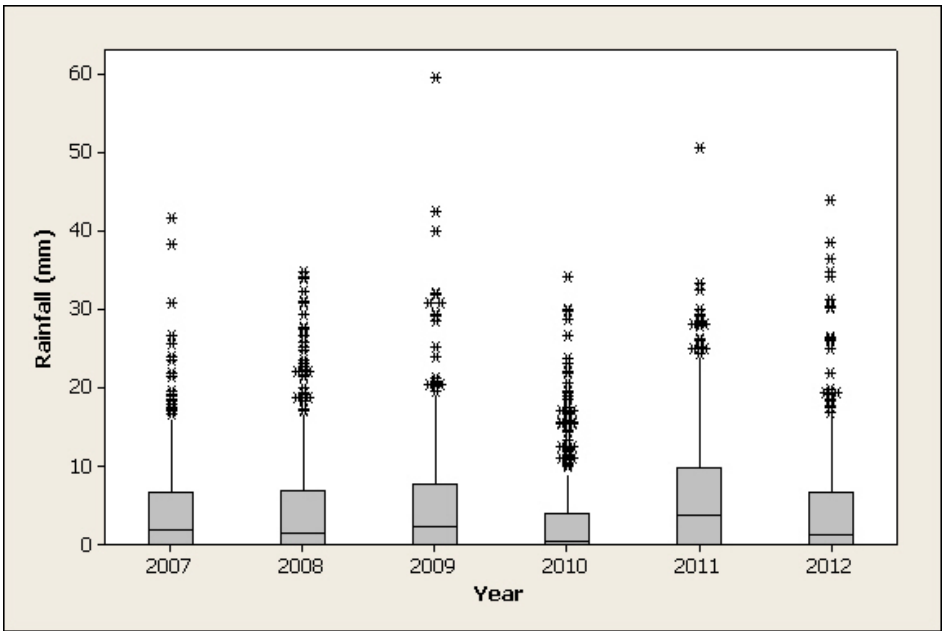

Figure 9.1 Box plot of daily rainfall values by year at Lismore: Frackersaig Farm (2007 – 2012)

Daily rainfall values varied from year to year, with 2010 being the driest year. The wettest year was 2011. High rainfall values of more than 30 mm/d occurred in all years but an extreme rainfall event of nearly 60 mm/d was seen in 2006.

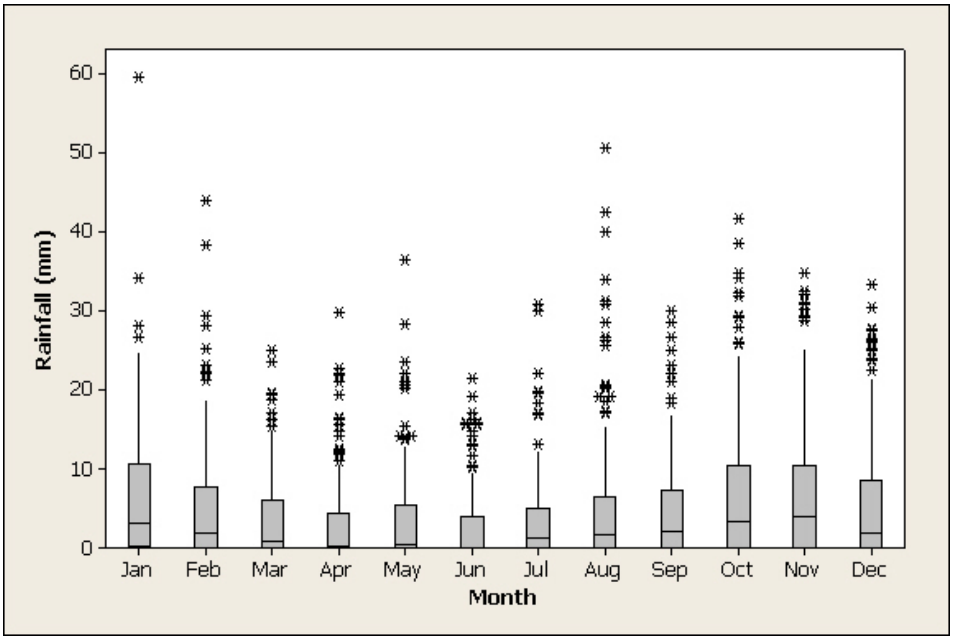

Figure 9.2 Box plot of daily rainfall values by month at Lismore: Frackersaig Farm (2007 – 2012)

Daily rainfall values were higher during the autumn and winter. Rainfall increased from August onward and was highest in October, November and January. Weather was drier from March to August. Rainfall values exceeding 30 mm/d were seen in all months except March and June. The 2009 extreme event occurred in January.

For the period considered here (2007 – 2012) 46% of days received daily rainfall of less than 1 mm and 17% of days received rainfall of over 10 mm.

It is therefore expected that run-off due to rainfall will be higher during the autumn and winter months. However, extreme rainfall events leading to episodes of high runoff can occur in most months and when these occur during generally drier periods in summer and early autumn, they are likely to carry higher loadings of faecal material that has accumulated on pastures when greater numbers of livestock were present.

9.2 Wind

Wind data was collected from Glasgow, Bishopton and summarised in seasonal wind roses in Figure 9.3 and annually in Figure 9.4.

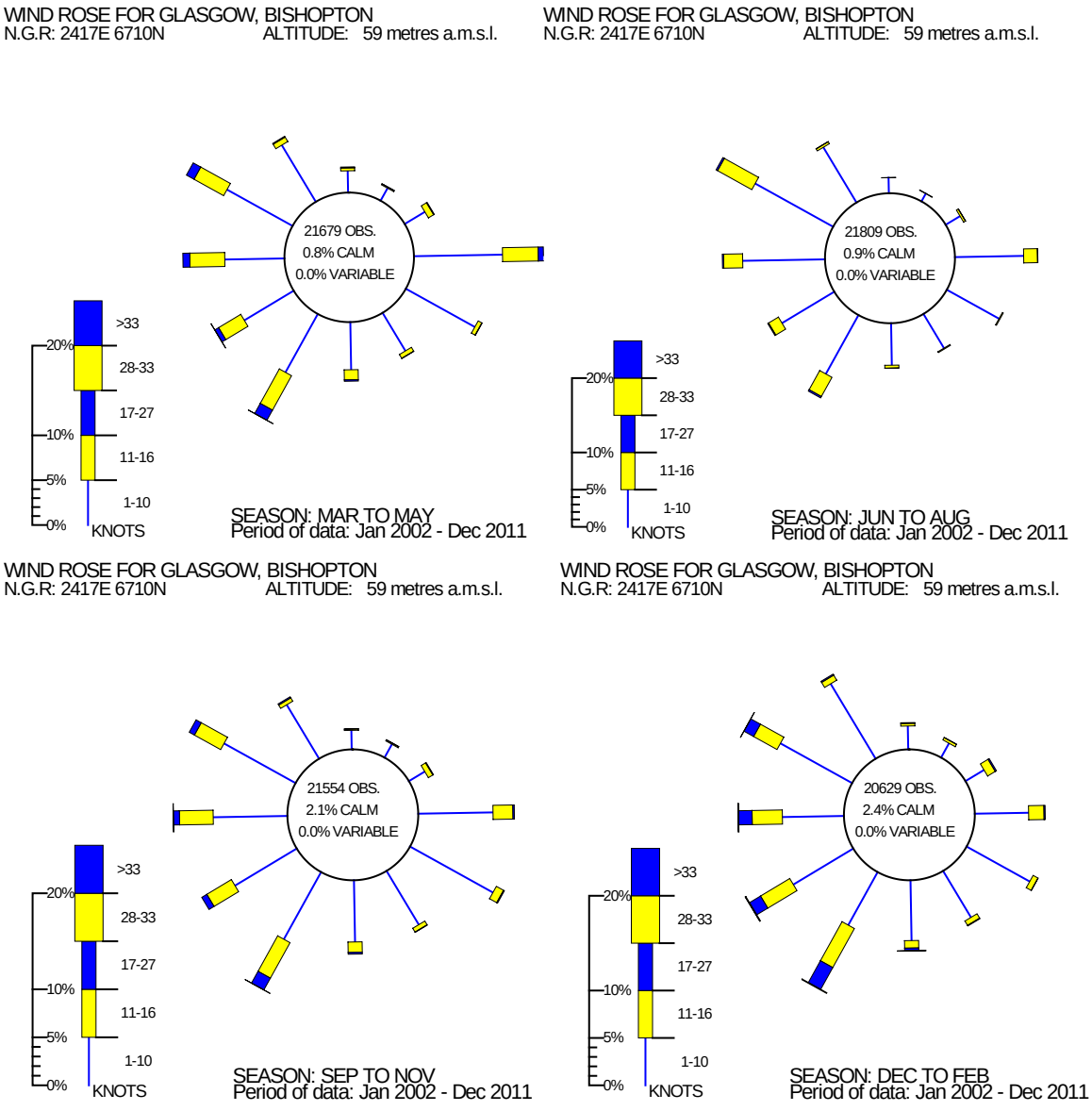

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Figure 9.3 Seasonal wind roses for Glasgow, Bishopton

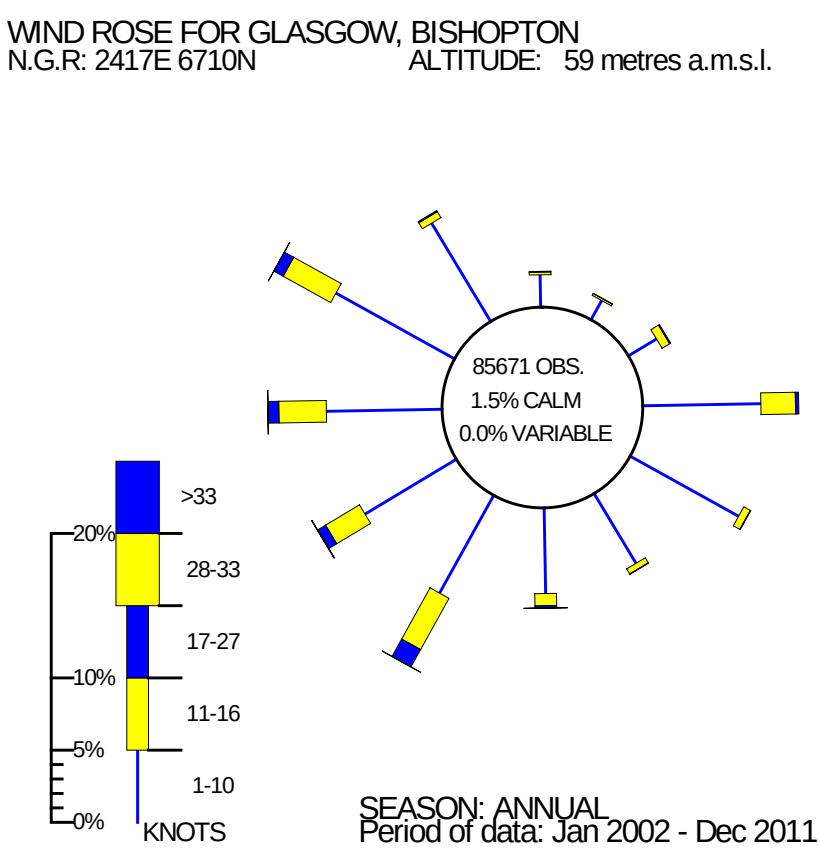

Figure 9.4 Annual wind rose for Glasgow, Bishopton

Overall the annual wind direction showed that wind was stronger when coming from the west than the east, and winds from the southerly direction were stronger than those from the north. Predominant winds were from the west south-west. There was no marked change in wind direction throughout the months; however winds were much stronger in the winter months than in the summer months.

Wind is an important factor in the spread of contamination as it has the ability to 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 can significantly alter the pattern of surface currents. Strong winds also have the potential to affect tide height depending on wind direction and local hydrodynamics of the site. A strong wind combined with a spring tide may result in higher than usual tides, which will carry any accumulated faecal matter at and above the normal high water mark into the production area.

10. Classification Information

As this is a new application the site has not been classified. No representative monitoring point (RMP) has been designated.

Loch na Cille lies within the Loch Melfort production area which is currently classified for the production of mussels. Its classification history is presented in table 10.1

Table 10.1 Classification history for Loch Melfort mussel production

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	A	A	A	A	A	A	A	A	A	A	A	A
2007	A	A	A	A	A	A	A	A	A	A	A	A
2008	A	A	A	A	A	A	A	A	A	A	A	A
2009	A	A	A	A	A	A	A	A	A	A	A	A
2010	A	A	A	A	A	A	A	A	A	A	A	A
2011	A	A	A	A	A	A	A	A	A	A	A	A
2012	A	A	A	A	A	A	A	A	A	A	A	A
2013	A	A	A									
2014												

It should be noted, that the RMP location for Loch Melfort is a significant distance from Loch na Cille and is unlikely to be representative of the conditions in Loch na Cille.

Loch na Cille was given a fast track application from 26 May -25 September 2012 and was classified as B.

