Scottish Sanitary Survey Review

Loch Roag: Ceabhagh and Eilean Chearstaigh

LH-344 and LH-381

February 2015

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Review Specification and Introduction

Sanitary surveys are used to demonstrate compliance with the requirements stated in Annex II (Chapter II Paragraph 6) of Regulation (EC) 854/2004, whereby if the competent authority decides in principle to classify a production or relay area it must:

- make an inventory of pollution sources of human/animal origin likely to be a contamination source for the production areas;
- examine the quantities of organic pollutants which are released during the different periods of the year, according to the seasonal variations of both human and animal populations in the catchment area, rainfall readings, wastewater treatment, etc.;
- determine the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal regime in the production area;
- establish a sampling programme of bivalve molluscs in the production area which is based on the examination of established data, and with a number of samples, a geographical distribution of the sampling points and a sampling frequency which must ensure that the results of the analysis are as representative as possible for the area considered.

The EURL Good Practice Guide (GPG) for the monitoring of bivalve molluscs harvesting areas recommends the re-evaluation of sanitary surveys every six years. Location, extent and nature of fisheries and faecal pollution sources may change over time and the review is conducted to determine whether the sampling plan and/or production area boundaries remain appropriate and protective of public health.

As specified by the Food Standards Agency, this review is comprised of a brief desktop search of publicly available information together with a shoreline survey. No additional data requests are submitted to external bodies. The review is intended to identify significant changes in:

- Historic microbiological data.
- Sewage treatment and sewerage infrastructure.
- Housing and development.
- Harvester operations.

The output of the review is a report identifying any new information that has been obtained and/or whether major elements of the original sanitary survey can be regarded as essentially unchanged. That report includes an overall assessment as to whether the production area/classification zone boundaries and/or RMPs should be modified from those recommended in the original report and if so, a description of the revised boundaries and a revised sampling plan with the boundaries and RMP(s) locations.

A sanitary survey was undertaken in 2008 for Loch Roag: Ceabhagh and Eilean Chearstaigh. The survey was conducted to identify the location, extent and nature of the shellfishery and the potential sources of faecal contamination to the shellfishery, and to recommend boundaries and sampling plans for the production areas. The associated shoreline survey was undertaken in August 2007.

The output of the sanitary survey included a report and recommended sampling plans for the four production areas within the sound. These sampling plans are identified on the following pages alongside the recommended changes following findings from this review.

The present report constitutes a review of publicly available information in order to assess changes that have occurred since the 2008 sanitary survey report (see the Review Specification section for further detail). It is not intended to present detailed information relating to pollution sources that were identified in the previous report. This review should be read in conjunction with the 2008 sanitary survey report.

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APPENDICES

Sampling Plan - Loch Roag: Ceabhagh

	2008 report	2014 review	Changes from 2008
PRODUCTION AREA	Loch Roag: Ceabhagh		No change
SITE NAMES	Keava		
SIN	LH-381-772-08		
SPECIES	Common mussels		
TYPE OF FISHERY	Long-line		
NGR OF RMP	NB 2005 3450	NB 1200 3450	Changed to locate the RMP within the current fishery boundaries
EAST	120050	120000	
NORTH	934500	934500	
TOLERANCE (M)	10 m	40 m	Changed to allow for movement of mussel lines
DEPTH (M)	3	1-3	Changed to reflect contamination in the upper layer
METHOD OF SAMPLING	Hand		No change
FREQUENCY OF SAMPLING	Monthly		
LOCAL AUTHORITY	Lewis and Harris		
AUTHORISED SAMPLER(S)	Paul Tyler		
RECOMMENDED PRODUCTION AREA	Area bounded by lines drawn between NB 1941 3460 and NB 1983 3460 and between NB 2014 3465 and NB 2073 3438 and between NB 2027 3360 and NB 2011 3359 and between NB 1939 3361 and NB 1908 3361 extending to MHWS	Area bounded by lines drawn between NB 1941 3460 and NB 1985 3460 and between NB 2010 3467 and NB 2073 3436 and between NB 2028 3360 and NB 2011 3360 and between NB 1941 3360 and NB 1908 3360 extending to MHWS.	Minor amendments to boundaries to conform to the adjacent boundaries for Loch Roch: Eilean Chearstaigh and to meet MHWS

Sampling Plan – Loch Roag: Eilean Chearstaigh

	2008 report	2014 review	Changes from 2008
PRODUCTION AREA	Loch Roag: Eilean Chearstaigh		No change
SITE NAMES	Buckle Point and Eilean Scarastaigh		
SINS	LH-344-791-08 and LH-344-697-08		
SPECIES	Common mussels		
TYPE OF FISHERY	Long-line		
NGR OF RMP	NB 2020 3240	NB 2009 3245	Changed to reflect identified area of potentially higher contamination
EAST	120200	120090	
NORTH	932400	932449	
TOLERANCE (M)	10 m	40 m	To allow for movement of mussel lines
DEPTH (M)	3	1-3	Changed to reflect higher contamination levels near surface
METHOD OF SAMPLING	Hand		No change
FREQUENCY OF SAMPLING	Monthly		
LOCAL AUTHORITY	Lewis and Harris		
AUTHORISED SAMPLER(S)	Paul Tyler		
RECOMMENDED PRODUCTION AREA	Area bounded by lines drawn between NB 1891 3352 and NB 1867 3308 and between NB 2094 3244 and NB 2114 3260 and between NB 2028 3360 and NB 2011 3360 and between NB 1941 3360 and NB 1908 3360	Area bounded by lines drawn between NB 1891 3352 and NB 1867 3308 and between NB 2094 3244 and NB 2114 3260 and between NB 2028 3360 and NB 2011 3360 and between NB 1941 3360 and NB 1908 3360	No change

1. Area Description and Fishery

The location of East Loch Roag, which contains the production areas Loch Roag: Ceabhagh and Loch Roag: Eilean Chearstaigh, is shown in Figure 1.1.

Figure 1.1 Location of East Loch Roag

The three mussel farm sites classified within the two production areas in East Loch Roag remain the same as those identified in the 2008 report. Details of these are listed in Table 1.1.

Table 1.1 Currently monitored fisheries operating in East Loch Roag

Production area	Site	SIN	Species	RMP
Loch Roag: Ceabhagh	Keava	LH-381-772-08	Common mussels	NB 2005 3450
Loch Roag: Eilean Chearstaigh	Buckle Point	LH-344-791-08		NB 2020 3240
	Eilean Scarastaigh	LH-344-697-08		

Ownership of the mussel farms in these two production areas was transferred to Loch Fyne Oysters Limited in January 2014. The current RMPs and production areas identified in the 2014/15 FSAS classification document remain unchanged from those recommended in the 2008 sanitary survey report. These are displayed alongside the mussel farm boundaries recorded in the 2007 and 2014 shoreline surveys in Figure 1.2.

Overall, there appears to have been a slight decrease in extent covered by the mussel lines at all three sites, as shown in Figure 1.2. Specific details on individual sites are as follows.

- Keava consisted of two long-lines running east to west in 2014, the same as in 2008. The 2014 survey noted that the southernmost line has sunk at its eastern end, but was due to be repaired imminently.

- Eilean Scarastaigh had increased from three to four long-lines.

- Buckle Point had decreased from three to two long-lines.

The 2014 survey found stock of mixed ages at all three sites. Dropper lengths are assumed to remain the same as observed in the 2007 survey (10 m at Keava and 7 m at Eilean Scarastaigh and Buckle Point), with no updated information provided during the 2014 survey. The 2014 survey noted all three sites were using continuous New Zealand culture lines, intended to facilitate handling, deployment and grading. Harvesting continues to take place year round and the site manager stated that the recent sale of all three sites to Loch Fyne Oysters was not anticipated to cause any major changes to the sites or to methods of harvesting.

The RMP locations (as identified by the harvester) were recorded during the 2014 shoreline survey differed slightly to those currently specified by FSAS. The recorded monitoring point locations are displayed in Figure 1.2. Neither of the nominal RMPs currently lie on the active mussel farms. At Keava, the recorded monitoring point lies approximately 50 m southwest of the nominal RMP and on the southeast corner of the mussel farm at NB 2001 3448.

At Buckle Point, the recorded monitoring point lies approximately 60 m south of the nominal RMP, near the southeast corner of the mussel farm at NM 2020 3234.

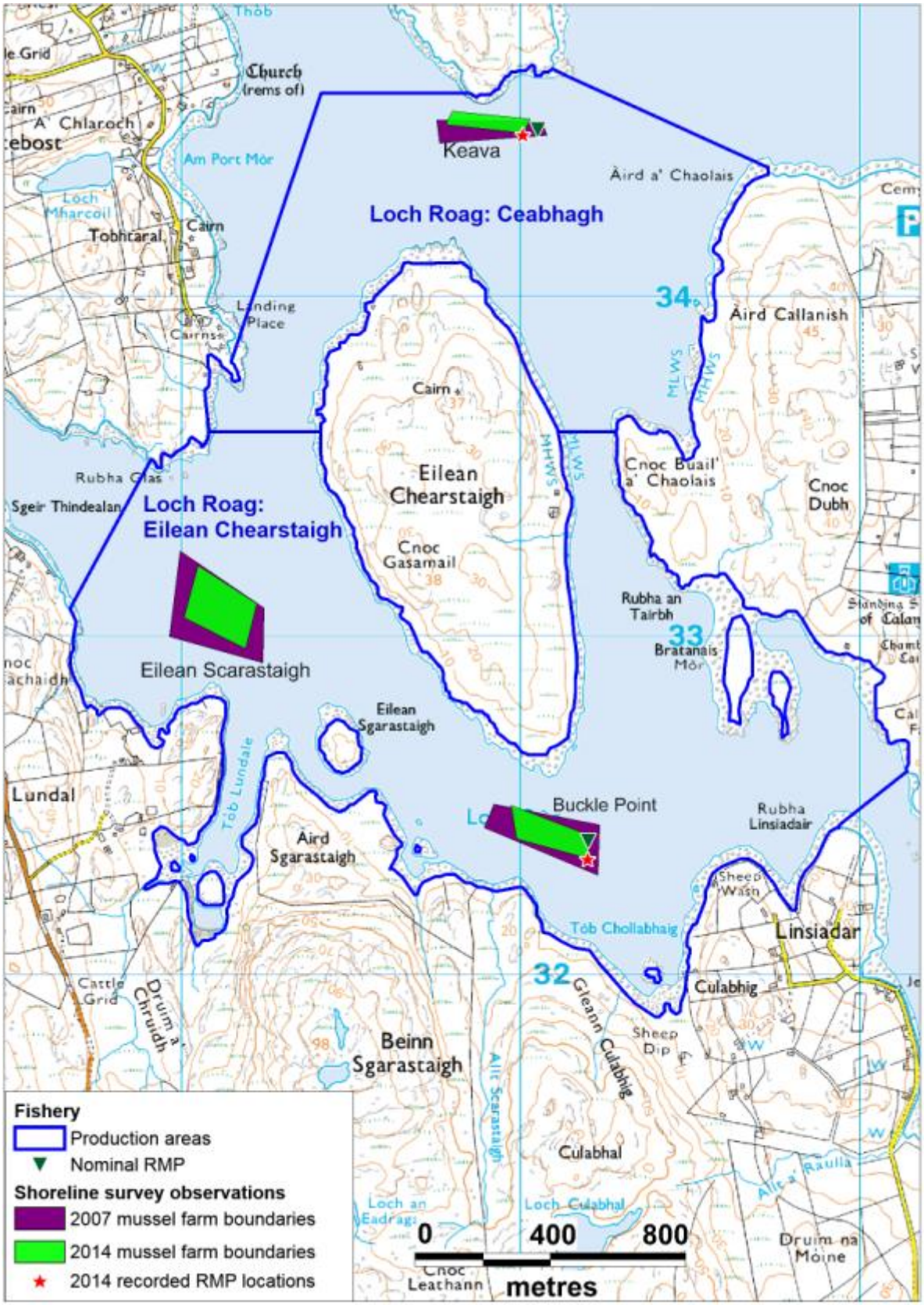

Figure 1.2 East Loch Roag fisheries

2. Population and Human Sewage Impacts

2.1 Population

Population data from the General Register Office for Scotland from both the 2001 and 2011 censuses are shown in Table 2.1 and in Figure 2.1.