11. Historical *E. coli* Data

11.1 Validation of historical data

Results for all samples assigned against Loch na Cille for the period between 01/01/2012 to the 02/04/2013 were extracted from the FSAS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. All *E. coli* results were reported as most probable number (MPN) per 100 g of shellfish flesh and intravalvular fluid.

All common cockle samples were recorded in the database as valid. All samples arrived within the allowed 48 hr window between sample collection and delivery, and all samples had a box temperature of < 8°C. A summary of microbiological results is given in Table 11.1 below.

Table 11.1 Summary of historical sampling and results

Sampling Summary	
Production area	Loch na Cille
Site	Loch na Cille; Cockles
Species	Common cockles
SIN	AB-617-1204-04
Location	Various
Total no of samples	14
No. 2012	11
No. 2013	3
Results Summary	
Minimum	20
Maximum	16000
Median	270
Geometric mean	398
90 percentile	9750
95 percentile	16000
No. exceeding 230/100g	7 (50%)
No. exceeding 1000/100g	4 (29%)
No. exceeding 4600/100g	1 (7%)
No. exceeding 18000/100g	0 (0%)

The area has a relatively short sampling history. However, over that time the results have shown moderate levels of faecal contamination in cockles. Due to the low number of results, no analysis has been undertaken with respect to the relationship between environmental factors and *E. coli* levels in cockles.

11.2 Overall geographical pattern of results

The overall geographic distribution of historical monitoring results is shown in Figure 11.1.

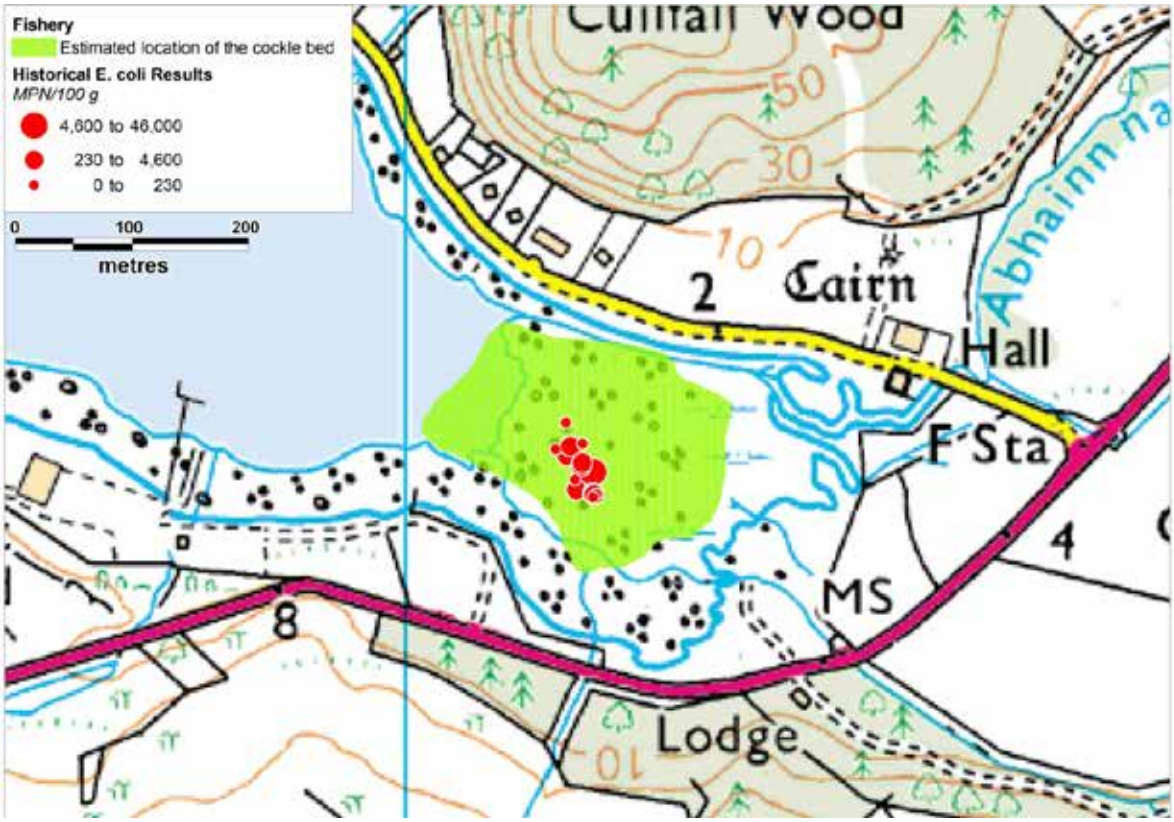

Figure 11.1 Map of Loch na Cille sampling result locations.

All samples plotted close to one another toward the southern side of the cockle bed. There is no apparent spatial trend in the monitoring results to date.

11.3 Overall temporal pattern of results

A scatterplot of common cockles *E. coli* results against date is presented below. The dataset is fitted with a lowess trend line. Lowess trendlines allow for locally weighted regression scatter plot smoothing. At each point in the dataset an estimated value is fitted to a subset of the data, using weighted least squares. The approach gives more weight to points near to the x-value where the estimate is being made and less weight to points further away. In terms of the monitoring data, this means that any point on the lowess line is influenced more by the data close to it (in time) and less by the data further away. The trend line helps to highlight any apparent underlying trends or cycles.

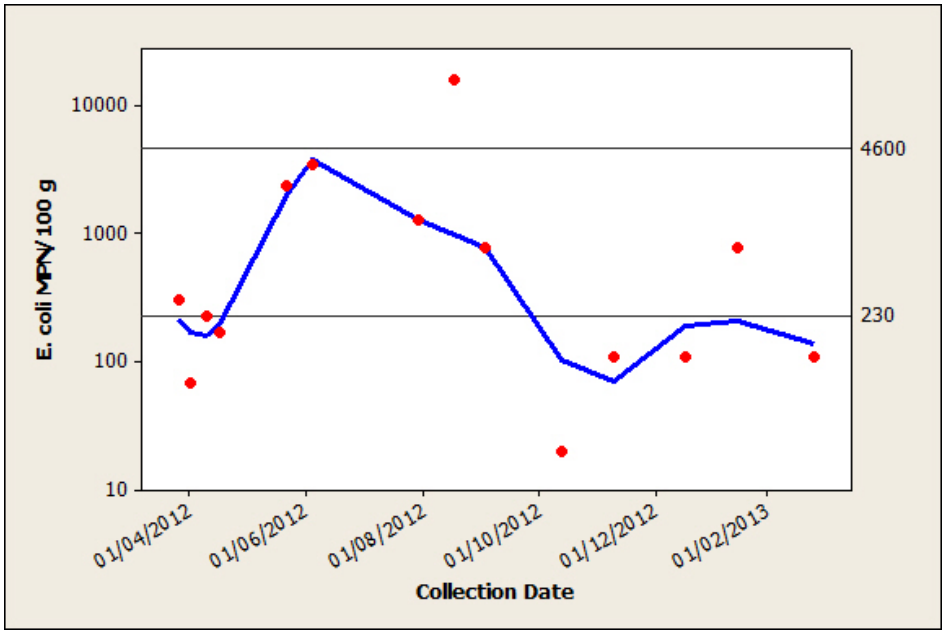

Figure 11.2 Scatterplot of common cockle *E. coli* results by date with a lowess line.

11.4 Evaluation of results over 1000 *E. coli MPN*/100g

Sampling results from Loch na Cille exceeding 1000 *E. coli MPN*/100 g are listed in Table 11.2.

Table 11.2 Historical *E. coli* results over 1000 *E. coli MPN*/100 g

Collection Date	*E. coli* (MPN/ 100g)	Location	2 day rainfall (mm)	7 day rainfall (mm)	Water Temp (°C)	Tidal state (high/low)	Tidal State (spring/neap)
20/06/2012	2400	NM 8415 1254	0.0	9.7	20	Ebb	Spring
04/07/2012	3500	NM 8414 1255	8.1	30.0	16	Low	Spring
29/08/2012	1300	NM 8415 1252	30.8	-	14	Ebb	Increasing
17/09/2012	16000	NM 8416 1254	16.3	49.7	12	Ebb	Spring

All elevated *E. coli* results > 1000 *E. coli* MPN/ 100 g were from samples taken during 2012, with three taken in the summer months, and one in the autumn (September). Results varied from 1300 to 16000 *E. coli* MPN/ 100 g. Rainfall levels during the two and seven days prior to sampling varied between 0.0-30.8 mm and 9.7-49.7 mm respectively. Water temperature varied between 12 and 20°C. All samples were taken on an increasing or spring tide and at low or ebb tide.

11.5 Summary and conclusions

The results from the 14 samples that were taken at Loch na Cille there is a lot of variation in results (20 to 16000 *E. coli MPN*/ 100 g). No trend was able to be identified during geographical mapping, though the largest sample was closest to Abhainn na

Cille. The median illustrates that the majority are just above class A at 270 *E. coli MPN*/ 100 g. No statistical variation was found in results between seasons, though this is likely to reflect the low numbers of samples that have so far been taken at this site.

No statistically significant correlation was found between rainfall in either two days prior or seven days prior to sampling and contamination levels, with both low and high rainfall levels correlating to low levels of contamination. A statistically significant correlation was found between water temperature and *E. coli* levels, with temperatures > 10^{o}C correlating positively with contamination levels > 230 *E. coli MPN*/ 100 g.

Statistically significant correlations were also found between results and spring/neap tidal states, with higher results associated with spring tides, and between high/low tidal states, with the majority of higher results taken on an ebb tide, which is likely to reflect the conditions required for harvest the cockles at low tidal states.

12. Designated Waters Data

Loch na Cille lies within the Loch Melfort designated Shellfish Growing Water, which comprises of the whole of Loch Melfort. The area was designated in 2002 and has been monitored by SEPA since then. Under the Shellfish Waters Directive (European Communities, 2006), designated waters must be monitored quarterly for faecal coliforms in the shellfish flesh and intervalvular fluid, as well as for a variety of chemical parameters. SEPA is responsible for ensuring that this monitoring is undertaken, and have used common mussels for this purpose. The monitoring point is located at NM 8320 1409 approximately 1 km north of Loch na Cille. Since 2007, SEPA have based the SGW assessment on FSAS *E. coli* results from Loch Melfort.

The relative positions of the Shellfish Growing Waters (SGW) boundary and the SGW monitoring point in relation to Loch na Cille are shown in Figure 12.1.

The shellfish growing water report for the area identified that there are two known farms within the area that operate extensive cattle and sheep production systems. The freshwater inputs to the designated area, the largest being the River Oude are considered to be of at least good quality. The report identifies that Scottish Water is consented to discharge effluent from the septic tank serving Kilmelford into Loch na Cille.

The waters failed to comply with the guideline standards for faecal coliforms from 2003 to 2006. However the waters passed from 2007 to 2010, when FSAS monitoring data was used. This is likely to be due to change in monitoring point. The FSAS monitoring is undertaken on the classified mussel farm near the mouth of the loch and therefore it will not be representative of contamination levels nearer the head of the loch and the faecal pollution sources identified there.

Shellfish growing waters are currently under review by SEPA and Scottish Government, and the boundaries of the Loch Melfort SGW may be amended as part of that process. SEPA aim to have a Parliamentary Order in force by December 2013, outlining the new designation, in time for the repeal of the Shellfish Waters Directive.