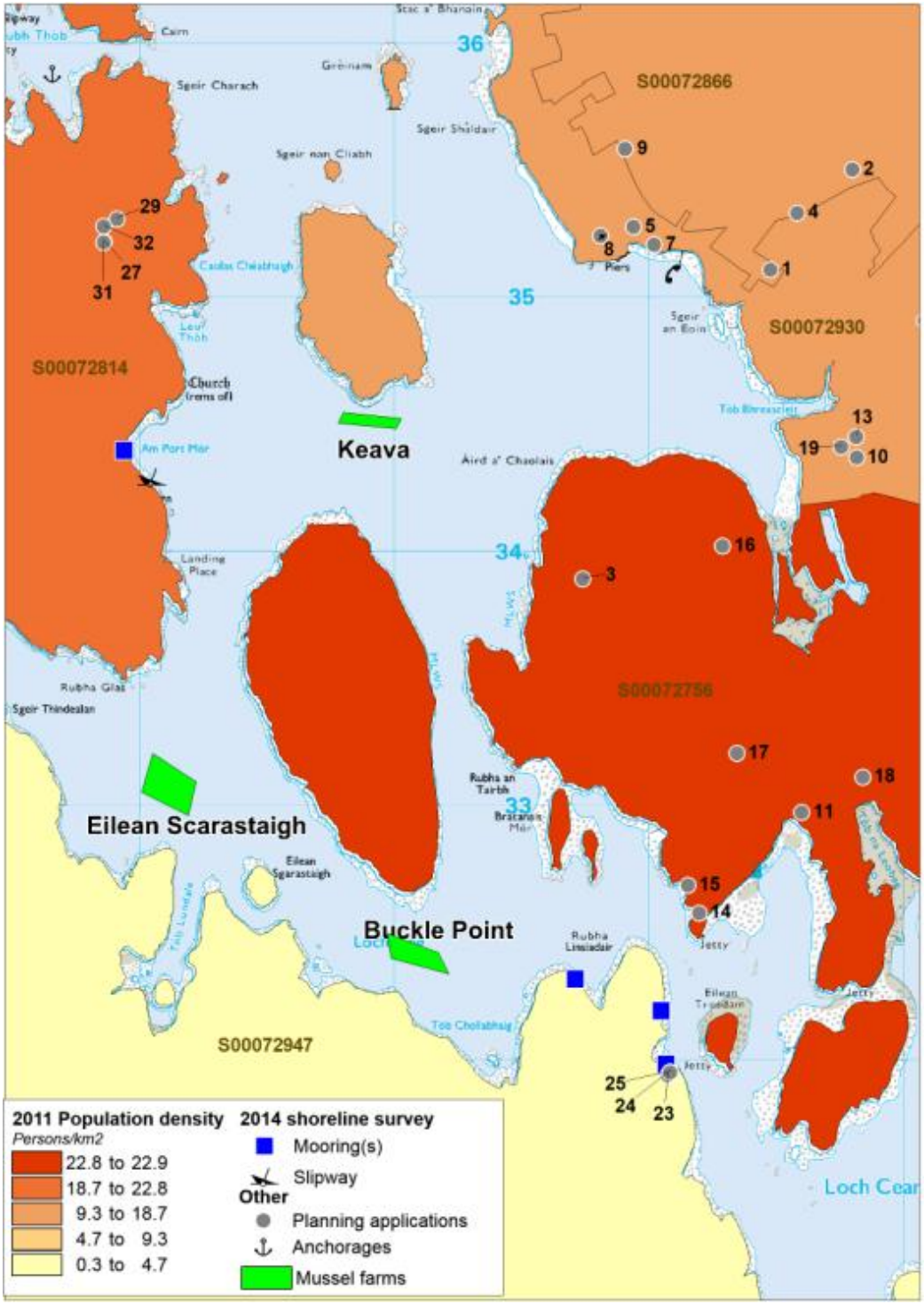

Figure 2.1 Current distribution of human population around East Loch Roag

Although the islands of Ceabhagh and Eilean Chearstaigh, as well as numerous smaller islands, are shown as part of the census output areas, they were uninhabited at the time of the 2011 census and are presumed to remain so.

Table 2.1 Scottish Government Census data for years 2001 and 2011

	2001			2011	
Output area	Population	Area (km^2)	Output area	Population	Area (km^2)
60RJ000060	182	87	S00072756	111	4.8
60RJ000061	66	97	S00072947	124	159
60RJ000066	128	8.1	S00072814	152	8.0
60RJ000068	78	9.4	S00072866	109	9.4
60RJ000069	111	13.2	S00072930	125	13
TOTAL	**565**	**215**	**TOTAL**	**621**	**194**

Census output areas were changed for the 2011 census data, with the population more evenly distributed between the 2011 output areas than in the 2001 output areas. The major changes were to areas on along the east shore of Loch Roag. The settlement of Ghearraidh na-Abhine (Garynahine) was moved from the output area containing Calanais into a large output area covering the west side of Loch Ceann Hulabhaig, and a strip of shoreline to the west of Breascleit, including the piers, was moved into the output area south of Breascleit. A number of uninhabited islands, including Ceabhagh and Eilean Chearstaigh, were not included in the GIS file for the output areas in 2011 but were included in the 2011 files.

Despite the inclusion of the islands, the overall land area covered by the five output areas listed above decreased by 9.8%, while the total population increased by 9.9%. Population density increased in all output areas. The picture is complicated by the changes in census output areas, but the main increases in population appear to be associated with the settlements of Calanais, Breascleit and Garynahine along the eastern shore of the loch and on Great Bernera. Since the 2008 report, there have been 37 planning applications to the areas of Breasclete, Callanish, Garynahine, Kirkibost, Crulivig and Linshader located around East Loch Roag. These were downloaded from the Lewis and Harris Council planning portal (Comhairle nan Eilean Siar, 2014) accessed in October 2014. Further details of these applications can be found in Appendix 1. Where locations were not specifically provided in the applications, they were deduced from the associated maps. Application locations are displayed in Figure 2.1.

Of the 37 planning applications, 28 were for new dwellings and included a repeat application for a three year temporary residential caravan at Kirkibost Pier. A further six applications were associated with new visitor accommodation and included a self catering cottage and log chalet in Breasclete, a camp site in Callanish (Callanish Camping, 2014) and two outbuilding conversions at Linshader (these were adjacent to existing buildings). The remaining three applications were for changes to the

BASF (formerly Equateq) pharmaceuticals factory in Breasclete, the Breasclete Community Centre and a new temporary portable office unit in Callanish. The factory change application indicated the use of existing sewage treatment provision, the office unit application indicated that a new septic tank would be provided and the community centre application did not give information on sewage treatment or disposal.

Visitors to this area support several guest houses, B&Bs and self catering cottages.

The 2007 shoreline survey noted little in the way of boat activity with a jetty, six moorings and a workboat at Breasclete and a fishing pier with six boats and a processing shed northwest at the Dubh Thob inlet. The 2014 shoreline survey similarly noted little boating activity with a pier, five moorings and four boats including a 6 m RIB, a seaweed harvesting workboat and two small boats at Linshader. An abandoned slipway and moored yacht were also noted at Kirkibost. An anchorage is located at Dubh Thob, northwest of Keava (Clyde Cruising Club, 2005),

1.2 Sewage Discharges

The 2008 sanitary survey report identified six owned community septic tanks, which are listed in Table 2.2 and displayed in Figure 2.2.

Table 2.2 Community sewage discharges identified in the 2008 Loch Roag: Ceabhagh and Eilean Chearstaigh sanitary survey report

Discharge Name	NGR	Discharge Type	Level of Treatment	Consented flow (m^3/d)	Population Equivalent
Breasclete B	NB 2120 3520	Continuous	ST	42	188
Breasclete C&D	NB 2160 3470	Continuous	ST	27	120
Callanish A	NB 2150 3370	Continuous	ST	25	116
Callanish C	NB 221 325	Continuous	ST	-	-
Callanish D Garrynahine	NB 2330 3150	Continuous	ST	10.5	-
Kirkibost dun Innes	NB 1810 3420	Continuous	ST	10.8	-

Updated information on discharges in the area was obtained from Loch Roag: Barraglom sanitary survey report (Cefas/FSAS, 2013). This report covered the area around the island of Great Bernera, but none of the eastern shoreline of the loch. Updated information from Scottish Water was only available for the Kirkibost dun Innes community ST and identified it served a PE of 144. Information on 56 additional consented discharges was obtained from the Loch Roag: Barraglom data; these are displayed in Figure 2.2 (two marine cage fish farm locations are not shown). A list of the consents is given in Appendix 2.

Nineteen of the planning applications summarized in Section 1.1 included a plan to connect or use an existing connection to the public sewerage network and six applications identified intent to connect to existing septic tanks. The remaining nine applications identified the use of a new/upgraded private wastewater facility which

were all categorised as septic tanks. Four of these new septic tanks were associated with new dwellings in Kirkibost, one in Crulivig, three were associated with the main house and two ancillary buildings at Linshader House and one was associated with a three year application for a portable office unit in Callanish. The discharge from eight of these septic tanks would receive further treatment (reed bed or additional filtration). A septic tank associated with the portable office unit in Callanish was intended to discharge to soakaway.

The 2007 East Loch Roag shoreline survey reported 28 sewage-related observations, the majority of which related to individual private septic tanks primarily located around the villages of Breasclete and Callanish. The Kirkibost dun Innes septic tank was noted to be overflowing into a stream on the shoreline at the time of survey. The 2008 report concluded that septic tanks along the eastern shore were unlikely to impact the fisheries due to predicted hydrodynamic gyres retaining contaminants within the localised area around the source. Some level of impact was expected from sources on Great Bernera, including from Kirkibost dun Innes septic tank, to the Eilean Scarastaigh and Buckle Point fisheries.

Sewage-related observations from the 2014 shoreline survey are listed in Table 2.3 and displayed in Figure 2.2. The majority of the sewage-related observations were made around Kirkibost, and are therefore expected to contribute to contamination levels at the Keava fishery (to the east) and the Eilean Scarastaigh fishery (to the south). Significant contributions are expected from the two sewage pipes noted to be overflowing to shore (Table 2.3, numbers. 5 and 6). The first pipe was associated with a ST approximately 750 m and 880 m from the Eilean Scarastaigh and Keava sites respectively and returned a sample result of 200,000 *E. coli* cfu/100 ml and an estimated daily loading (assuming constant flow and E. coli content) of 5.7×10^8 *E.coli*/day. The second pipe was located approximately 800 m and 1.1 km of the Keava and Eilean Scarastaigh sites respectively. The freshwater sample taken from this pipe returned a result of 1,400,000 *E. coli* cfu/100 ml and an estimated daily loading of 1.6×10^{10} *E. coli*/day. Three private discharges were noted approximately >1 km southeast of the Buckle Point fishery, though none were found to be actively flowing at the time of the survey.

Table 2.3 Sewage discharge-related observations around East Loch Roag from the 2014 shoreline survey

No.	NGR	Description
1	NB 1892 3237	Septic tank at house above shore. No outflow observed.
2	NB 2105 3220	Standard 10 cm diameter plastic soil pipe plus one metal 5 cm diameter pipe ending on upper foreshore. No discharge in either. Ground above inspected for septic tank but none observed.
3	NB 2105 3221	Ceramic 15 cm diameter pipe running down foreshore. End not visible due to tide level. Section broken near to high water mark, no flow visible.
4	NB 2115 3187	Large covered septic tank on shore with one 10 cm plastic pipe inlet. No sign of discharge pipe to shore below. Discharge pipe present on upper side of tank, with no active discharge.
5	NB 1910 3396	Septic tank above shoreline with 10 cm plastic outfall pipe with discharge. Flow from pipe 3.3ml/second.
6	NB 1901 3430	No septic tank visible above shoreline. Smell present at 10 cm diameter plastic discharge pipe. Flow rate 13ml/second.
7	NB 1889 3468	Large plastic septic tank below road, partially uncovered.
8	NB 1881 3472	Pipework and new septic tank by cottage renovation on site of consented private discharge.
9	NB 1886 3496	Septic tank by road below abandoned house. Not in use at the time of the visit as the house was clearly uninhabited.
10	NB 1889 3497	Plastic soil pipe 10 cm diameter apparently running into soak-away in marshy ground. No end visible in field or on shoreline

Conclusions

The human population in the vicinity of the East Loch Roag production areas has increased since the sanitary survey. The main increases in population appear to be associated with the settlements of Calanais, Breascleit and Garynahine along the eastern shore of the loch and on Great Bernera. Seasonal increases in the local population are still expected, with the peak population likely to be present during the summer holiday months of July and August.

Human sewage impacts at East Loch Roag are expected to have increased generally due to the higher population in the area. More recent discharge data shows a significant number of registered private septic tanks along the east shore of Great Bernera. These are likely to have been present at the time of the sanitary survey, and registered with SEPA since then. Two septic tank discharges to shore were identified on the east shore of Great Bernera, both of which are estimated to contribute significant loadings to the vicinity. However, they lie over 500 m from the nearest mussel farms at Ceabhagh and Eilean Scarastaigh and therefore the predicted impact on these farms will depend on the predicted movement of contaminants.

Contamination from Kirkibost dun Innes community ST is expected to continue to pose as an impact risk to the Eilean Scarastaigh site. There were no identified discharges within 1 km of the Buckle Point mussel farm.

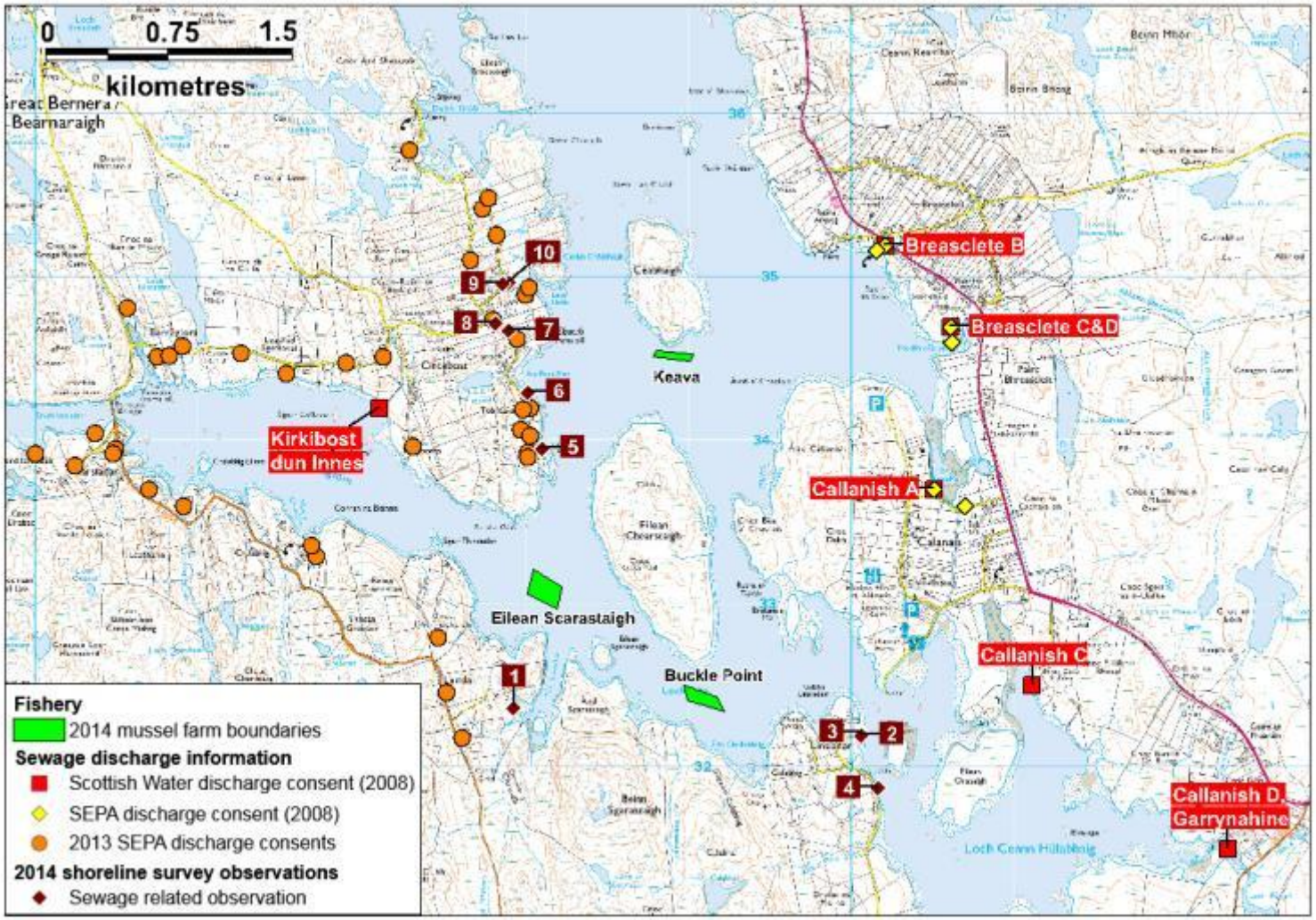

Figure 2.2 Sewage discharges in the vicinity of East Loch Roag

NB: Information on consented discharges was only available for the area around Loch Barraglom and the southeastern side of Great Bernera

3.Farm Animal Population and Agricultural Impacts

No farm census data was provided by Scottish Government for the 2008 sanitary survey report, as there were too few farms in the relevant parishes to ensure that farm specific data could not be ascertained. That report therefore primarily considered the observations made on the August 2007 shoreline survey. The 2008 sanitary survey report concluded that livestock were more numerous on the eastern shoreline but that livestock found around Kirkibost on Great Bernera and at Linshader to the south of the production area could both contribute contaminants that may impact the shellfisheries.

Agricultural census data to parish level was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the Uig parish for the 2013 Loch Roag: Barraglom sanitary survey report. The Uig parish encompasses land adjacent to East Loch Roag and reported livestock populations for the parish in 2012 are listed in Table 3.1.

Table 3.1 Agricultural census data (2012) for the Uig parish

	Uig	
	567 km^2	
	Holdings	Numbers
Pigs	5	27
Poultry	26	389
Cattle	24	286
Sheep	65	5,648
Other horses and ponies	6	10

The Uig parish area is large and it is therefore not possible to determine spatial distribution of livestock in relation to East Loch Roag or to identify how many animals are likely to impact the mussel farms. The data indicates sheep are the main livestock reared in the area, though pigs, poultry, cattle, horses and ponies are also present in low numbers. The Loch Roag: Barraglom sanitary survey report also included information on agricultural practices in Lewis from a report by (Osgathorpe, et al., 2011) It highlighted that production consisted mainly of store lamb production and the majority of livestock was kept on or very close to enclosed crofts. The accompanying Loch Barraglom shoreline survey report from June 2013 reported a total of 103 sheep on land along the southern shore of Great Bernera, with cattle droppings also noted.

Updated information on agricultural-based contamination sources has been obtained for this review from the shoreline survey conducted on the 25th and 26th August 2014. Figure 3.1 displays the locations of animals observed during the 2014 survey. An internet search returned information relating to a small croft attached to the

Leumadair Guest House on the east coast, which has nine highland cattle, three pigs and four Hebridean sheep (Leumadair , 2010). No further information on agricultural practices or individual farms was found during this internet search.

A total of 92 sheep and three cows along the west and southern coastlines were observed during the 2014 shoreline survey. A sheep pen, grazed land and silage bales were also observed at Linshader. The highest numbers of sheep were observed south of Eilean Scarastaigh, though the majority were set back from the shoreline. Faecal contamination from livestock set back from the shoreline may still add to contamination levels within the sea through flushing into nearby watercourses during and after periods of heavy rainfall. It should be noted that the shoreline survey did not cover the headland near Callanish, or the two islands of Keava and Eilean Scarastaigh.

Conclusions

Sheep are kept at a number of locations around East Loch Roag and all three mussel sites may be exposed to contamination from this source.

Figure 3.1 Map of farm animals and associated observations made during the 2014 shoreline survey

4. Wildlife

The 2008 sanitary survey report concluded that birds, seals, deer and potentially otters would be the most significant wildlife contributors of faecal contamination at the fisheries, but that overall the impact from wildlife was expected to be unpredictable and highly localised.

For this review, information on pollution sources from wildlife has been obtained from the JNCC collated dataset (JNCC, 2014) through shoreline surveys conducted in 2007 and 2014, and through a desk-based internet search. Shoreline survey observation information only relates to the time of the surveys undertaken on the 21st to 24th August 2007 and on the 25th and 26th August 2014. Wildlife observations from the 2014 survey and the JNCC dataset are displayed in Figure 4.1.

Pinnipeds

Specific information on harbour and grey seals within East Loch Roag and the Outer Hebrides was available from the Special Committee on Seals Report 2013. This report indicated Outer Hebridean harbour seal populations are currently stable at 2,739 seals in 2011. Approximately 20 harbour seals were counted within Loch Roag in August between 2007 and 2011. Small numbers of harbour seals were recorded within Loch Roag in the August 2011 survey. The Outer Hebrides is also noted to contain a large concentration of the UK's grey seal breeding population. Population estimates are not available, though pup production in the Outer Hebrides has been at a stable constant since the mid-1990's and was 12,900 in 2011. No grey seals have been observed in Loch Roag in the aerial surveys undertaken between 2007 and 2011, although approximately 20 grey seals were noted at the mouth of the loch.

One grey seal was observed to the northwest of East Loch Roag during the 2014 shoreline survey.

Cetaceans

Updated information regarding cetaceans within East Loch Roag was available from the Hebridean Whale and Dolphin Trust sightings index (Hebridean Whale and Dolphin Trust, 2014). Between 2008 and 2014 there have been two reported sightings of common dolphin pods within East Loch Roag. These sightings were made in 2013 and 2014, with 17 common dolphins counted in total. No cetaceans were observed during the 2014 shoreline survey.

Seabirds

Seabird data was downloaded from the collated JNCC dataset from the website (JNCC, 2014) in March 2014. The dataset was then manipulated to show the most

recent data where repetitions of counts were present. Data applicable for the 5 km area around the fishery are listed in Table 6.1.

Table 4.1 JNCC seabird data for within 5 km of East Loch Roag

Common name	Species name	Count	Qualifier	Accuracy
Common Gull	*Larus canus*	28	Occupied nests	Accurate
Black-Headed Gull	*Chroicocephalus ridibundus*	256	Occupied nests	Accurate

*Counts for occupied nests, sites and territory were doubled, with total counts given using the adjusted data.

The JNCC data indicated a significant black headed gull breeding colony is located approximately 3 km southeast of the East Loch Roag production areas. The species occur on Lewis all year round (https://www.virtualheb.co.uk/black-headed-gull-hebridean-birds-western-isles-birdlife/). This colony may pose as a contamination source to the Buckle Point fishery.

The 2014 shoreline survey identified small gatherings of gulls located on buoys at Eilean Scarastaigh and Buckle Point, which included immature gulls located at the latter site.