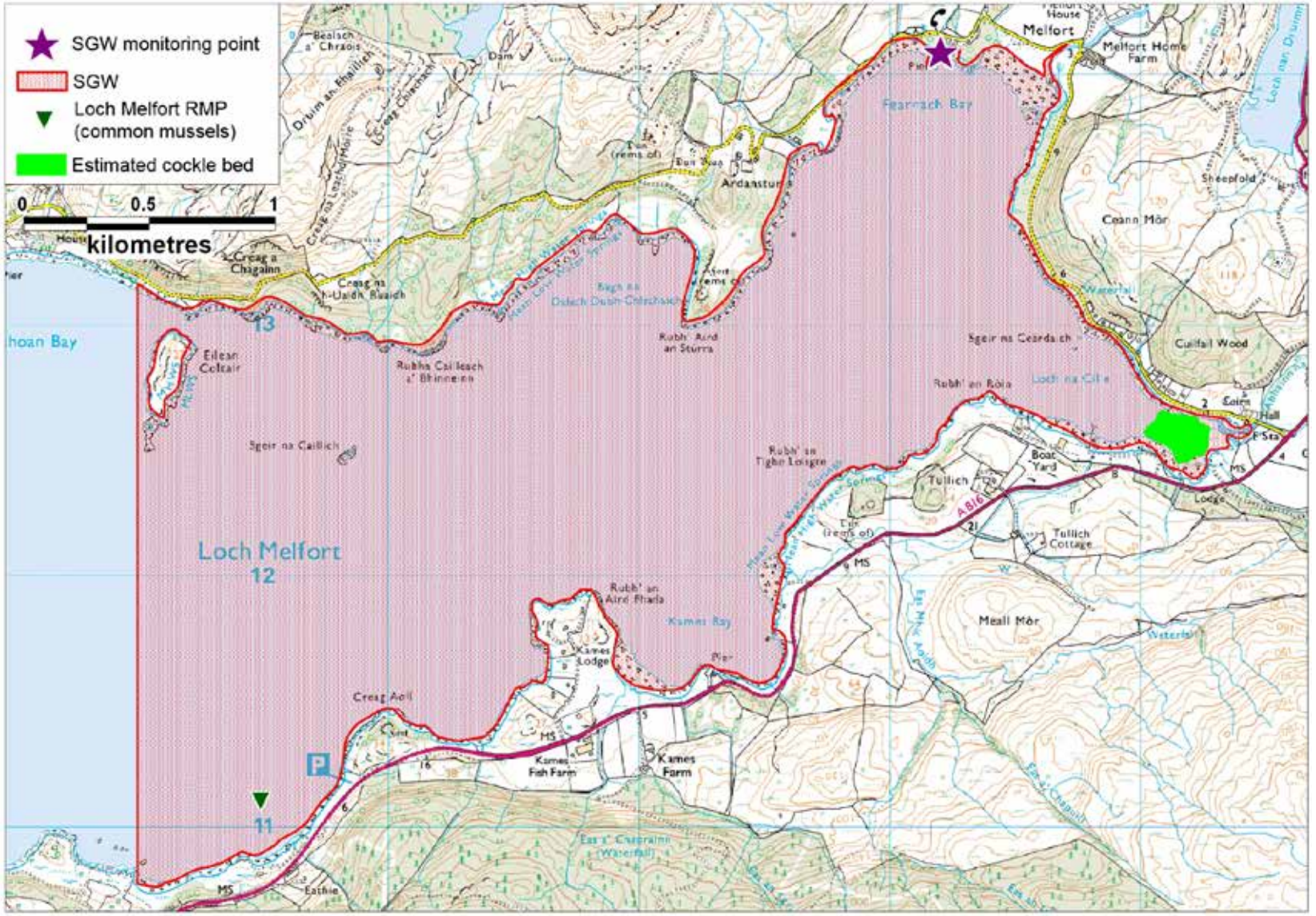

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Figure 12.1 Designated shellfish growing water – Loch Melfort

13. Hydrographic Analysis

13.1 Introduction

The Study Area

Loch na Cille is a small inlet situated at the head of Loch Melfort on the west coast of Scotland. It is approximately 0.5 km wide and is sheltered from prevailing winds and swell. In particular, the large islands of Luing and Shuna located at the mouth of Loch Melfort help to create the sheltered conditions within the area. The largest settlement near Loch na Cille is the township of Kilmelford in the northeast but there is also sporadic housing situated all over the northern and southern shoreline including several farms to the northeast and southwest. The other areas surrounding Loch na Cille consist of grassland, woodland and grazing areas. Within Loch na Cille there is a small pier with several moorings along the southern shore which is popular in the summer season with visiting craft. Figure 13.1 shows the extent of the hydrographic study area.

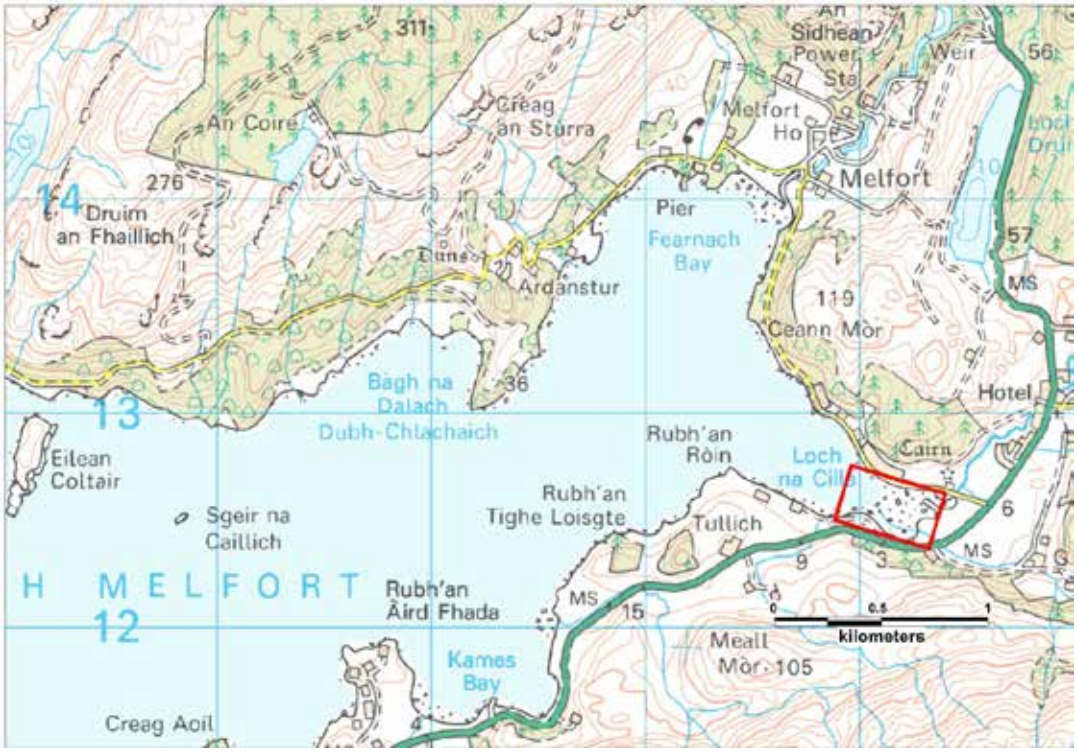

Figure 13.1 Extent of hydrographic study area

Coordinates for middle of Loch na Cille:

56° 15.47' N 005° 29.45' W

NM 83940 12681

13.2 Bathymetry and Hydrodynamics

13.2.1 Bathymetry

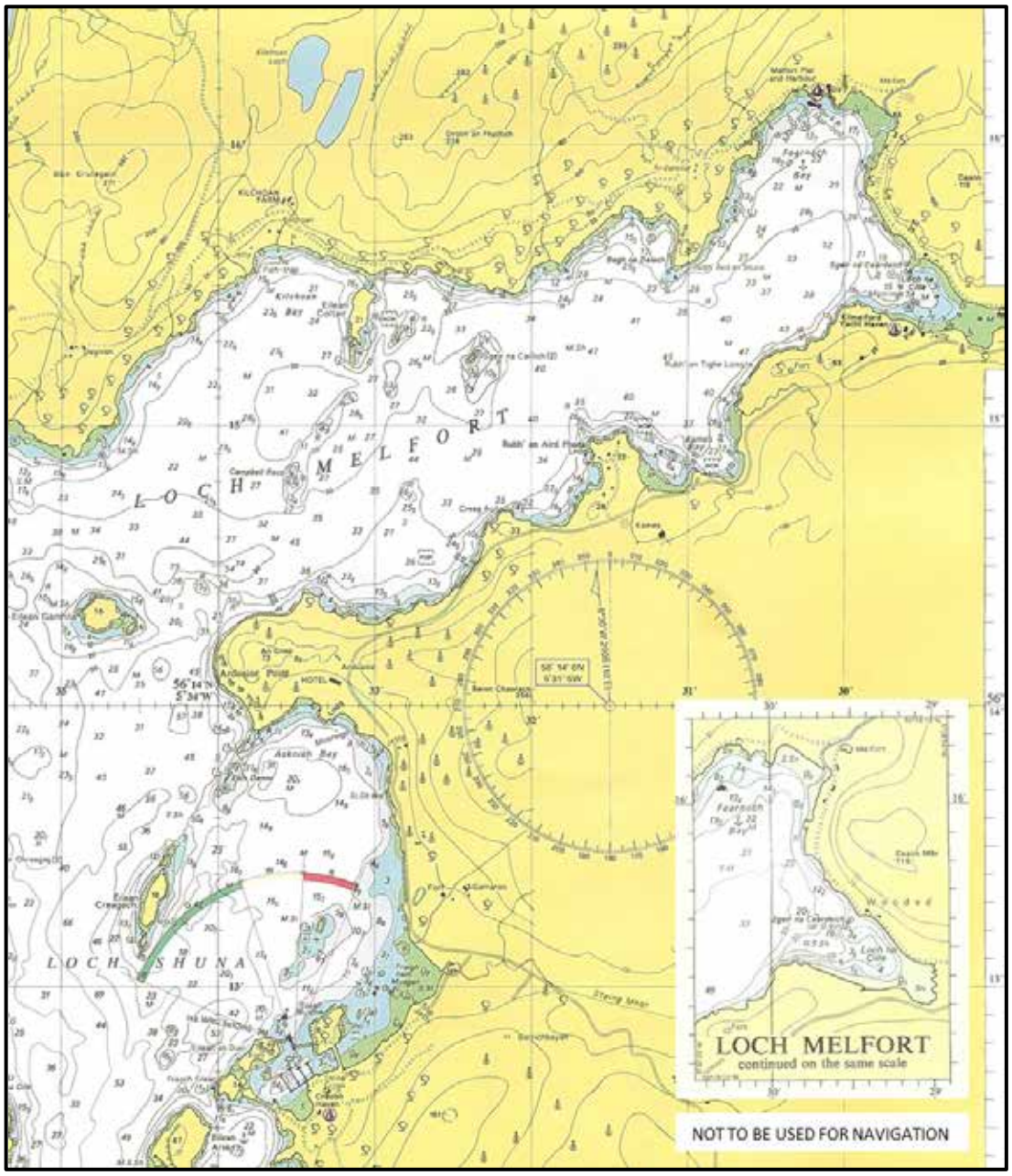

Figure 13.2 Admiralty chart (5611.16) extract for Loch Melfort and Loch na Cille (Insert from Admiralty chart 2326).

Figure 13.2 shows the bathymetry of Loch Melfort and Loch na Cille. The insert shows a close-up of the bathymetry of Loch na Cille. At the entrance to Loch Melfort there is a sill of 36 m depth which presents no significant restriction to the flow at the mouth of the Loch. The island Eilean Gamhna is situated at the entrance of Loch

Melfort. Loch na Cille faces NW and its entrance connects directly to Loch Melfort. The head of Loch na Cille consists of a sandy intertidal area, approximately 6 x 10^4 m^2, from which the depth gradually increases from the shore to the 20 m depth contour which approximately defines the entrance where it joins Loch Melfort. Loch na Cillie is reasonably shallow compared to larger Scottish sea lochs with the majority of it being < 10 m in depth. The exchange between Loch Melfort and Loch na Cille is not restricted in the sense that there is a continuous open entrance with no shallow sill.

13.2.2 Tides

Loch na Cille has a typical semi-diurnal tidal characteristic. Data on tidal information is given from charted information for the nearest area to Loch na Cille.

Standard tidal data for the nearest area to Loch na Cille is from Loch Melfort and are given below. The spring/neap cycle of tidal height around the time of the survey (25-27 March 2013) is also shown for Loch Melfort in figure 2.2:

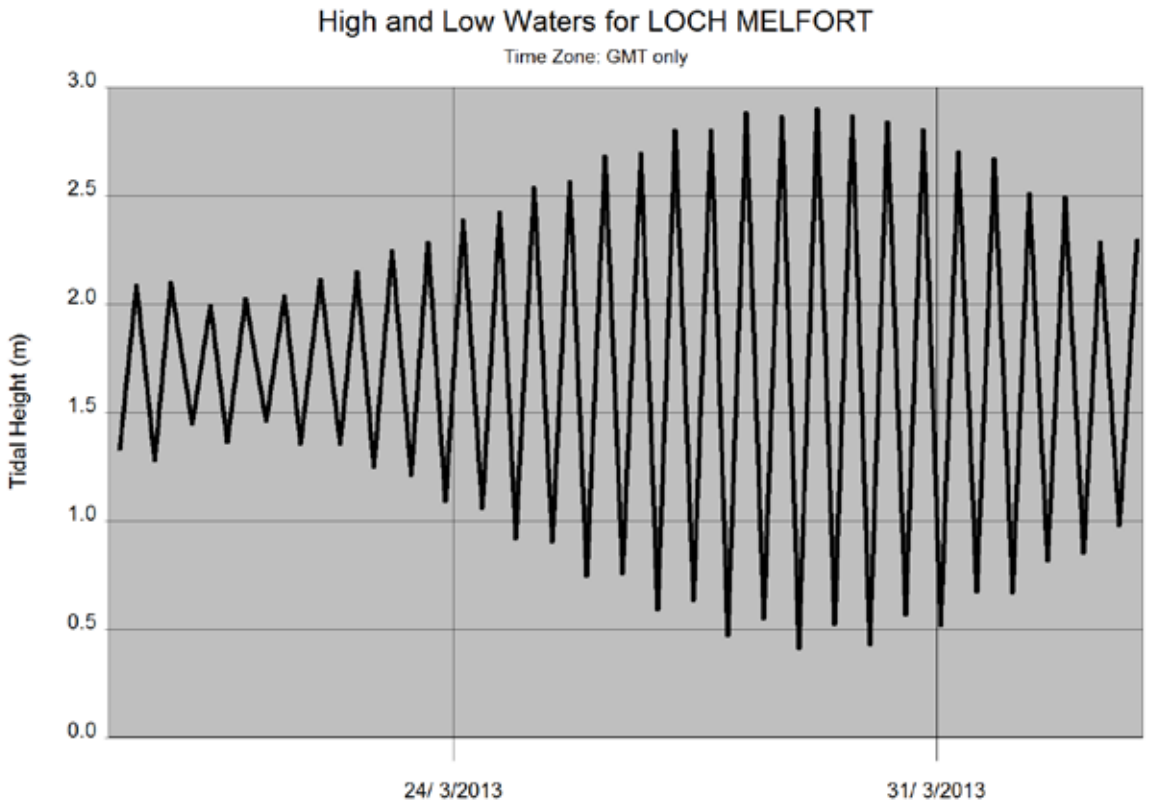

Figure 13.3 Two week tidal curve for Loch Melfort. Reproduced from Poltips3 [www.pol.ac.uk/appl/poltips3]

<u>Tidal Heights for Loch Melfort (from Admiralty Chart 5611.16):</u>

Mean High Water Springs = 2.8 m

Mean Low Water Springs = 0.6 m

Mean High Water Neaps = 2.1 m

Mean Low Water Neaps = 1.3 m

Tidal Ranges averaged for Loch Melfort:

Mean Spring Range = 2.2 m

Mean Neap Range = 0.8 m

13.2.3 Tidal Streams/Currents

There are no tidal diamonds for the waters contained within Loch Melfort. Enhancement of tidal streams caused by straights and channels are negligible in Loch na Cille due to its relatively simple bathymetric topography. However, there may be some localised effects around the mouth of Loch Melfort where Eilean Gamhna is situated, and also at Campbell Rock, Eilean Coltair and Sgeir na Caillich located near the middle of the loch. Some current meter data are available from a previous survey carried out by TransTech Limited (MacFarlane, 2012). Although the survey was not positioned within Loch na Cille itself, these are the nearest extant current speed measurements, situated in Kames Bay (NM 82030 11246), the adjacent bay to the west, approximately 1 km from the survey area. The survey spanned 15 days between the 9th & 24th September 2011 which encompasses the half-lunar period to capture a spring-neap cycle. In these reports sub-surface refers to 17.6 m above the sea bed (approximately 5.3m below spring tide), mid-depth is 10.6m above bed and near-bottom is 2.6m above the bed.

The data collected from Kames Bay in 2011 is summarised in Table 13.1 (MacFarlane, 2012). In general, the currents were of moderate-to-low velocity with the near-bed, mid- and sub-surface velocities all being of a comparable magnitude. There was also similarity of current direction at all depths, being aligned with the shoreline (Murray, et al., 1910).

Table 13.1 Kames Bay, Loch Melfort current data measured in 2011.

	Near-bed	Mid	Sub-surface
Mean Speed (ms^{-1})	0.028	0.029	0.032
Principal Axis Amp & Dir (ms^{-1}) & (^oM)	0.034 (305)	0.036 (295)	0.041 (290)
Eccentricity Ratio	2.23	1.97	1.93
Residual speed (ms^{-1})	0.022	0.022	0.022
Residual direction (^oM)	302	289	297

One might anticipate slightly enhanced surface flow in Loch na Cille as there is freshwater discharging into the head of it (see Section 13.2.4). However, it is reasonable to treat the measurements in Table 13.1 as indicative of the locality in terms of current magnitude.

Based upon a measured surface principal current amplitude of 0.04 m/s (Table 13.1) and the assumption of a uniform sinusoidal tide, the cumulative transport that might be expected in the surface during each phase of the tide has been estimated as approximately 0.5 km. No distinction is made here for springs and neaps, nor has any estimate been made for any seasonal variation.

Dispersion is an important property of a water body with respect to redistribution of contaminants over time. There are no measurements or published data relating to dispersion in Loch na Cille. Without such data it is difficult to judge what the dispersive environment might be like, but the open nature of the loch, the shallow depth and the rocky obstructions to flow on the NE and SW sides of the loch may enhance dispersion.

13.2.4 River/Freshwater Inflow

There is a multitude of watercourses around Loch na Cille. Most are unnamed on the OS chart. However, the most influential freshwater bodies close to the head of Loch na Cille are Loch Dubh-mor, Loch a' Chaoruinn, Loch a' Phearsain, Loch nan Druimnean and Loch an Losgainn Mor (Murray, et al., 1910). From these stem several smaller rivers such as Abhainn na Cille, Eas na Caillich and Eas a' Choire which flow directly into Loch na Cille. There are rivers at the head of Loch Melfort which may be significant due to their close proximity to Loch na Cille, namely River Oude which flows into Fearnach Bay.

The annual freshwater runoff into Loch Melfort is estimated as 109 Mm^3yr^{-1} (Edwards & Sharples, 1986). The ratio of freshwater flow to tidal flow in Loch Melfort is moderate at approximately 1:100 and therefore the input of freshwater has limited influence over the salinity of the loch as a whole although the influence will be much greater in the relatively small volume of Loch na Cille.

13.2.5 Meteorology

Whilst quantitative data for this specific study area are sparse, below there are several data collations from different studies which may be useful for meteorological assessment of the area. Edwards and Sharples report (1986) that the mean annual rainfall for Loch Melfort is roughly 1750 mm and it can be reasonably deduced that Loch na Cille will have a similar amount due to their close proximity to one another.

Rainfall data was collected from a Meteorological Office weather station situated on Lismore approximately 26 km to the north west of the production area. The data spanned from January 2007 to August 2012 and showed that the highest daily rainfalls were in the autumn and winter with the increase starting in August and peaking in October and November. The driest weather occurred between March and September. Over the duration of this period, the data show that 46% of days had daily rainfall of below 1 mm, 37% of days had daily rainfall of between 1 – 10 mm and 17% of days had daily rainfall of above 10 mm. It can be concluded from this therefore that runoff will be greater within the autumn to winter seasons. It must be noted however, that high rainfall in this area can occur in any month.

During a 15-day period between the 9th and 24th September 2011, the mean wind speed recorded in Kames Bay positioned at NM 82030 11246 (approximately 1 km from Loch na Cille) was 4.2 m/s (MacFarlane, 2011)

Long-term wind speed records can also be used from Bishopton near Glasgow, approximately 80 km from the study area, to give a general pattern of seasonal variations. Annually, the stronger winds came from a westerly and southerly direction and the main winds were from a west south-west direction. The direction of the wind was reasonably similar throughout every month but during the winter they were markedly stronger. However, the data from this station is rather distant from the study site and should be used with caution.

13.2.6 Model Assessment

The exchange characteristics of Loch Melfort have been assessed using a layered box model approach. The model represents the Loch as a box made up of three layers and was formulated according to the method of Gillibrand et al (2013). The box layers are forced with surface wind stress, estimates of fresh water discharge, surface heat flux parameters and, at the open coastal boundary, profiles of temperature and salinity are prescribed from climatology compiled by the UK Hydrographic Office. This sets the model with climatological boundary conditions to represent an ‘average’ year. The model has been tuned and validated for Lochs Creran and Etive. A full validation for Loch Melfort was not done due to lack of seasonal data.

The box model quantifies the primary exchange mechanisms. The key outputs from the model with respect to this hydrographic assessment is a series of annual mean values that describe the relative importance of the estuarine (gravity) exchange, tidal exchange, exchange between the layers and the flushing time, which is the inverse of the exchange rate.

The ratio of Tidal volume flux to estuarine circulation volume flux is around 1. Values between 2.0 and 0.5 indicate a system where tidal and density driven exchanges are comparable (Gillibrand, et al., 2012).

Although Loch na Cille is a relatively small component of that system the model approach gives some indication of the likely exchange conditions. The flushing time for Loch Melfort is around 9 days which is comparable to the tidal prism model. However, it is likely that Loch na Cille will experience a much shorter flushing time due to its relatively small volume.

13.3 Hydrographic Assessment

13.3.1 Surface flow

The site and the meteorological data indicate that there is likely to be a rather steady freshwater discharge into the surface waters of the loch, though the absolute value of discharge would be seasonally varying. The distribution of fresh water sources is concentrated at the head of Loch na Cille.

The Loch is relatively small such that there is unlikely to be much variation in properties of flow across the Loch. The freshwater discharge would suggest that stratification might dominate under exceptionally calm conditions, but the relatively shallow waters would mean that a mixed water column would be most likely.

Loch na Cille is not open to the prevailing south westerly wind but surface flows would be enhanced/retarded by winds blowing out of/into the Loch and also enhance the mixing of the waters through the full depth.

It is likely that any surface contaminant would be transported primarily along the axis of the loch. The dispersive characteristics of the site are unknown.

Net transport of contaminants is related to the residual flow presented in Table 13.1. The residual surface flow measured in the surface waters of the adjacent bay (MacFarlane, 2012) follow the shoreline to the north west. This can be interpreted as a weak outflow of the surface waters. With the measured surface residuals of order 0.02 m/s, the net transport over a tidal cycle of approximately 12 hours would be less than 1 km. It is therefore likely that any surface contaminant would follow the contours of the loch and disperse effectively via the surface estuarine flow.

13.3.2 Exchange Properties

An important assessment for Loch Melfort in terms of the exchange is that the estuarine volume flux is comparable to the tidal volume flux. This means that exchange of waters in Loch Melfort is probably not dominated by either process. Hence, the exchange is likely to have some seasonal variation relating to the estuarine exchange. It is assumed that this is also the case for Loch na Cille.

Exchange modelling predicts a mean flushing time for Loch Melfort of 9 days which implies a moderately flushed system. It is worth noting that the simple tidal prism method which is used in some box modelling applications eg the Sea Loch Catalogue (Edwards & Sharples, 1986) also gives a flushing time of 9 days.

Current meter measurements in an adjacent bay to Loch na Cille, suggest that in a relatively small area, the tidal transport would be approximately 0.5 km, a similar order of magnitude to the length of the site, therefore exchange in this relatively small study area may be greater than for Loch Melfort as a whole and that surface contamination could be flushed within a few days in this location under most circumstances, particularly when freshwater discharge is high.

There are no data available from current meters for Loch na Cille and there is a paucity of any measured hydrographic data. However, there is some data from a location close by and sufficient ancillary data derived from interpolated data sets to set up the layered box model with the caveat that it is not validated. Therefore the confidence level of this assessment is LOW.

14. Shoreline Survey Overview

The shoreline survey was conducted between the 26th and 27th March 2013. No precipitation fell in the week prior to this survey and it was noted that the weather had been very dry during the 3-4 weeks prior to the survey.

The planned fishery at Loch na Cille consisted of the hand harvesting of common cockles from the sands at the head of the loch. At the time of survey, there was no activity during the survey from harvesters.

Detached houses and some self catering houses/chalets were found at Fearnach Bay where there are small holiday villages around Melfort. No campsites or caravan parks were observed in the survey area, but there was a hotel and B&B in the village of Kilmelford. The houses at Kilmelford and around Loch na Cille are served by the Kilmelford waste water treatment works (WWTW). This is located east of the harvest area.

There are three piers in the survey area at Melfort Pier, Melfort boatyard and Kames Bay. Approximately 24 unoccupied moorings were present around Melfort Pier and Melfort boatyard had approximately 60 moorings with 4 yachts on the water during the survey. There were also five boats and 3 moorings, as well as a pontoon with two boats in the water noted on the northwest and north shorelines. An additional mooring at Kames Bay pier was thought to be associated with management of the nearby fish farms.

Land surrounding the harvest area was varied. To the north, land was a mixture of grassland/improved pasture with areas of native woodland. To the south, it was a mixture of grassland/improved pasture along with heath and areas of plantation forest/native forest. Overall it was predominantly rural.

Agriculture consists largely of cattle and sheep farming on the lower fields surrounding the survey area. The only livestock seen during the survey were four sheep in a field immediately to the west of Melfort Pier. Sheep and cattle were observed in fields around the loch while travelling to the survey site. There was no visible arable cultivation. However, there were small pockets of forest that varied from some cultivated spruce plantation (southern shore) to native woodland (both north and south shores).

During the survey gulls, oystercatchers, geese, mallard ducks and an otter were noted, along with evidence of geese droppings on the shoreline at several locations. Gulls were the most prevalent wildlife noted on the survey, with large numbers on the northeast and southwest shorelines.

There were two major watercourses discharging into the survey area; the River Oude and the Abhainn na Cille. There were also nine smaller, unnamed streams

discharging into the survey area. Contamination levels of sampled watercourses varied between < 100 to 130000 *E. coli* cfu/100 ml.

Contamination levels in freshwater samples taken from discharge pipes also varied hugely between < 100 to 2700000 *E. coli* cfu/ 100 ml. The highest result came from a pipe discharging to shore above the harvesting area.

Results from seawater samples also varied greatly, from 0 to 300 *E. coli* cfu/100 ml. The highest result was from a sample taken on the southern shoreline, adjacent to several houses.

Two cockle samples returned similar results (80 and 110 *E. coli* MPN/ 100 g). Figure 14.1 presents a map showing the most significant observations from the shoreline survey.