Otters

The Eurasian otter (*Lutra lutra*) is known to be common in the Outer Hebrides, with Uig and Bernera districts identified as being some of the best places to see otters on the Isles of Lewis (Outer Hebrides Tourism Industry Association, 2014). No otters were observed during the 2014 shoreline survey.

Deer

Red deer are common in the Outer Hebdrides. During summer and autumn they are located on hillsides, whilst during winter and early spring, they migrate down to lower lying grounds (Outer Hebrides Tourism Industry Association, 2014). There are also anecdotal reports of deer on moorland along the east shore (Whitefall Spa Lodges, 2014). No deer were observed during the 2014 shoreline survey.

Conclusions

The information acquired for this review indicates that birds, seals, otters, deer and cetaceans continue to be potential contributors to background contamination levels in East Loch Roag. However, these are largely expected to remain unpredictable and highly localised. Higher contamination inputs may stem from the breeding colony of blacked headed gulls located approximately 3 km east-southeast of the Buckle Point fishery. Significant inputs of bird faeces may also cause localised impacts from birds using the buoys to preen/rest upon.

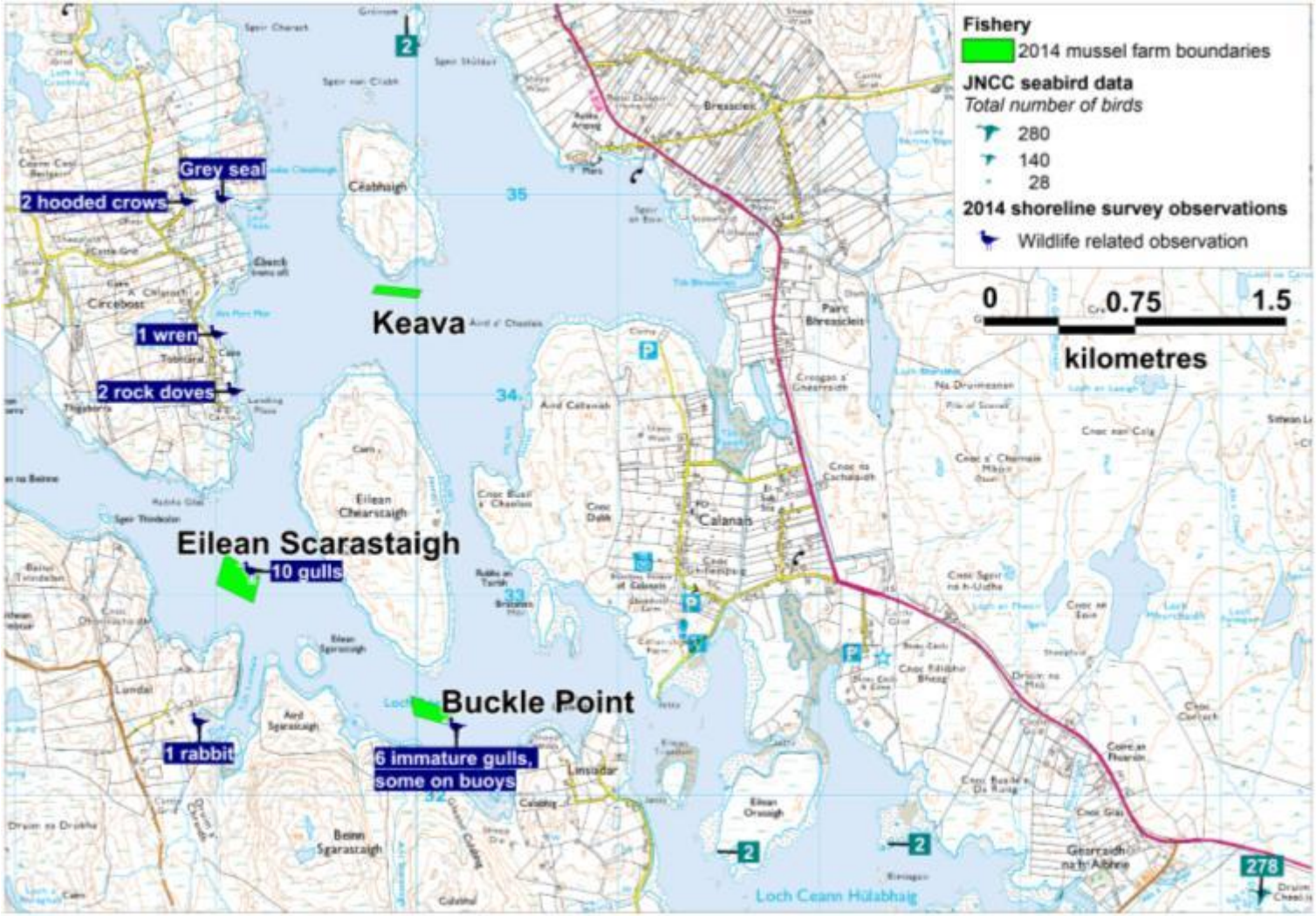

Figure 4.1 Map of wildlife around East Loch Roag

5. Watercourses

No gauging station data was available for watercourses in the area covered by this review. Although a planning application was found that related to a hydroelectric scheme on Breasclete River, no flow data was available at the time of this review.

Weather conditions during the shoreline surveys were as follows:

2007: sunny and dry, westerly winds F1-3.

2014: dry with sunny spells, temperatures of 9-11^{o}C, F3-4 easterly winds. No rainfall was recorded 48 hours prior to survey.

A comparison of watercourse loadings estimated on the basis of the 2007 and 2014 shoreline survey measurements and *E. coli* concentrations are displayed in Table 5.1. In total seven watercourses were measured and sampled in the 2007 survey, only one of which was re-sampled in 2014. The others were not anticipated to pose a significant contamination risk to the fisheries and therefore were not addressed in the 2014 shoreline survey. Sample loadings estimated from the 2014 shoreline survey data are displayed in Figure 5.1. A full list of recorded flow measurements and sample results from the 2014 shoreline survey can be found in Appendix 3.

Table 5.1 Watercourse loadings to East Loch Roag estimated from measurements made during the 2007 and 2014 shoreline surveys

No.[1]	Description	NGR	2007 Loading (*E. coli*/day)	2014 Loading (*E. coli*/day)
1	Freshwater from Loch Mharcoil	NB 1894 3440	-	$1.7x10^{8}$
2	Unnamed watercourse	NB 1903 3498	-	$1.1x10^{10}$
3	Lundale River	NB 1885 3223	-	$2.1x10^{9}$
4	Allt Scarastaigh	NB 1992 3221	-	$4.8x10^{7}$
5	Unnamed watercourse	NB 2048 3191	-	Not determined
6	Unnamed watercourse	NB 2102 3199	$2.0x10^{11}$	$2.4x10^{7}$
7	Allt a' Raulla	NB 2113 3154	-	$2.1x10^{8}$

[1]Numbers relate to those given in the labels in Figure 5.1, - indicates no recording

The 2014 estimates indicated low to moderate contamination levels in freshwater inputs to East Loch Roag. The highest loading was associated with an unnamed watercourse that entered the loch approximately 900 m northwest of the Keava site. The watercourse closest to a fishery was located to the south of the western end of the Buckle Point mussel lines. This had a low estimated loading. All loadings would be expected to be higher after rainfall.

Contamination at the mussel farms arising from freshwater sources is generally anticipated to be low: the only direct impact may be at the western end of the Buckle Point fishery after rainfall.

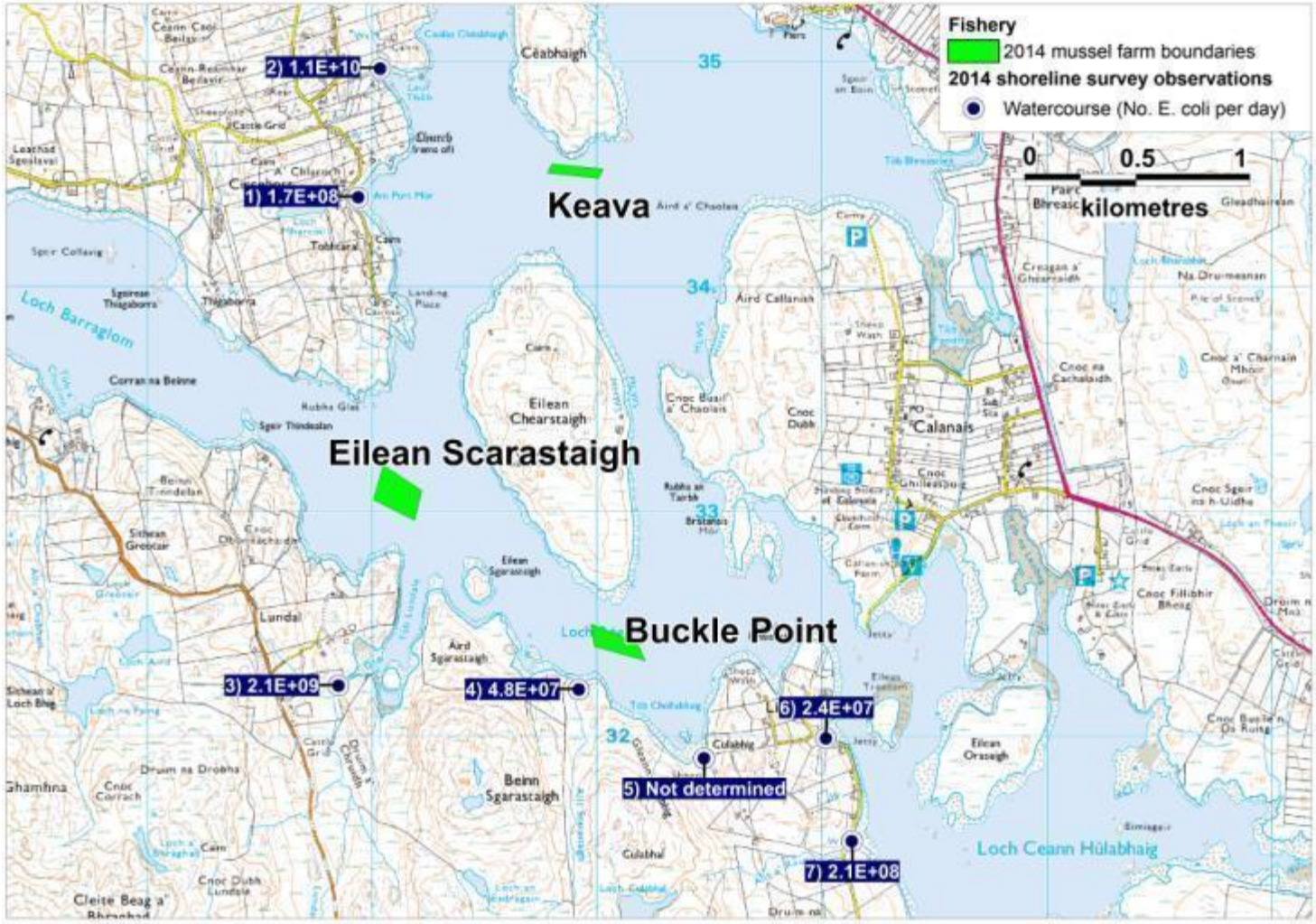

Figure 5.1 Watercourse loadings at East Loch Roag during the 2014 shoreline survey

Where the bacterial loading is labelled on the map, the scientific notation is written in digital format, as this is the only format recognised by the mapping software. So, where normal scientific notation for 1000 is $1x10^3$, in digital format it is written as 1E+03.

6. Meteorological data

Meteorological data had been purchased from the Meteorological Office for the survey period 01/01/2003 - 31/12/2006 for the analyses undertaken for the 2008 Loch Roag: Ceabhagh and Eilean Chearstaigh sanitary survey report: rainfall boxplots and wind roses for 2003-2006 period are presented in that report and have not been reproduced here. Rainfall was recorded in total daily rainfall (mm) were taken from the Stornoway weather station, which lays 25 km west of East Loch Roag. Wind roses were also taken from the Stornoway weather station.