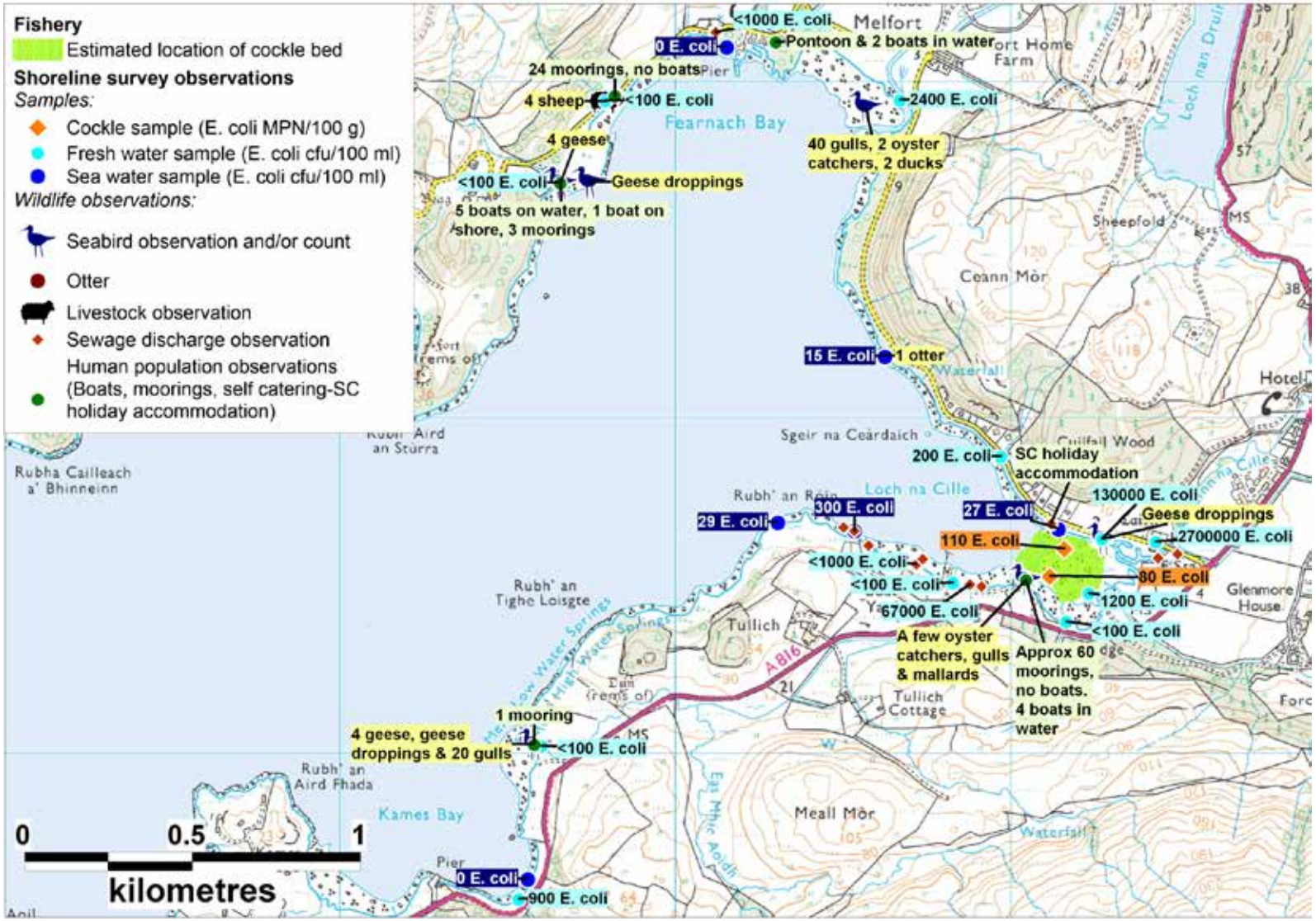

Figure 14.1 Summary of shoreline survey findings for Loch na Cille

15. Overall Assessment

Human sewage impacts

Despite the relatively small population reported for the area, there is significant sewage impact to the sands at the head of Loch na Cille. Discharge from the WWTW at Kilmelford is carried across the northern end of the cockle bed via the Abhainn na Cille. This system has CSOs to the lower Abhainn na Cille and therefore rainfall related overflows can be expected. During the shoreline survey, a sample taken from Abhainn na Cille was found to be highly contaminated, with a result of $1.3x10^5$ *E.coli*/100 ml. Further sewage impact was identified from private septic tanks discharging via outfall pipes and/or to soakaways near the high tide line along the both the north and south shores of the loch.

The large number of moorings present just offshore of the cockle bed suggests that overboard discharges may be a significant source of contamination when the moorings are in use.

A significant proportion of properties in the area are holiday homes or self-catering accommodation, suggesting that there will be a seasonal variation in impact. Impacts from all these sources are expected to be significantly higher in summer, when the number of visitors to the area will be highest.

Agricultural impacts

The area was found to be used for some extensive sheep and cattle rearing, and there are large areas of improved pasture along the north and east of the Loch na Cille and around the north shore of Fearnach Bay. In satellite imagery, the field adjacent to the northeast corner of the loch appeared to have been mown. Sheep were only seen along the shore west of Melfort Pier during the shoreline survey. Any runoff from the improved pasture areas is likely to result in faecal contamination either directly to the head of the loch or via watercourses discharging to the loch, with impacts highest near the head of the loch. Impact to the immediate area of the cockle bed from farm animals is presumed to be low.

Wildlife impacts

Wildlife likely to contribute to background *E. coli* levels at Loch na Cille include gulls, geese, otters and deer. Apart from sea birds, the majority of these are likely to be carried via freshwater runoff and therefore the greatest impacts would be where watercourses discharge to the cockle bed.

Seasonal variation

Due to the large proportion of holiday accommodation in the area, significant seasonal variation in sewage input is anticipated, with peaks in July to September and during

the latter half of December. Some evidence of seasonal variation was seen in the first year of monitoring results, with higher results occurring from May to October. Monitoring samples are not taken over the Christmas holiday period and therefore any impact from an increase in visitors during this period is not likely to be reflected in the monitoring results.

Rivers and streams

A number of watercourses discharge to Loch na Cille, the most significant of which is Abhainn na Cille. This river receives sewage effluent from the Kilmelford WWTW and on the day of shoreline survey was found to be heavily contaminated. The loading was extremely high, suggesting that this was a highly significant source of faecal contamination to the loch. Other watercourses in the area were found to be substantially less contaminated.

Abhainn na Cille discharges to the northern side of the head of Loch na Cille. The sampled effluent from the WWTW was reported to be brown in colour, and therefore it is likely to contribute contamination to the seabed where particular matter settles out of the river as it flows into the loch.

Movement of contaminants

The number of fresh water sources concentrated at the head of Loch na Cille suggests that stratification may occur under very calm conditions. However, due to the shallow depths the water column is most likely to be mixed under most conditions. Surface flows would be enhanced by winds blowing out of the loch and retarded by winds blowing into the loch.

It is likely that any surface contaminant would be transported primarily along the axis of the loch. A weak outflow of the surface waters is predicted, with surface contaminants following the contours of the loch and dispersing via the surface estuarine flow out of Loch na Cille.

Current meter measurements in an adjacent bay to Loch na Cille, suggest that in a relatively small area, the tidal transport would be approximately 0.5 km. This is approximately the length of the bay.

Therefore, contamination arising from sources within Loch na Cille are expected to be the most significant with respect to contamination levels found in cockles there. Sources arising from outwith the bay are less likely to add to the contaminant loading at the cockle bed.

Temporal and geographical patterns of sampling results

There did not appear to be any clear geographical pattern in the sampling results.

Conclusions

The cockle bed at Loch na Cille is subject to significant human source faecal contamination that is likely to show seasonal variability.

The Kilmelford WWTW was reported by a local resident to have problems and a water sample taken directly from the effluent returned a result of $2.7x10^6$ *E. coli,* consistent with primary treated sewage. The WWTW provides approximately half the sewage loading to Loch na Cille, with the remainder coming from smaller treatment plants and private septic tanks. Additional sewage is likely to be contributed by yachts visiting the area, particularly during the summer cruising season.

Contamination arising from other sources, such as agricultural diffuse contamination and wildlife sources, while likely to contribute to background contamination levels within the loch are not expected to significantly impact water quality there.

Contamination arising from within the loch is considered likely to have a greater impact on water quality at the cockle bed than contamination arising from other sources outside the loch (ie at Kames Bay and Fearnach Bay). Geographically, the contamination is likely to be greatest in the vicinity of Abhainn na Cille.

Overall Risk Table

Risk	
Sewage discharges from WWTW and CSOs	High
Overboard discharges from yachts	High in summer
Rainfall-dependent diffuse sources	High
Wildlife sources	Low
Seasonal variability	Moderate

16. Recommendations

The recommendations for the Loch na Cille production area are presented below and shown mapped in Figure 16.1.

Production area

The recommended production area boundaries are the area bounded by lines drawn between points NM 8400 1279 and NM 8388 1249 extending to the MHWS. This area incorporates the entire cockle bed area. It was not practical to exclude all point sources of contamination from this area.

Representative Monitoring Zone

It is recommended that a RMZ approach be taken at Loch na Cille in order to accommodate sufficient scope for obtaining monthly monitoring samples. Samples should be taken from within the area bounded by lines drawn from NM 8418 1266 to NM 8419 1246 to NM 8429 1249 to NM 8427 1264 and back to NM 8418 1266, which includes the part of the cockle bed nearest the mouth of Abhainn na Cille.

Tolerance

As the monitoring zone is recommended, no tolerance is applied.

Frequency

Based on limited sampling data, there appears to be a seasonal trend in results and therefore monthly monitoring is recommended.

Depth of sampling

Not applicable

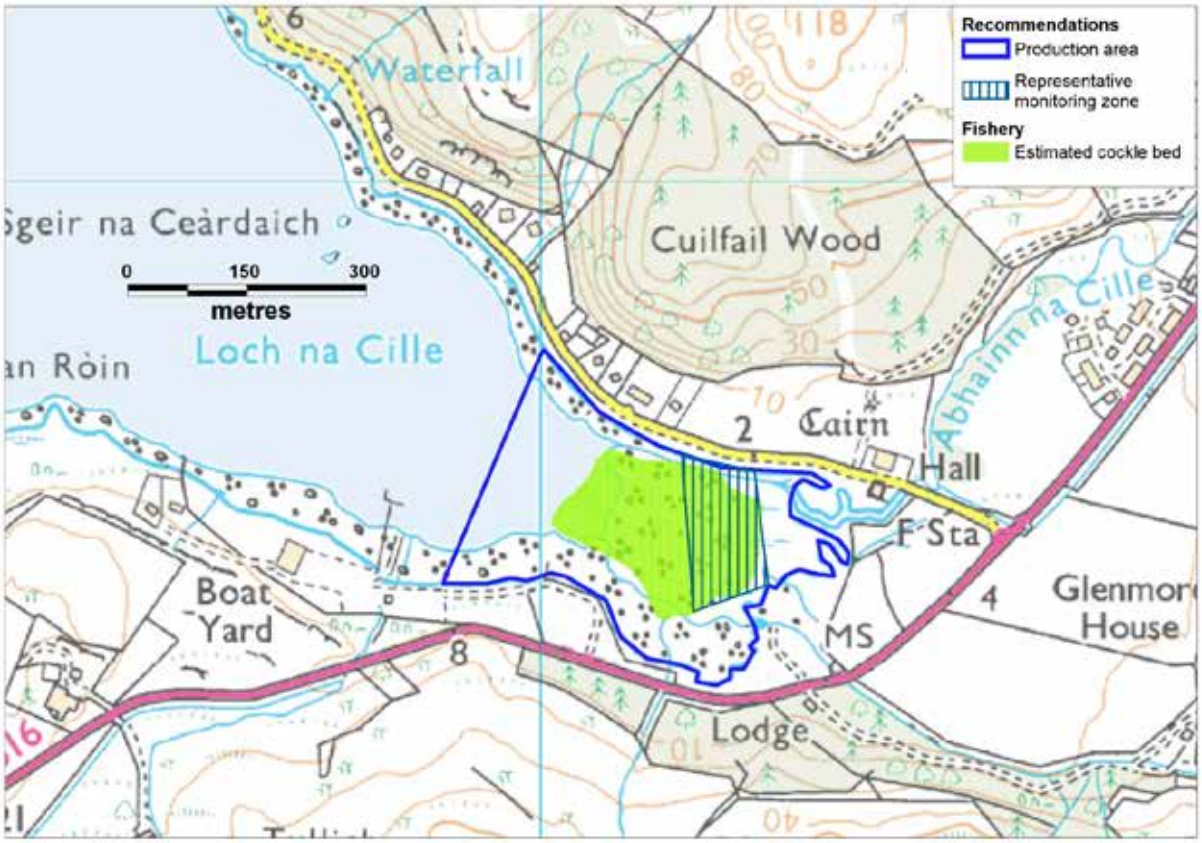

Figure 16.1 Map of recommendations at Loch na Cille

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18. List of Figures and Tables

Appendices

1. **General Information on Wildlife Impacts**
2. **Tables of Typical Faecal Bacteria Concentrations**
3. **Hydrographic Section Glossary**
4. **Shoreline Survey Report**

1. 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 50-170 kg. 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 & 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 (Gauthier & Bedard, 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 National Heritage, n.d.). 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 treams, which may be washed into the water during periods of rain.

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2. 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	$1.7 \times 10^{7*}$ (+)	1.4×10^{7}	2.0×10^{7}	282	$2.8 \times 10^{6*}$ (-)	2.3×10^{6}	3.2×10^{6}
Crude sewage discharges	252	$1.7 \times 10^{7*}$ (+)	1.4×10^{7}	2.0×10^{7}	79	$3.5 \times 10^{6*}$ (-)	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	$1.0 \times 10^{7*}$ (+)	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	$3.3 \times 10^{5*}$ (-)	2.9×10^{5}	3.7×10^{5}	184	$5.0 \times 10^{5*}$ (+)	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	$2.8 \times 10^{5*}$ (-)	2.2×10^{5}	3.5×10^{5}	93	$5.1 \times 10^{5*}$ (+)	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}		
Reed bed/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, et al., 2008)

Geometric mean (GM) and 95% confidence intervals (CIs) of the GM faecal indicator organism (FIO) concentrations (cfu 100ml$_{-1}$) under base- and high-flow conditions at the 205 sampling points and for various subsets, and results of paired t-tests to establish whether there are significant elevations at high flow compared with base flow

FIO	*n*	Base Flow			High Flow		
Subcatchment land use		Geometric mean	Lower 95% CI	Upper 95% CI	Geometric mean[a]	Lower 95% CI	Upper 95% CI
Total coliforms							
All subcatchments	205	5.8×10^{3}	4.5×10^{3}	7.4×10^{3}	7.3×10^{4}**	5.9×10^{4}	9.1×10^{4}
Degree of urbanisation							
Urban	20	3.0×10^{4}	1.4×10^{4}	6.4×10^{4}	3.2×10^{5}**	1.7×10^{5}	5.9×10^{5}
Semi-urban	60	1.6×10^{4}	1.1×10^{4}	2.2×10^{4}	1.4×10^{5}**	1.0×10^{5}	2.0×10^{5}
Rural	125	2.8×10^{3}	2.1×10^{3}	3.7×10^{3}	4.2×10^{4}**	3.2×10^{4}	5.4×10^{4}
Rural subcatchments with different dominant land uses							
≥75% Imp pasture	15	6.6×10^{3}	3.7×10^{3}	1.2×10^{4}	1.3×10^{5}**	1.0×10^{5}	1.7×10^{5}
≥75% Rough Grazing	13	1.0×10^{3}	4.8×10^{2}	2.1×10^{3}	1.8×10^{4}**	1.1×10^{4}	3.1×10^{4}
≥75% Woodland	6	5.8×10^{2}	2.2×10^{2}	1.5×10^{3}	6.3×10^{3}*	4.0×10^{3}	9.9×10^{3}
Faecal coliform							
All subcatchments	205	1.8×10^{3}	1.4×10^{3}	2.3×10^{3}	2.8×10^{4}**	2.2×10^{4}	3.4×10^{4}
Degree of urbanisation							
Urban	20	9.7×10^{3}	4.6×10^{3}	2.0×10^{4}	1.0×10^{5}**	5.3×10^{4}	2.0×10^{5}
Semi-urban	60	4.4×10^{3}	3.2×10^{3}	6.1×10^{3}	4.5×10^{4}**	3.2×10^{4}	6.3×10^{4}
Rural	125	8.7×10^{2}	6.3×10^{2}	1.2×10^{3}	1.8×10^{4}**	1.3×10^{4}	2.3×10^{4}
Rural subcatchments with different dominant land uses							
≥75% Imp pasture	15	1.9×10^{3}	1.1×10^{3}	3.2×10^{3}	5.7×10^{4}**	4.1×10^{4}	7.9×10^{4}
≥75% Rough Grazing	13	3.6×10^{2}	1.6×10^{2}	7.8×10^{2}	8.6×10^{3}**	5.0×10^{3}	1.5×10^{4}
≥75% Woodland	6	3.7×10	1.2×10	1.2×10^{2}	1.5×10^{3}**	6.3×10^{2}	3.4×10^{3}
Enterococci							
All subcatchments	205	2.7×10^{2}	2.2×10^{2}	3.3×10^{2}	5.5×10^{3}**	4.4×10^{3}	6.8×10^{3}
Degree of urbanisation							
Urban	20	1.4×10^{3}	9.1×10^{2}	2.1×10^{3}	2.1×10^{4}**	1.3×10^{4}	3.3×10^{4}
Semi-urban	60	5.5×10^{2}	4.1×10^{2}	7.3×10^{2}	1.0×10^{4}**	7.6×10^{3}	1.4×10^{4}
Rural	125	1.5×10^{2}	1.1×10^{2}	1.9×10^{2}	3.3×10^{3}**	2.4×10^{3}	4.3×10^{3}
Rural subcatchments with different dominant land uses							
≥75% Imp. pasture	15	2.2×10^{2}	1.4×10^{2}	3.5×10^{2}	1.0×10^{4}**	7.9×10^{3}	1.4×10^{4}
≥75% Rough Grazing	13	4.7×10	1.7×10	1.3×10^{2}	1.2×10^{3}**	5.8×10^{2}	2.7×10^{3}
≥75% Woodland	6	1.6×10	7.4	3.5×10	1.7×10^{2}**	5.5×10	5.2×10^{2}
[a] Significant elevations in concentrations at high flow are indicated: **po0.001, *po0.05.							
[b] Degree of urbanisation categorised according to percentage built-up land: 'Urban' (X10.0%), 'Semi-urban' (2.5–9.9%) and 'Rural' (o2.5%).							

Source: (Kay, et al., 2008a)

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 x 108
Cow	230,000	23,600	5.4 x 109
Duck	33,000,000	336	1.1 x 1010
Horse	12,600	20,000	2.5 x 108
Pig	3,300,000	2,700	8.9 x 108
Sheep	16,000,000	1,130	1.8 x 1010
Turkey	290,000	448	1.3 x 108
Human	13,000,000	150	1.9 x 109

Source: (Gauthier & Bedard, 1986)

3. Hydrographic Assessment 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.

MHW. Mean High Water, The highest level that tides reach on average.

MHWN. Mean High Water Neep, The highest level that tides reach on average during neep tides.

MHWS. Mean High Water Spring, The highest level that tides reach on average during spring tides

MLW. Mean Low Water, The lowest level that tides reach on average.

MLWN. Mean Low Water Neep, The lowest level that tides reach on average during neep tides.

MLWS. Mean Low Water Spring, The lowest level that tides reach on average during spring tides.

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. Spring tides occur during or just after new moon and full moon when the tide-generating force of the sun acts in the same direction as that of the moon, reinforcing it. The tidal range is greatest and tidal currents strongest during spring tides.

Neep tides occur during the first or last quarter of the moon when the tide-generating forces of the sun and moon oppose each other. The tidal range is smallest and tidal currents are weakest during neep 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. A surface flow at the surface may be accompanied by a compensating flow in the opposite direction at the bed.

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.

4. Shoreline Survey Report

Report Title	Loch na Cille Shoreline Survey Report
Project Name	Shellfish Sanitary Surveys
Client/Customer	Cefas
SRSL Project Reference	00561_B0067

Document Number	B0067_Shoreline 0008
Revision	Issue 02
Date	23/04/2013

Revision History

Revision	Changes	Date
A	Issue for internal review	16/04/13
01	First formal issue to CEFAS for comment	17/04/13
02	Second issue to CEFAS incorporating comments at Rev 01.	23/04/13

	Name & Position	Date
Author	Lars Brunner & Eilidh Cole	16/04/13
Checked	Andrea Veszelovszki	23/04/13
Approved	Andrea Veszelovszki	23/04/13

SRSL, Scottish Marine Institute, Oban, Argyll, PA37 1QA, tel 01631 559 470, www.samsrsl.co.uk

Shoreline Survey Report

Production area:	Loch na Cille
Site name:	Loch na Cille Cockles
SIN:	AB-617-1204-04
Species:	Cockles
Harvester:	Mr Samuel McGeachy
Local Authority:	Argyll & Bute Council
Status:	New application
Date Surveyed:	26th & 27th March 2013
Surveyed by:	Eilidh Cole, Debbie Brennan, Lars Brunner
Existing RMP:	None
Area Surveyed:	From Ardanstur eastward round Fearnach Bay and Loch na Cille to the southernmost point of Kames Bay

Weather

There was no rainfall in the week preceding the survey. Rainfall has been well below average for around 4 – 5 weeks preceding the survey.

Tue 26th March 2013: Cloud cover 99%, sea state 0 – 1 (calm). Temp 3.5°C Slight breeze, 5-12km/hr. (E).

Wed 27th March 2013: Cloud cover 15-20%, sea state 0 – 1 (calm). Temp 3.6°C. No wind.

Stakeholder engagement during survey

There have been several attempts to try to get in contact with the harvester prior to the survey (via phone, email and post) however these attempts proved to be unsuccessful. As a result, the harvester was not met/present during the survey, also noting that harvesting has not yet started, as the site is not yet classified.

Contact was made with the local Sampling Officer (Alison Hardie) prior to the survey, but she was not available to attend on the planned survey dates. It is notable that the local Sampling Officer has also been unable to contact the harvester to date.

The local Sampling Officer collects a monthly cockle sample (of 40 cockles for E.coli testing) at the site, at NM 8416 1251. The sampling officer notes that cockles are abundant at the site, with the area around the sampling point consisting of mud and shingle.

Fishery

The planned fishery at Loch na Cille consists of the hand harvest of common cockles from the sands at the centre of the bay. At the time of survey, the site was not yet classified for harvesting and hence there was no activity during the survey from harvesters and no fixed infrastructure was noted for harvest handling (i.e. shore base) during the survey.

At the time of survey, the site was not yet classified for harvesting

Sewage Sources

The majority of the survey area around Loch na Cille is inhabited. In the north of the survey area around Fearnach Bay there are mostly individual detached houses, with small holiday villages situated at Melfort Pier (NM 8315 1411 and Melfort Village (NM 8323 1433. Loch na Cille itself has detached houses and a village hall along its northern shore. There is a boatyard with some detached houses on the southern shore. Kilmelford Waste Water Treatment Works (WWTW) and its associated discharge is located immediately to the east of Loch na Cille. The southern shore of Loch na Cille heading towards Kames Bay is largely uninhabited except for one detached dwelling at Kames and a fish farm in Kames Bay (NM 8236 1166).

Seasonal Population

There are no campsites or caravan parks in the survey area. There is a hotel and B&B present in the village of Kilmelford, just to the east of the survey area. The holiday villages of Melfort Pier and Melfort Village consist of self-catering houses and chalets that are predominantly let out during the summer months, but have partial occupancy at other times of the year. Some of the houses around Fearnach Bay and Loch na Cille are likely to be holiday homes, but it was not possible to verify the exact number.

Boats/Shipping

There are piers in the survey area at Melfort Pier, Melfort boatyard and Kames Bay with anchorages present around Melfort Pier (approximately 24 moorings with no boats on water during survey) and Melfort boatyard (approximately 60 moorings with 4 yachts on water during survey). The area around Kames Bay pier had three moorings with no vessels on mooring – it is probable that these are moorings for workboats for the associated fish farm.

Farming and Livestock

Agriculture consists largely of cattle and sheep farming on the lower fields surrounding the survey area, with no visible arable cultivation. The only livestock seen during the survey were four sheep in a field immediately to the west of Melfort Pier on the first day of survey. Sheep and cattle were observed in the fields around the loch while travelling to the survey site.

Land Use

The land use around the survey area is varied, but predominantly rural based. Habitation consists of detached dwellings, most of which have small areas of garden/ground with them. There is small industrial activity, from the boatyard at the head of Loch na Cille, to the fish farm at Kames Bay and the holiday cottages at Melfort Pier. Agriculture consists largely of cattle and sheep farming on the lower fields surrounding the survey area, with no visible arable cultivation. There are small pockets of forest, some of cultivated spruce plantation on the southern shore of the survey area, and some areas of native woodland on both the north and south shores.

Land Cover

Land cover over the survey area is varied. The northern shore has a mixture of grassland/improved pasture with areas of native woodland adjoining the shoreline. The southern shore contains a mixture of grassland/improved pasture along with heath and areas of plantation forest/native forest.

Watercourses

The major watercourses discharging into the survey area are the River Oude, which discharges at NM 8366 1399, and the Abhainn na Cille, which discharges at NM 8439 1259.

There a several smaller, unnamed streams discharging in the survey area, and noted in the sampling plan and results. Typical discharge of all streams and rivers was low due to the long period of dry weather preceding the survey.

Wildlife/Birds

During the survey gulls, oystercatchers, geese, mallard ducks and an otter were noted, along with evidence of geese droppings on the shoreline at several locations.