Meteorological data for this Review was purchased from the Meteorological Office in March 2014 for the period 01/01/2007 - 31/12/2013. Rainfall data from Stornoway was available for all survey days.

6.1 Rainfall

Storm events and high rainfall levels are commonly associated with increased faecal contamination of coastal waters through surface water run-off from land where livestock or wild animals are present and through sewer and waste water treatment plant (WWTP) overflows (Mallin, et al., 2001; Lee & Morgan, 2003).

The Stornoway weather station rainfall dataset for 2007-2013 is presented by year in Figure 6.1 and by month in Figure 6.2.

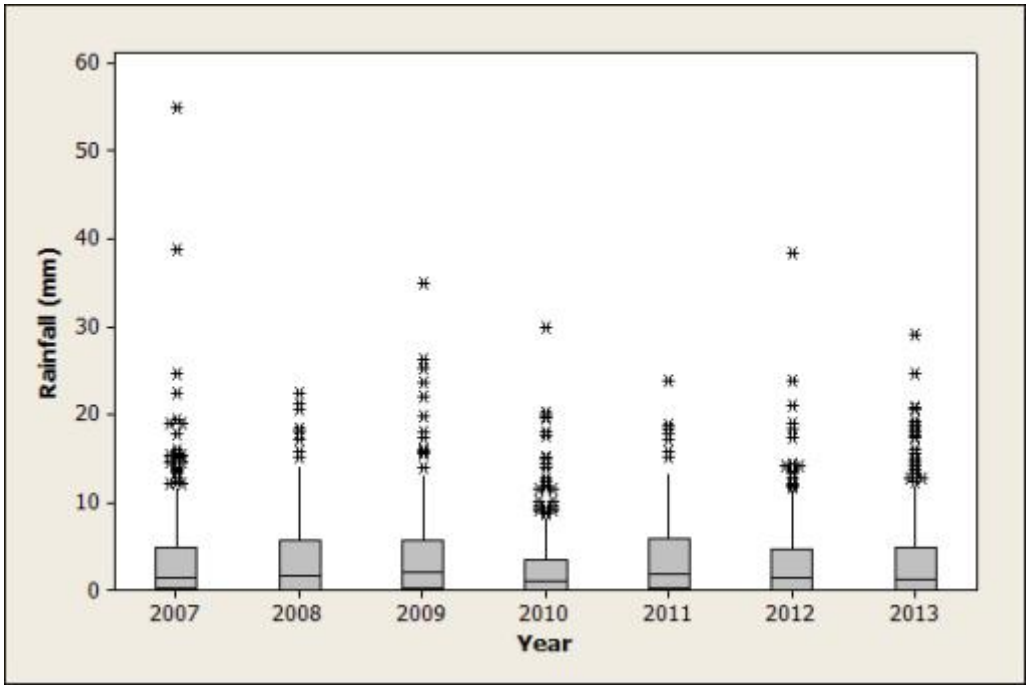

Figure 6.1 Boxplot of daily rainfall at Stornoway by year (2007-2013)

The bulk of rainfall results in both the 2003-2006 and 2007-2013 periods were with events >30 mm rainfall/day occurring on a small number of occasions in most years. An extreme event >50 mm rainfall/day occurred in 2007.In the 2007-2013 period, 2010 showed markedly lower total rainfall than the other years.

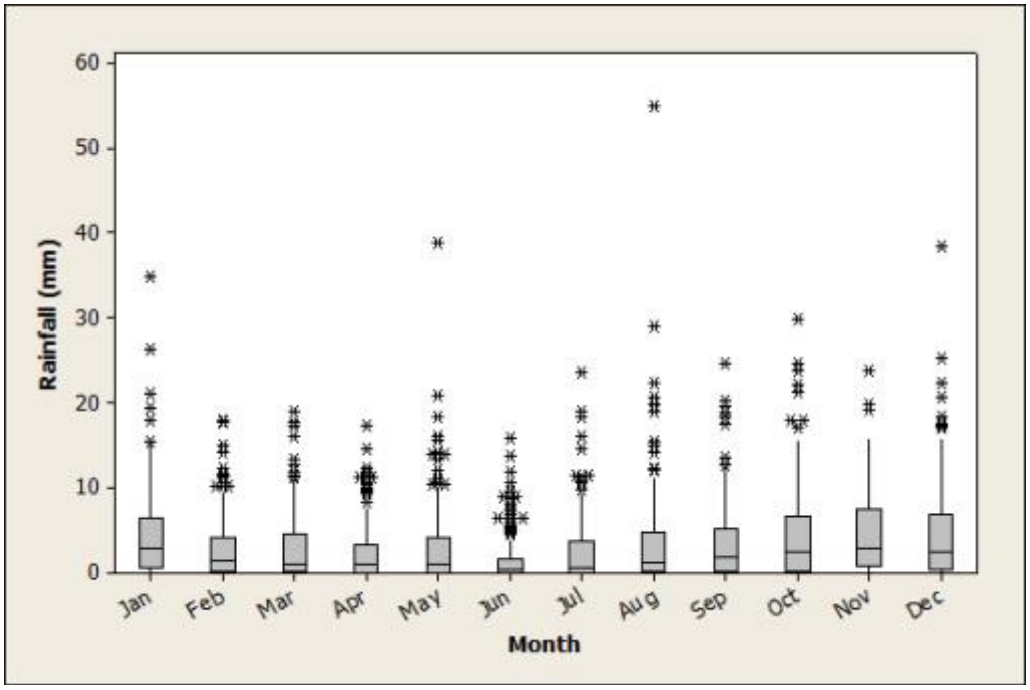

Figure 6.2 Boxplot of daily rainfall at Stornoway by month (2007-2013)

The 2008 sanitary survey report noted that the wettest months in the 2003-2006 rainfall series occurred between September and January, with the driest month in July. Total monthly rainfall was also highest between October and January: during the 2007-2013 period June continued to show the lowest monthly rainfall. The rainfall event of >50 mm rainfall/day during the more recent period was recorded in August High rainfall events of >30 mm rainfall/day also occurred in January, May and December.

6.2 Wind

Wind speed and direction drive surface water and currents that play an integral part in particulate dispersal. Winds typically drive surface water at ca. 3% of the wind speed (Brown, 1991) so a gale force wind (a minimum of 34 knots/17.2 m/s) would drive a surface water current of about 1 knot or 0.5 m/s.

Figure 6.3 shows seasonal wind roses for Stornoway for the period 2004-2013 while Figure 6.4 shows the annual wind rose for the same period. The local topography at East Loch Roag may result in differing wind patterns to those shown in the wind roses (Stornoway is 23 km away and on the east coast of Lewis, whilst East Loch Roag is on the west coast). In addition, the land in the vicinity of Stornoway is predominantly flat while there are hills surrounding parts of Loch Roag which will affect wind direction.

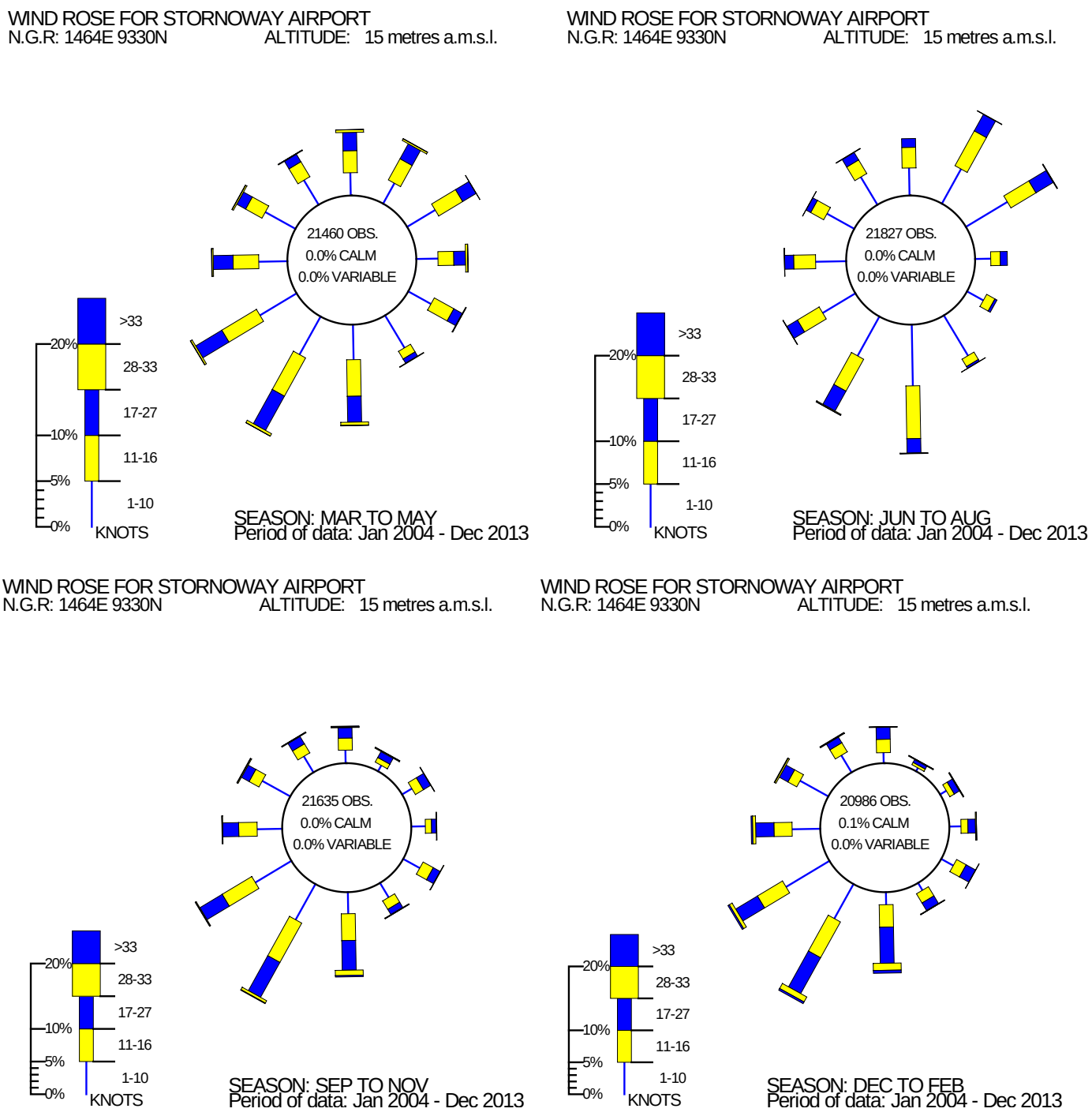

Figure 6.3 Seasonal wind roses for Stornoway (2004-2013)

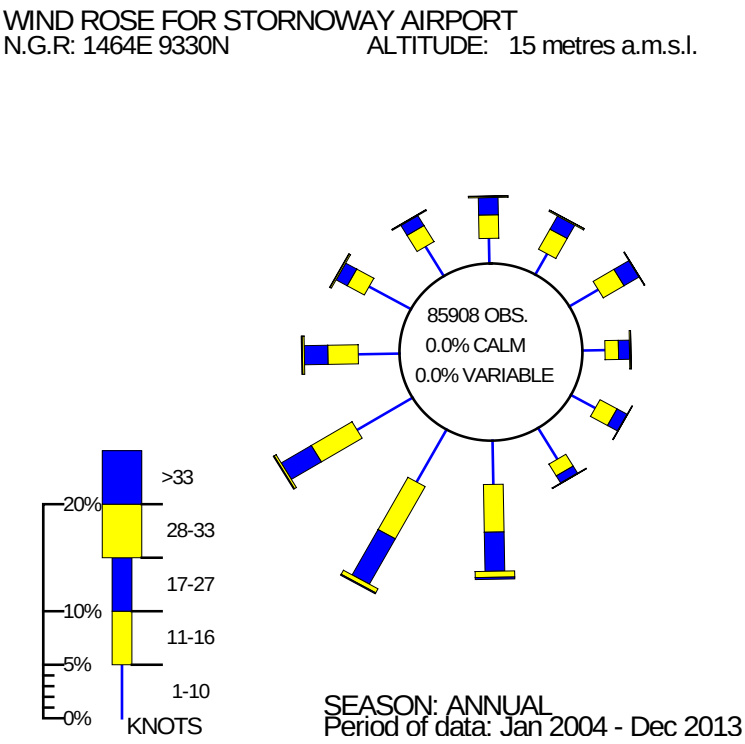

Figure 6.4 Annual wind rose for Stornoway (2004-2013)

Overall, winds were predominantly from the southwest. However, during summer, southerly winds predominated and there were also relatively strong winds from the north-west.