Shoreline Survey Maps

Figure 1. Loch na Cille Waypoints

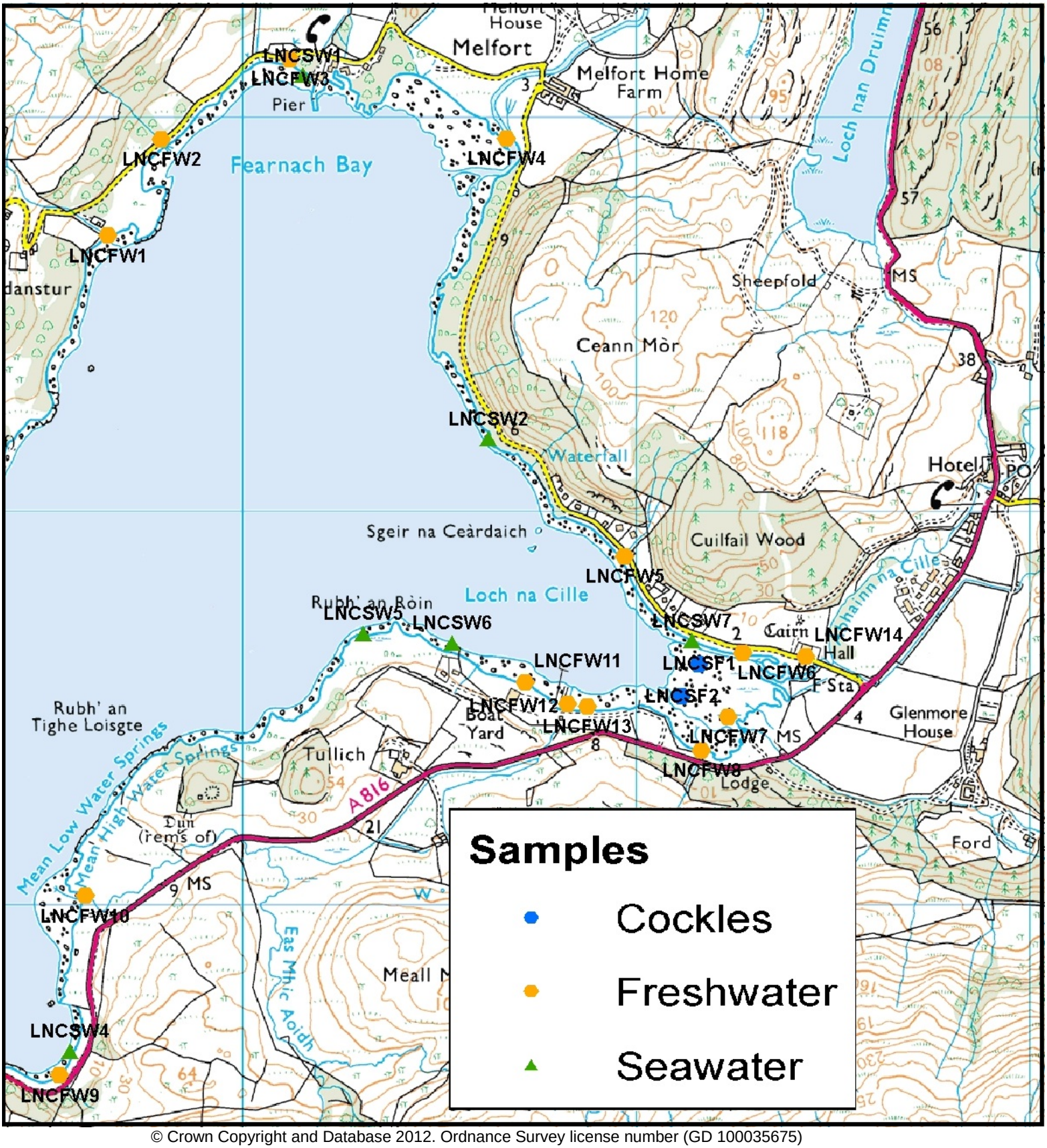

Figure 2. Loch na Cille samples

Table 1 Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	26/03/2013	10:19	NM 82659 13698	182659	713699	Fig. 3		Start of survey. Small river running next to house onto shore. Width - 75 cm; Depth - 15 cm; Flow - 0.044 m/s; SD - 0.015. Four geese in field next to house. One boat on water and one boat on shore. Three moorings (on this side of loch). Approximately ten houses and four boats seen on the other side of the loch.
2	26/03/2013	10:23	NM 82658 13699	182659	713700		LNCFW1	Freshwater sample taken associated with waypoint 1.
3	26/03/2013	10:35	NM 82744 13700	182745	713701	Fig. 4		Geese droppings on shore.
4	26/03/2013	10:42	NM 82804 13928	182805	713929			Small river running under road onto shore. Width - 58 cm; Depth - 24 cm; Flow - 0.096 m/s. SD - 0.006.
5	26/03/2013	10:44	NM 82794 13944	182795	713945	Fig. 5	LNCFW2	Freshwater sample taken associated with waypoint 4.
6	26/03/2013	10:49	NM 82797 13941	182798	713942			Four sheep in field above shore next to road. The small river from which sample LNCFW2 was taken runs through this field.
7	26/03/2013	10:52	NM 82821 13958	182821	713959	Fig. 6		Very small stream, looks like land drainage from the road. Pipe diameter is approximately 50 cm. No sample taken. Approximately twenty four moorings in the loch but no boats on water.
8	26/03/2013	11:04	NM 83121 14150	183122	714150	Fig. 7		Concrete structure on shore next to road with Melfort Village Pier Houses behind. Small burn runs under road and next to concrete structure. Smell of sewage. Width - 25 cm; Depth - 2 cm; Flow approx. - 30 ml / 1 sec. House occupants stated that this was the lowest the small burn had been for twenty years.
9	26/03/2013	11:07	NM 83122 14149	183123	714149	Fig. 7	LNCFW3	Freshwater sample taken associated with waypoint 8.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
10	26/03/2013	11:14	NM 83152 14116	183153	714117			Location of Melfort Pier in Fearnach Bay. Not possible to go around it.
11	26/03/2013	11:16	NM 83155 14105	183155	714106		LNCSW1	Planned seawater sample taken associated with waypoint 10.
12	26/03/2013	11:25	NM 83301 14119	183301	714119			Access to shore difficult. Harbour office is at this location. Harbour office master suggested where access to the shore is possible. Also holiday homes at location. Pontoon for small boats with two boats in the water. Outflow from pipe, heavily flowing, no smell but looks contaminated - lot of green algae growing. No access to it, therefore no sample taken.
13	26/03/2013	11:37	NM 83567 13925	183568	713926			Approximately 40 seagulls and two oyster catchers on the water at the shore edge. Two ducks on the shore.
14	26/03/2013	11:42	NM 83671 13946	183671	713946	Fig. 8	LNCFW4	Freshwater sample taken associated with waypoint 15.
15	26/03/2013	11:45	NM 83671 13946	183672	713946			River Oude. Width - 7.5 m; Depth 1 - 21 cm; Flow 1 - 0.332 m/s; SD 1 - 0.02. Depth 2 - 15 cm; Flow 2 - 0.149 m/s; SD 2 - 0.013.
16	26/03/2013	12:03	NM 83535 13567	183536	713568			Access to shore difficult here, went back to road for approximately 5 m then back onto shore.
17	26/03/2013	12:15	NM 83626 13183	183627	713184		LNCSW2	Planned seawater sample taken at the north side of Loch na Cille.
18	26/03/2013	12:18	NM 83627 13184	183628	713184			One otter in water at shore's edge.
19	26/03/2013	12:29	NM 83857 12985	183857	712986			Holiday home with two manhole covers in garden. No discharge seen on shore.
20	26/03/2013	12:34	NM 83972 12885	183972	712885		LNCFW5	Freshwater sample taken associated with waypoint 21.
21	26/03/2013	12:35	NM 83972 12884	183972	712884	Fig. 9		Stream running off hill next to houses, through a pipe, then onto shore. Width - 25 cm; Depth - 2 cm; Flow - approx. 30 ml / 2 secs.
22	26/03/2013	12:40	NM 84013 12803	184014	712803			Concrete manhole cover on shore. No discharge seen.
23	26/03/2013	12:43	NM 84121 12686	184122	712686			Metal pipe cast in concrete. Not flowing. ‘Pebble Beach View’ house behind shore.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
24	26/03/2013	12:48	NM 84273 12639	184274	712640		LNCFW6	Freshwater sample taken associated with waypoint 25.
25	26/03/2013	12:50	NM 84275 12638	184275	712639			Large river, unnamed. Width - 5m 40 cm; Depth 1 - 23 cm; Flow 1 - 0.059 m/s; SD 1 - 0.02. Depth 2 - 15 cm; Flow 2 - 0.207 m/s; SD 2 - 0.051. Some goose droppings next to river.
26	26/03/2013	13:01	NM 84234 12478	184235	712479		LNCFW7	Freshwater sample taken associated with waypoint 27.
27	26/03/2013	13:01	NM 84233 12478	184233	712479			Small river, unnamed. Width - 1m 80 cm; depth - 6 cm; Flow - 0.373 m/s; SD - 0.009.
28	26/03/2013	13:07	NM 84167 12393	184167	712393		LNCFW8	Freshwater sample taken associated with waypoint 29.
29	26/03/2013	13:09	NM 84164 12392	184164	712392			Small stream, unnamed. Width - 90 cm; Depth - 15 cm; Flow - 0.125 m/s; SD - 0.004. End of survey day 1.
30	27/03/2013	8:39	NM 82515 11571	182516	711572			Start of survey day 2. Fish farm (possibly salmon but not certain). Moorings and mooring buoys. No boats present. Remnants of a sewage pipe but no pipe present.
31	27/03/2013	8:43	NM 82532 11567	182532	711567			One house on hill. Small river flowing under road and onto shore. Width - 55 cm; Depth - 6 cm; Flow - 0.084 m/s; SD - 0.002.
32	27/03/2013	8:45	NM 82535 11567	182536	711567	Fig. 10	LNCFW9	Freshwater sample taken associated with waypoint 31.
33	27/03/2013	8:49	NM 82576 11618	182577	711618			Small stream running onto shore, looks as if it's from the same source as LNCFW9.
34	27/03/2013	8:51	NM 82562 11627	182563	711627		LNCSW4	Seawater sample taken due to proximity of fish farm.
35	27/03/2013	8:52	NM 82562 11626	182563	711626			Waypoint not used.
36	27/03/2013	9:01	NM 82603 12023	182603	712024		LNCFW10	Burn running onto shore. Width - 1.60 m; Depth - 15 cm; Flow - 0.100 m/s; SD - 0.004. Freshwater sample taken.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
37	27/03/2013	9:09	NM 82580 12026	182581	712027			Four Canada geese - goose droppings on grass above beach. Approximately twenty gulls. One mooring.
38	27/03/2013	9:18	NM 82726 12311	182726	712312			Rocky shoreline.
39	27/03/2013	9:39	NM 83261 12640	183262	712641	Fig. 11		Several dead sea urchins on rocks.
40	27/03/2013	9:42	NM 83307 12689	183307	712689		LNCSW5	Planned seawater sample taken at Rubh' an Roin.
41	27/03/2013	9:54	NM 83502 12674	183503	712675			Cast iron outflow pipe. Diameter - 10 cm. Tide above outflow so no sample taken. No obvious discharge.
42	27/03/2013	9:57	NM 83534 12664	183535	712665			Outflow pipe (plastic) with discharge. 10 cm diameter.
43	27/03/2013	9:57	NM 83535 12665	183535	712665		LNCSW6	Extra seawater sample taken due to proximity of discharge pipes, and the fact that it was not possible to sample directly from the discharge pipes due to the state of the tide.
44	27/03/2013	10:03	NM 83577 12620	183578	712621			10 cm diameter plastic pipe on shore from house. No discharge.
45	27/03/2013	10:09	NM 83666 12588	183667	712588			Possible site of burn but dry. Narrow pipe 5 cm diameter. No discharge. Corner of boatyard.
46	27/03/2013	10:12	NM 83719 12565	183720	712565			Discharge from Melfort boatyard. Strong smell. Had to estimate the flow (using the sample vial [30mL] which was filled in 3 seconds = 10 mL / sec) due to difficulty in gaining access to the pipe.
47	27/03/2013	10:15	NM 83719 12565	183720	712566		LNCFW11	Freshwater sample taken, likely to be contaminated, associated with waypoint 46.
48	27/03/2013	10:18	NM 83739 12581	183739	712581			Plastic pipe 10 cm diameter. No outflow.
49	27/03/2013	10:21	NM 83828 12511	183828	712511			Stream. Width - 1 m; Depth - 5 cm; Flow - 0.259 m/s; SD - 0.004.
50	27/03/2013	10:21	NM 83828 12509	183829	712510		LNCFW12	Freshwater sample taken associated with waypoint 49.
51	27/03/2013	10:27	NM 83879 12504	183880	712505	Fig. 12		Plastic outflow pipe - 10 cm diameter. Very strong smelling discharge.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
52	27/03/2013	10:27	NM 83879 12503	183879	712504		LNCFW13	Freshwater sample taken, likely to be contaminated, associated with waypoint 51.
53	27/03/2013	10:32	NM 83913 12498	183914	712499			Plastic outflow pipe, 10 cm diameter, no outflow.
54	27/03/2013	10:35	NM 84047 12517	184047	712517	Fig. 13		Approximately sixty moorings with no boats. Four boats in water. A few oyster catchers, gulls and mallards.
55	27/03/2013	11:04	NM 84161 12611	184161	712612		LNCSF1	Planned shellfish sample taken. Collected approximately forty cockles. Some were quite large.
56	27/03/2013	11:19	NM 84118 12529	184118	712530		LNCSF2	Planned shellfish sample taken. Approximately forty cockles were collected.
57	27/03/2013	11:34	NM 84498 12595	184498	712596			Sewage plant. Spoke to a local man who told us there were problems with the sewage plant even though it was relatively new. He said that it was ineffective and there was very strong smelling sewage came down the river at times.
58	27/03/2013	11:37	NM 84439 12583	184440	712584			Discharge from sewage plant (Kilmelford waste water discharge). Brown water.
59	27/03/2013	11:41	NM 84433 12631	184433	712632		LNCFW14	Freshwater sample taken, likely to be contaminated, associated with Waypoint 58.
60	27/03/2013	14:15	NM 84143 12670	184144	712670		LNCSW7	Planned seawater sample taken at the head of loch.

Photographs referenced in the table can be found attached as Figures 3 – 13.

Sampling

Water samples were collected at sites marked on the map shown in Figures 1 and 2. Samples were transferred to either Biotherm 10 or Biotherm 25 boxes with ice packs and shipped to Glasgow Scientific Services (GSS) for *E.coli* analysis. All samples were shipped on the day of collection and all of them were received and analysed the following day. The sample temperatures on arrival at the laboratory ranged between 1.5 ˚C and 6.3 ˚C.

Seawater samples were tested for salinity by GSS and the results reported in mg Chloride per litre. These results have been converted to parts per thousand (ppt) using the following formula:

$$\text{Salinity (ppt)} = 0.0018066 \text{ X } Cl^{-} \text{ (mg/L)}$$

At Loch na Cille, cockle samples were collected at the locations shown in Figures 1 and 2. These were taken at low tide in the intertidal zone therefore no salinity profiles were taken.

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (cfu/100ml)	Salinity (ppt)
1	26/03/2013	LNCFW1	NM 82658 13699	Freshwater	<100	
2	26/03/2013	LNCFW2	NM 82794 13944	Freshwater	<100	
3	26/03/2013	LNCFW3	NM 83122 14149	Freshwater	<1000	
4	26/03/2013	LNCSW1	NM 83155 14105	Seawater	0	35.60
5	26/03/2013	LNCFW4	NM 83671 13946	Freshwater	2400	
6	26/03/2013	LNCSW2	NM 83626 13183	Seawater	15	35.20
7	26/03/2013	LNCFW5	NM 83972 12885	Freshwater	200	
8	26/03/2013	LNCFW6	NM 84273 12639	Freshwater	130000	
9	26/03/2013	LNCFW7	NM 84234 12478	Freshwater	1200	
10	26/03/2013	LNCFW8	NM 84167 12393	Freshwater	<100	
11	27/03/2013	LNCFW9	NM 82535 11567	Freshwater	900	
12	27/03/2013	LNCSW4	NM 82562 11627	Seawater	0	34.90
13	27/03/2013	LNCFW10	NM 82603 12023	Freshwater	<100	
14	27/03/2013	LNCSW5	NM 83307 12689	Seawater	29	34.10
15	27/03/2013	LNCSW6	NM 83535 12665	Seawater	300	31.10
16	27/03/2013	LNCFW11	NM 83719 12565	Freshwater	<1000	
17	27/03/2013	LNCFW12	NM 83828 12509	Freshwater	<100	
18	27/03/2013	LNCFW13	NM 83879 12503	Freshwater	67000	
19	27/03/2013	LNCFW14	NM 84433 12631	Freshwater	2700000	
20	27/03/2013	LNCSW7	NM 84143 12670	Seawater	27	34.30

The numbering of the seawater samples is such that LNCSW3 does not exist.

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (MPN/100g)
1	27/03/2013	LNCSF1	NM 84161 12611	Cockles	110
2	27/03/2013	LNCSF2	NM 84118 12529	Cockles	80

Photographs

Figure 3. Waypoint 1. Small river running next to house onto shore with one boat on water. Site of sample LNCFW1.

Figure 4. Waypoint 3. Geese droppings on shore.

Figure 5. Waypoint 5. Small river running under road onto shore. Site of sample LNCFW2.

Figure 6. Waypoint 7. Approximately twenty four moorings in the loch but no boats on the water.

Figure 7. Waypoint 9. Small burn running under road and next to concrete structure. Smell of sewage. Site of sample LNCFW3.

Figure 8. Waypoint 14. River Oude. Site of sample LNCFW4.

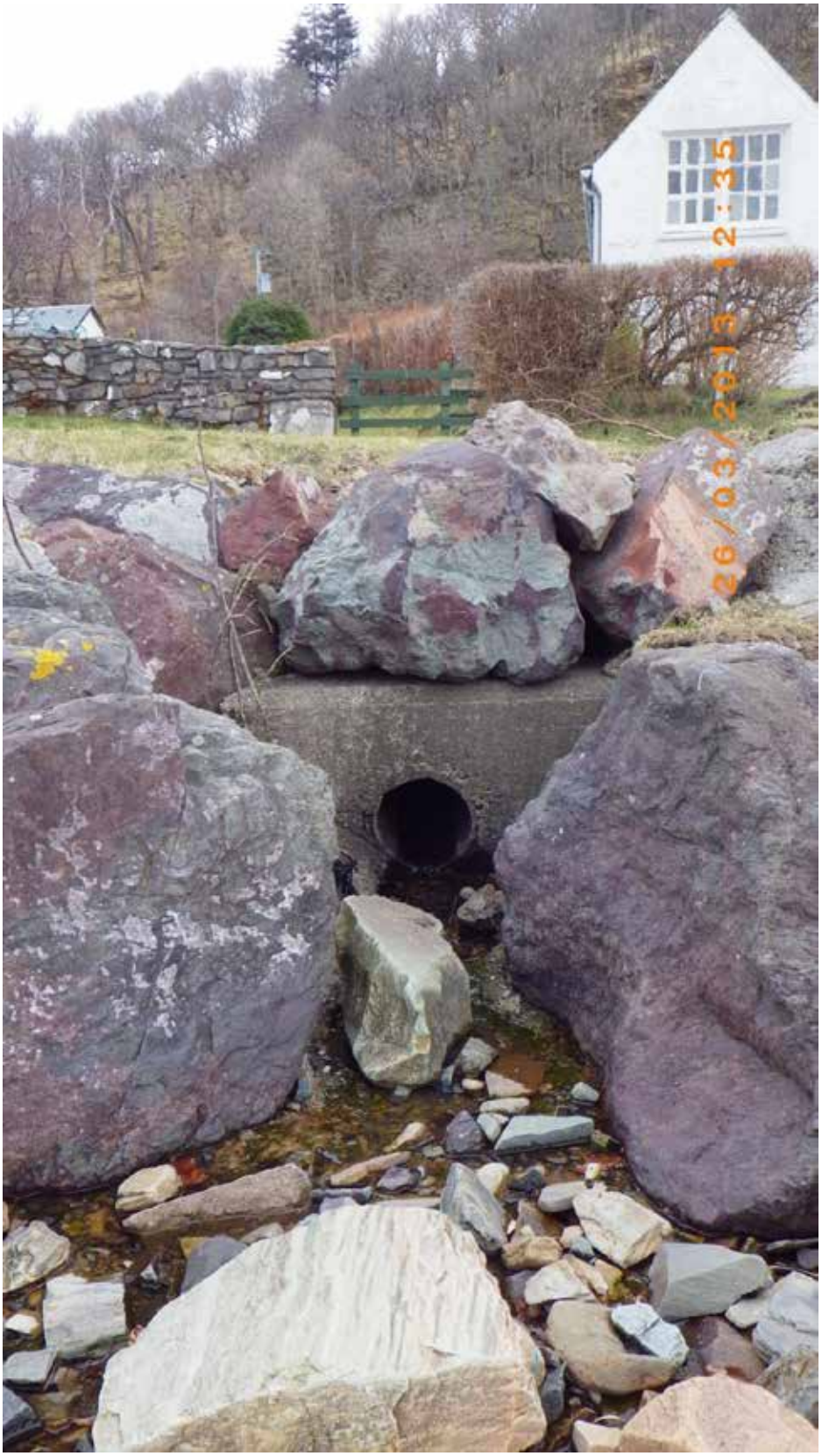

Figure 9. Waypoint 21. Stream running off hill next to houses, through pipe then onto shore. Site of sample LNCFW5.

Figure 10. Waypoint 32. Small river running under road and onto shore. Site of sample LNCFW9.

Figure 11. Waypoint 39. Several dead sea urchins found on rocks.

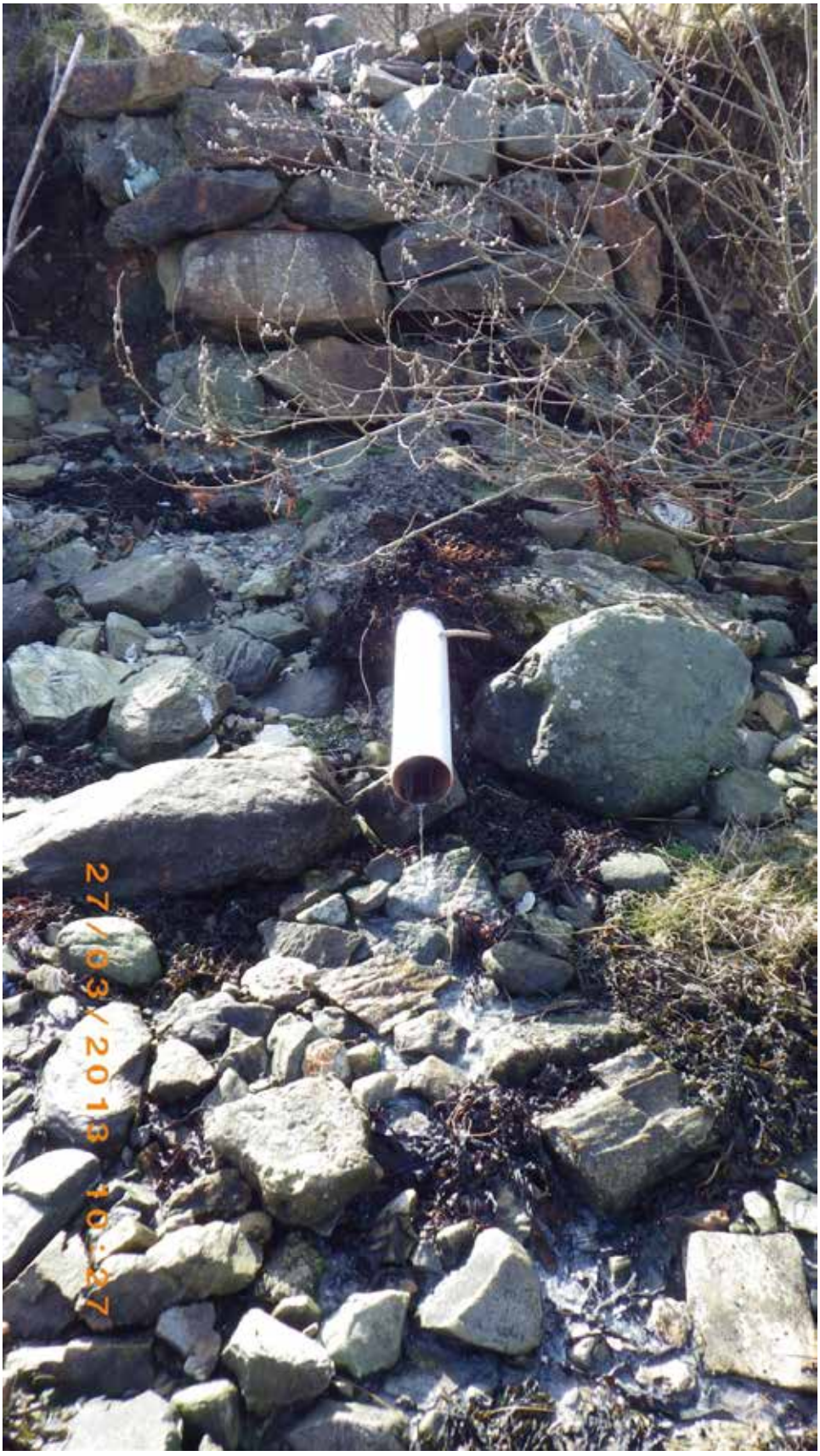

Figure 12. Waypoint 51. Plastic outflow pipe, smelling strongly of sewage. Site of sample LNCFW13.

Figure 13. Waypoint 54. Approximately sixty moorings but only four boats on the water.