Although there are expected to be local differences in the direction of wind at different locations around Loch Roag, it is still expected that southwesterly winds will broadly predominate.

7.Historical *E. coli* Data

Results from Loch Roag Ceabhagh and Loch Roag: Chearstaigh production areas between 01/01/2007 and 21/10/2014 were extracted from the FSAS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. Data was extracted in October 2014. Historical *E. coli* data used in the 2007 report had already been extracted and validated. All *E. coli* results were reported as most probable number per 100 g of shellfish flesh and intravalvular fluid.

E. coli results reported as <18, or <20 were reassigned a value of 10 *E. coli* MPN/100 g and results reported as >18000 were reassigned a value of 36000 *E. coli* MPN/100 g for the purposes of statistical evaluation and graphical representation.

Loch Roag: Keava

Four samples recorded as rejected were omitted from the dataset for this review. A sample without a result and a sample plotting 9 km north of the production area (possibly a transcription error in the NGR) were also omitted from this dataset. The remaining 86 sample results were received at the laboratory within 48 hours of collection and had box temperatures of <8^{o}C.

Loch Roag: Eilean Scarastaigh

All 37 sample results were reported as valid, received at the laboratory within 48 hrs of collection, plotted within the production area and had box temperatures of <8^{o}C.

Loch Roag: Buckle Point

Three samples reported as rejected were omitted from the dataset for this review. A sample without a result and a sample with a void result were also omitted from this dataset. The remaining 59 samples were received at the laboratory within 48hrs of collection, plotted within the production area and had box temperatures of 8^{o}C.

7.1 Summary of microbiological results

Summary results for the Loch Roag Keava, Eilean Scarastaigh and Buckle Point fisheries are displayed in Tables 7.1 to 7.3 respectively.

Table 7.1 Sampling summary results for Keava 2007-2014

Sampling Summary		
Production area	Loch Roag: Ceabhagh	
Site	Keava	
Species	Common mussels	
SIN	LH-381-772-08	
Location	Various	
Years	2007-2014	
Total no. of samples	86	
	2007	8
	2008	11
	2009	11
	2010	11
	2011	11
	2012	12
	2013	12
	2014	10
Results Summary		
Minimum	<20	
Maximum	>18000	
Median	74	
Geometric mean	78	
90 Percentile	553	
95 Percentile	3050	
No. Exceeding 230/100g	15 (17%)	
No. Exceeding 1000/100g	6 (7%)	
No. Exceeding 4600/100g	3 (4%)	
No. Exceeding 18000/100g	1 (1%)	

Table 7.2 Sampling summary results for Eilean Scarastaigh 2005-2012

Sampling Summary				
Production area	Loch Roag: Eilean Chearstaigh			
Site	Eilean Scarastaigh			
Species	Common mussels			
SIN	LH-344-697-08			
Location	Various			
Years	2005-2006		2007-2012	
Total no. of samples	14		37	
	[redacted]		2007	4
			2008	5
			2009	7
			2010	8
	2005	3	2011	10
	2006	11	2012	3
Results Summary				
Minimum	<20		<20	
Maximum	310		3500	
Median	75		130	
Geometric mean	59		124	
90 Percentile	265		1100	
95 Percentile	310		1340	
No. Exceeding 230/100g	1 (7%)		9 (24%)	
No. Exceeding 1000/100g	0		4 (11%)	
No. Exceeding 4600/100g	0		0	
No. Exceeding 18000/100g	0		0	

Table 7.3 Sampling summary results for Buckle Point 2006-2014

Sampling Summary				
Production area	Loch Roag: Eilean Chearstaigh			
Site	Buckle Point			
Species	Common mussels			
SIN	LH-344-791-08			
Location	Various			
Years	2006		2007-2014	
Total no. of samples	2		59	
	[redacted]		2007	10
			2008	7
			2009	5
			2010	4
			2011	2
			2012	9
			2013	12
	2006	2	2014	10
Results Summary				
Minimum	70		<20	
Maximum	160		9200	
Median	-		78	
Geometric mean	-		74	
90 Percentile	-		500	
95 Percentile	-		1300	
No. Exceeding 230/100g	0		13 (22%)	
No. Exceeding 1000/100g	0		3 (5%)	
No. Exceeding 4600/100g	0		1 (2%)	
No. Exceeding 18000/100g	0		0	

Sampling frequency has been irregular at Eilean Scarastaigh and Buckle Point over the 2007-2014 sampling period. Results >230 *E. coli* MPN/100 g have been recorded at all three sites, with the highest result of >18000 *E. coli* MPN/100 g coming from a sample taken at Keava. Although the maximum and 95 percentile was higher at Keava than at the other two sites, the geometric mean and median were lower. Further analysis is presented in Section 7.2.

7.2 Geographical patterns of results

Key summary statistics for the results at the three sites over the period 2007 – 2014 are presented in Table 7.4. These have been extracted from Tables 7.1 to 7.3 in order to simplify comparison.

Table 7.4 Summary statistic for the results from 2007-2014 for Keava, Eilean Scarastaigh and Buckle Point

Site	No. of samples	Minimum	Maximum	Geometric Mean	95%ile
Keava	86	<20	>18000	78	3050
Eilean Scarastaigh	37	<20	3500	124	1340
Buckle Point	59	<20	9200	74	1300

A boxplot of the results for the three sites is shown in Figure 7.1.

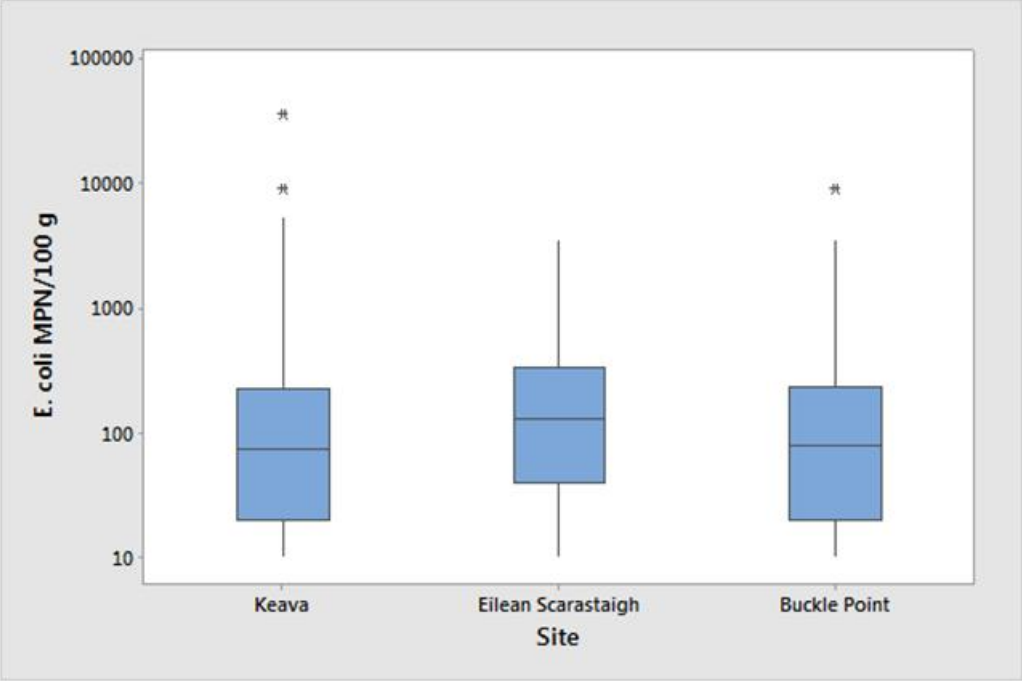

Figure 7.1 Boxplot of E. coli results at the three sites

The boxplot shows the slightly higher average result at Eilean Scarastaigh. The higher maximum and 95%ile at Keava appears to relate to the influence of a single result >18000 *E. coli* MPN/100 g. A one-way Analysis of Variance (ANOVA) was undertaken on the $\log_{10}$-transformed *E. coli* results for the three sites. There was no significant difference in average ($\log_{10}$-transformed) *E. coli* concentration between sites (F=1.33; df=2,179; p=0.266).

Keaver

The spatial distribution of sampling locations for Keaver is shown in Figure 7.2 with the size of the symbols proportional to the magnitude of the *E. coli* results.

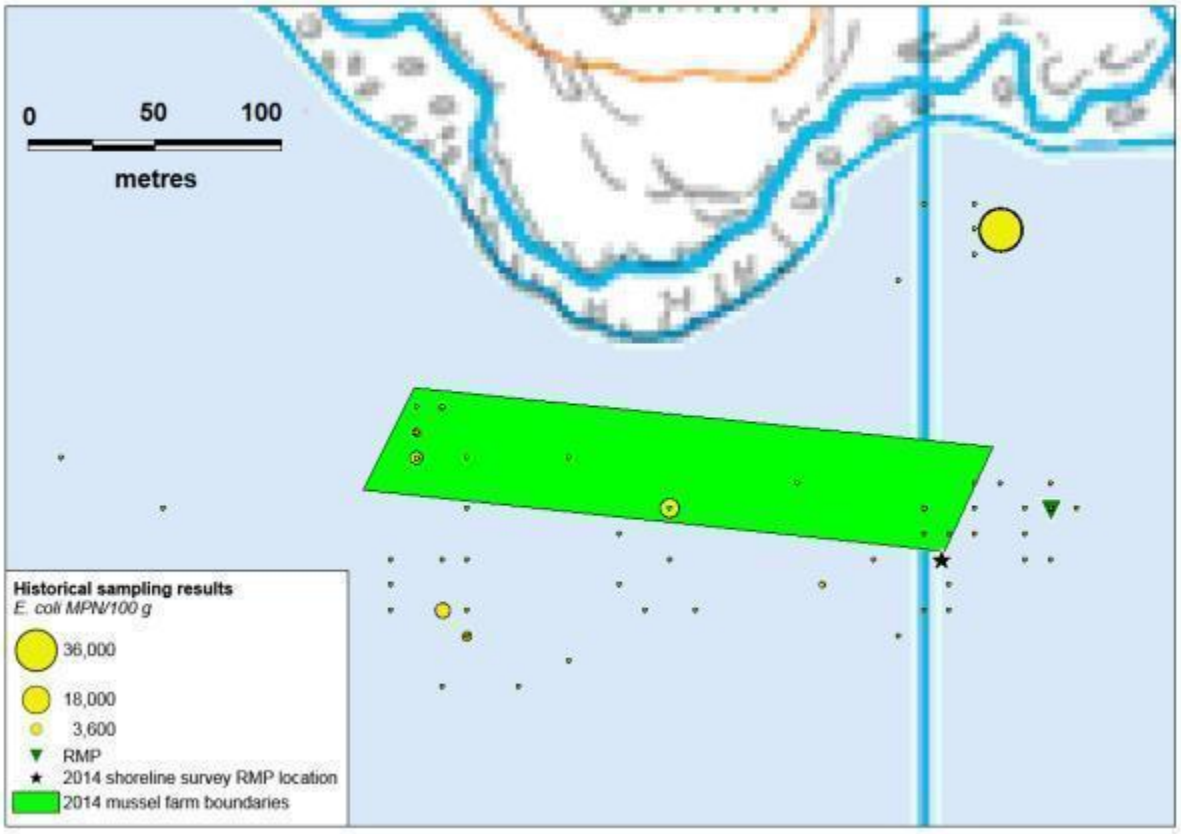

Figure 7.2 Sample results and locations of Loch Roag: Keava common mussel fishery

The sample yielding the highest result (>18000 *E. coli* MPN/100 g) was recorded as being taken at a location to the north of the RMP and mussel farm boundaries. A small number of samples were also recorded as having been taken in that vicinity: all were from 2008 and 2009. Other recorded sampling locations were located across the general area of the mussel lines although not necessarily within the recorded 2007 or 2014 boundaries. There was no apparent association between the magnitude of the *E. coli* result and the reported sampling location.

Eilean Scarastaigh

As sampling ceased at this site in 2012, and the sampling frequency until then had been variable, the spatial distribution of results is not shown.

Buckle Point

The spatial distribution of sampling locations for Buckle Point is shown in Figure 7.3 with the size of the symbols proportional to the magnitude of the *E. coli* results.

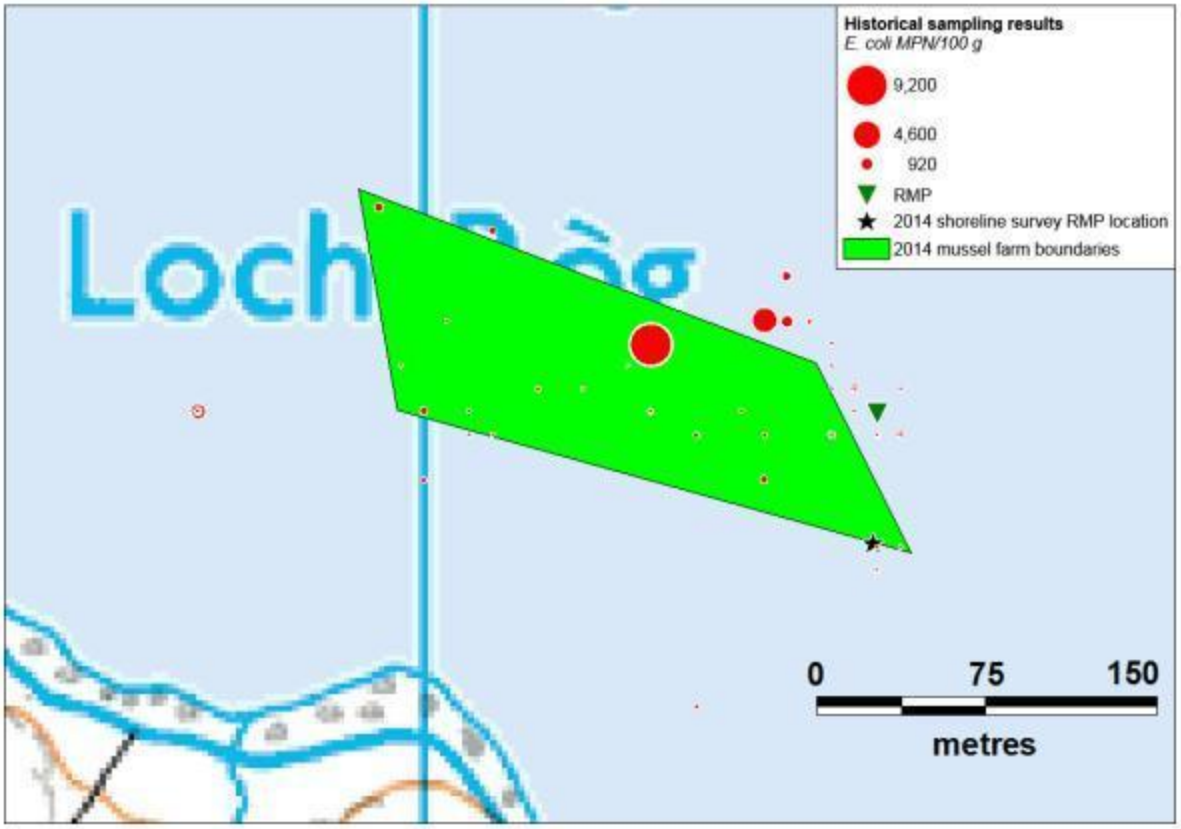

Figure 7.3 Sample results and locations of Loch Roag: Buckle Point common mussel fishery

One reported sampling location for sample plotted at the Eilean Scarastaigh site (not shown in Figure 7.3). The reported locations for the other 58 samples plotted within in the general vicinity of the mussel lines. Samples taken since April 2014 have been taken close to the alternate RMP location recorded in the 2014 shoreline survey survey (NB 2020 3234). The highest results have been in samples reported as having been taken to the northwest of the RMP and alternate RMP.

7.3 Temporal patterns of results

The temporal pattern of results for each site has been assessed separately.

Keava

The *E. coli* results for Keava against collection date are shown in Figure 7.4. A lowess trend line is superimposed on the plot.

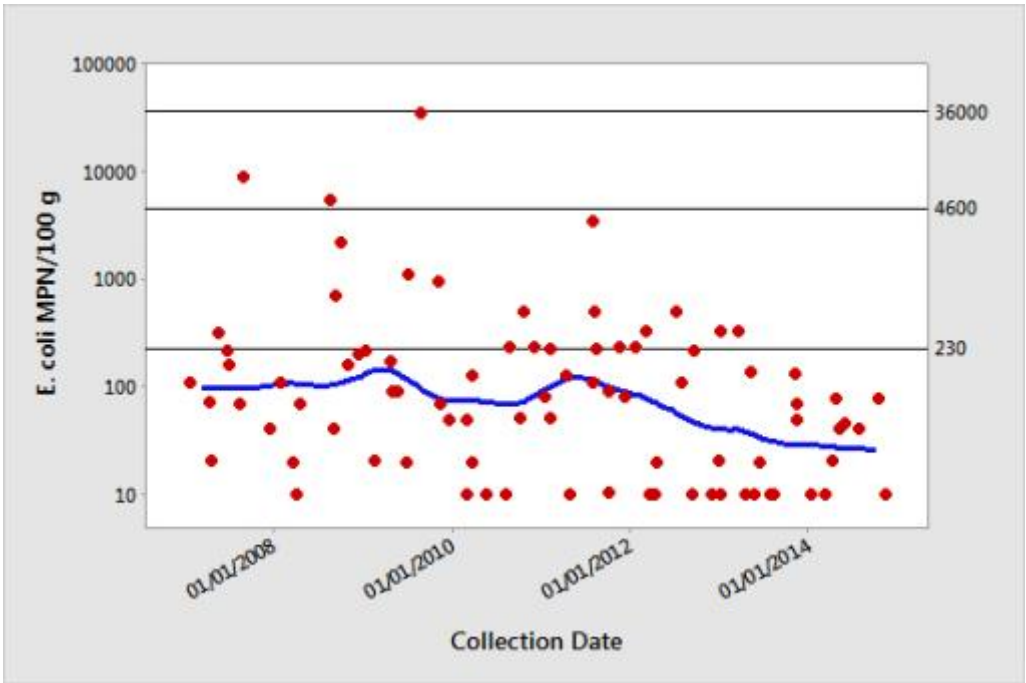

Figure 7.4 Scatterplot of Keava *E. coli* results by date (2007-2014)

Contamination levels have decreased slightly over the sampling period, with no results >4600 *E. coli* MPN/100 g since late 2009 and no results >1000 *E. coli* MPN/100 g since late 2011. As monitoring started in 2007, no comparison was possible between the results from 2007 on and a previous period.

Eilean Scarastaigh

The *E. coli* results for Eilean Scarastaigh against collection date are shown in Figure 7.4. A lowess trend line is superimposed on the plot.

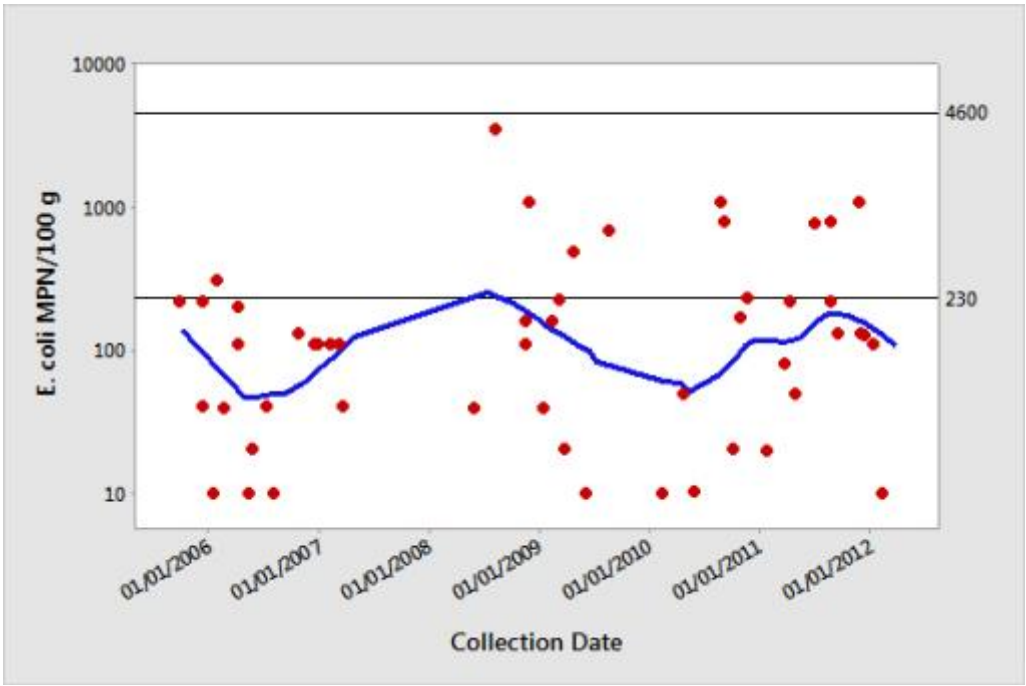

Figure 7.5 Scatterplot of Eilean Scarastaigh *E. coli* results by date (2005-2012)

The trend line is affected by the variable samplingfrequency at Eilean Scarastaigh. The highest results are associated with samples taken from 2008 onwards. Sampling ceased in 2012, with implementation of the sanitary survey recommendation to site the RMP for the production area at Buckle Point.

In addition an analysis was undertaken to compare the *E. coli* results between the previous sampling period (2005-2006) and the current sampling period (2007-2014). A two sample t-test (using $\log_{10}$ transformed *E. coli* data) was undertaken to determine whether there was a statistically significant difference between in average ($\log_{10}$-transformed *E. coli* results between the two sampling periods.

A Fisher's Exact Test was undertaken to test for a significant difference in the proportion of *E. coli* results above the levels of 230 and 1000 *E. coli* MPN/100 g between the two sampling periods (see Table 7.5). A Fisher's Exact Test was used instead of a Chi-squared test as two cells had expected counts at less than five from both sampling periods.

No significant difference was found in average *E. coli* results from the two survey periods (Two sample t-test, t = -1.79, DF = 28, p = 0.084).

Table 7.5 Results above and below 230 and 1000 E. coli MPN /100 g at Eilean Scarastaigh

	***E. coli* MPN/100g**			***E. coli* MPN/100g**		
	≤230	>230	**Total**	≤1000	>1000	**Total**
2005-2006	13	1	14	14	0	14
2007-2012	28	9	37	33	4	37
Total	41	10	51	47	4	102

No significant difference was found between the proportion of results ≤230 and >230 *E. coli* MPN/100 g between sampling periods (Fisher's Exact Test, p = 0.249).

No statistically significant difference was found between the proportion of results ≤1000 and >1000 *E. coli* MPN/100 g between sampling periods (Fisher's Exact Test, p = 0.564).

Buckle Point

The *E. coli* results for Buckle Point against collection date are shown in Figure 7.6.

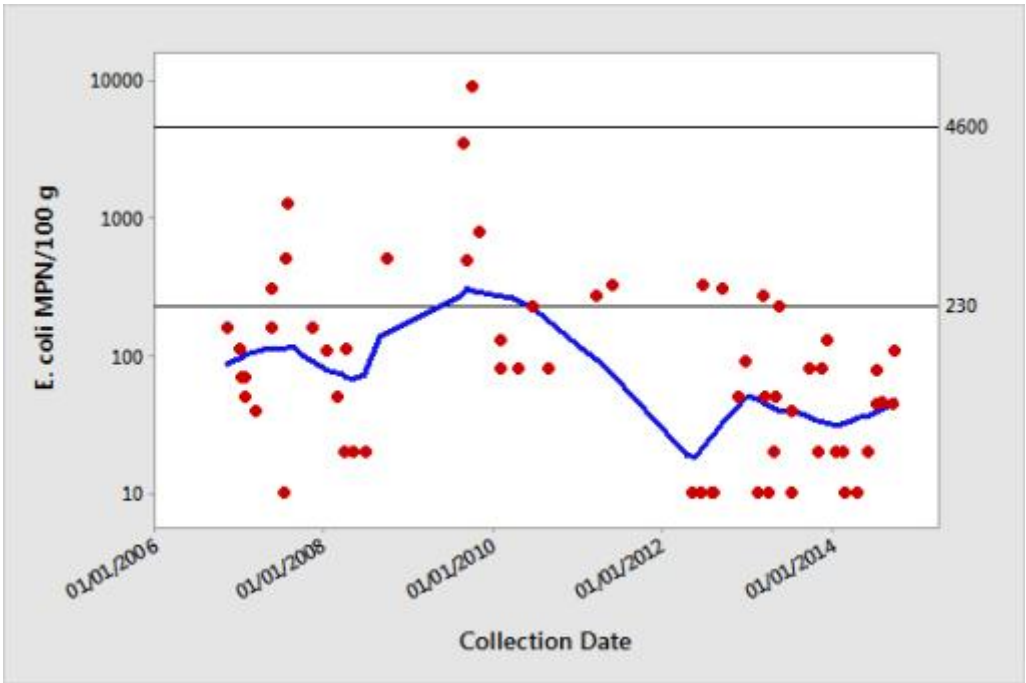

Figure 7.6 Scatterplot of Buckle Point *E. coli* results by date (2006-2014)

The three results >1000 *E. coli* MPN/100 g were from samples taken in 2007 and 2009. Contamination levels since 2012 have been predominantly low, with an increase in results at <20 *E. coli* MPN/100 g. No comparison could be undertaken between the results obtained from 2007-14 and the previous sampling period as only two results were available for the latter.

Conclusions

There was no significant difference in the average mussel *E. coli* levels between the three sites although the highest result (>18000 *E. coli* MPN/100 g) was seen at Keava. Assessment of results by sampling location for Keava was complicated by the fact that a sizeable proportion of sampling locations did not fall within the recorded boundaries of the 2007 or 2014 mussel lines. At Buckle Point, the highest results were seen to the northwest of the current RMP. At Keava and Buckle Point, higher *E. coli* results were seen prior to January 2012 and January 2010 respectively than after these dates. In contrast, results at Eilean Scarastaigh have tended to be higher since mid-2008, although analysis at that site is complicated by gaps in sampling and sampling ceasing in 2012. The proportion of results less than or equal to 230 and 1000 E. coli MPN/100g, and greater than these values at Eilean Scarastaigh did not differ significantly between the two sampling periods considered in this review.

8. Movement of contaminants

The 2008 report included information obtained through the full hydrodynamic modelling study using the Hydrotrack model. The findings were as follows:

- Transport distances due to tides vary with source, but can be up to 1 km.
- Basin exchange (between Loch Ceann Hulavig and East Loch Roag) of particles is possible under all wind forcing conditions and tides alone.
- Wind generated currents can significantly enhance exchange of particles when the wind direction aligns with the orientation of the loch (north-westerly/south-easterly).
- Particles released from Great Bernera, Grimersta and Linshader sources impact on existing production areas.
- Particles released from other sources are confided to their local regions, as the particles get trapped in local circular gyres.
- Impact on existing production sites was not found in the experiments, but can't always be excluded for Buckle Point.

The hydrographic assessment from the 2013 Loch Barraglom sanitary survey (Cefas.FSAS, 2013) covered part of the East Loch Roag area. It included the following conclusions:

- Cumulative transport during each phase of the tide has been estimated to be around 1.4 km.
- There is low tidal exchange through Loch Barraglom between East and West Loch Roag. Loch Barraglom is therefore considered part of the East Loch Roag system.
- Loch Barraglom has a general flushing time of <6 days and there is a potential for some particulates to be trapped within a weak localised gyre.
- Favourable wind conditions may allow for exchange of pollution between East Loch Roag and Loch Barraglom, though these are expected to take several days, over which time significant dispersion is expected to have occurred.

Salinity profiles undertaken at three locations during the shoreline survey showed salinity reductions at the surface of approximately 5.3 psu at Eilean Scarastaigh, 4.8 psu at Buckle Point and 2.6 psu at Keava (see Appendix 4). The shoreline survey was undertaken after a period of light rainfall and therefore greater salinity reductions might be expected after heavy rain.

In general, therefore, the only change is that an updated estimate of particle transport distance indicates that this may be slightly greater than previously determined.

9.Overall Assessment

The changes at East Loch Roag between the surveys in 2007 and 2014 are considered in the following section.

Human sewage Impacts

The human population around East Loch Roag has increased since 2008. This mainly appears to affect the settlements of Calanais, Breascleit and Garynahine along the eastern shore of the loch and the island of Great Bernera. The increased population will have increased the potential for sewage contamination at the fisheries. Contamination from Kirkibost dun Innes community ST is expected to continue to pose a potential source of contamination to the Eilean Scarastaigh site. Seasonal increases in the local population are still expected, with the peak population likely to be present during the summer holiday months of July and August.

Agricultural impacts

It is expected that all three mussel sites will be potentially exposed to contamination arising from sheep.

Wildlife Impacts

Birds, seals, otters, deer and cetaceans continue to be potential contributors to background contamination levels in East Loch Roag with the inputs unpredictable and localised. There may be some higher contimation at Buckle Point related to the breeding colony of blacked headed gulls located east-southeast of there.

Seasonal Variation

The tourist season remains largely restricted to the summer months. Increases in livestock numbers are expected to continue in the spring and summer months owing to the lambing season. Wettest months occur in the autumn and winter although high rainfall events also occur at other times. The time series plots of historical mussel *E. coli* data did not show any evidence of marked seasonal patterns.

Watercourses

Six watercourse samples were taken during the 2014 survey. A high result (40,000 *E. coli* cfu/100 ml) was associated with a sample from an unnamed watercourse northwest of the Keava site. The remaining five watercourse samples returned low results of between <10 and 100 *E. coli* cfu/100 ml. However, the only watercourse located near to mussel lines was Allt Scarastaigh, located to the south of the western end of the Buckle Point site. Contamination at the mussel sites arising from watercourses is expected to be low although there may be some direct impact at the western end of the Buckle Point fishery after rainfall. Only one watercourse was

sampled and measured during both the 2007 and 2014 shoreline surveys and this showed a markedly reduced loading in 2014 (a thousand-fold reduction).

Salinity profiles taken during the shoreline survey showed the greatest reductions at Eilean Scarastaigh and Buckle Point with the least at Keava.

Movement of contaminants

Information from the Loch Roag: Barraglom hydrographic assessment indicates that the maximum transport distance over a tidal cycle may be slightly further than previously expected (1.4 km as opposed to 1 km). Current flows around the area are still expected to be complex.

Analysis of Results

Historical *E. coli* results

An increase in the number of results at <20 *E. coli* MPN/100g from 2012 relates to a shift in sampling location, with samples taken closer to the classified RMP. A statistically significant difference was found between results at the three sampling locations, with the highest results taken >145 m west of the RMP.

There was no significant difference in the average mussel *E. coli* levels between the three sites. The highest result (>18000 *E. coli* MPN/100 g) was seen at Keava. No marked patterns of results against sampling location were seen at Keava. At Buckle Point, the highest results were seen to the northwest of the current RMP. Contamination levels at Keava have decreased since late 2009 and those at Buckle Point have decreased since late 2011.

Shoreline Survey results

Common mussel samples returned higher results in surface samples than samples taken at 6-7 m depth, at both Keava (45 versus <18 *E. coli* MPN/100 g) and Eilean Scarastaigh (330 versus 130 *E. coli* MPN/100 g). The highest results (both at 330 *E. coli* MPN/100 g) were from surface samples taken at Eilean Scarastaigh and Buckle Point. A second surface sample taken at the western extent of the Buckle Point site returned a lower result (45 *E. coli* MPN/100 g). Accompanying seawater results were low at between 2 and 5 *E. coli* cfu/100 ml.

Two other seawater samples were taken, one in the vicinity of Kirkibost and one adjacent to several sewage discharge pipes in Linshader: these returned higher results of 62 and 47 *E. coli* cfu/100 ml respectively.

Conclusions

There has been an increase in human population round the area. However, there has not been any demonstrable increase in the level of *E. coli* results: on the contrary, these have tended to be lower in recent years. The lack of impact of the

increased population at the sites may be due to the distances involved and the low expected particle transport distance. However, this does not explain the decline in *E. coli* levels in the mussel monitoring. The decline may reflect reductions, not apparent from the available survey data, in farm or wild animal (including bird) populations. Such a change may have influenced the reduction in the *E. coli* loading seen in the one watercourse sampled and measured during both shoreline surveys. Analysis of the historical *E. coli* data for Buckle Point supports movement of the RMP to the northwest of the present location. Mussel samples taken during the 2014 shoreline survey showed higher results at the surface than at depth: this would appear to be consistent with the salinity reductions seen in the salinity profiles.

10. Recommendations

It is recommended that the production areas remain essentially as present, but with a slight amendment to that for Loch Roag: Ceabhagh to yield common adjacent boundaries for the two areas and to ensure that the defined boundaries meet MHWS. The assessment has shown that monitoring should continue to be undertaken at the present two sites (Keava for Loch Roag: Ceabhagh and Buckle Point for Loch Roag: Eilean Chearstaigh) but that slight modifications should be made to the locations of the RMPs.

Loch Roag: Ceabhagh

Production area
It is recommended that the production area be amended slightly to be defined as: the area bounded by lines drawn between NB 1941 3460 and NB 1985 3460 and between NB 2010 3467 and NB 2073 3436 and between NB 2028 3360 and NB 2011 3360 and between NB 1941 3360 and NB 1908 3360 extending to MHWS.

RMP
It is recommended that the previously identified RMP is moved to NB 1200 3450 to be located within the present mussel farm boundaries.

Tolerance
A tolerance of 40 m is recommended to allow for movement of mussel lines.

Depth of sampling
A depth of 1-3 m is recommended to reflect contamination constrained in the upper layer.

Frequency
It is recommended that monthly sampling be maintained.

Loch Roag: Eilean Chearstaigh

Production area
It is recommended that the production area remain as currently specified: the area bounded by lines drawn between NB 1891 3352 and NB 1867 3308 and between NB 2094 3244 and NB 2114 3260 and between NB 2028 3360 and NB 2011 3360 and between NB 1941 3360 and NB 1908 3360.

RMP
On the basis of the analysis of historical monitoring data for the area, it is recommended that the RMP be located at NB 2009 3245.

Tolerance
A tolerance of 40 m is recommended to allow for movement of mussel lines.

Depth of sampling

A depth of 1-3 m is recommended to reflect contamination constrained in the upper layer.

Frequency

It is recommended that monthly sampling be maintained.

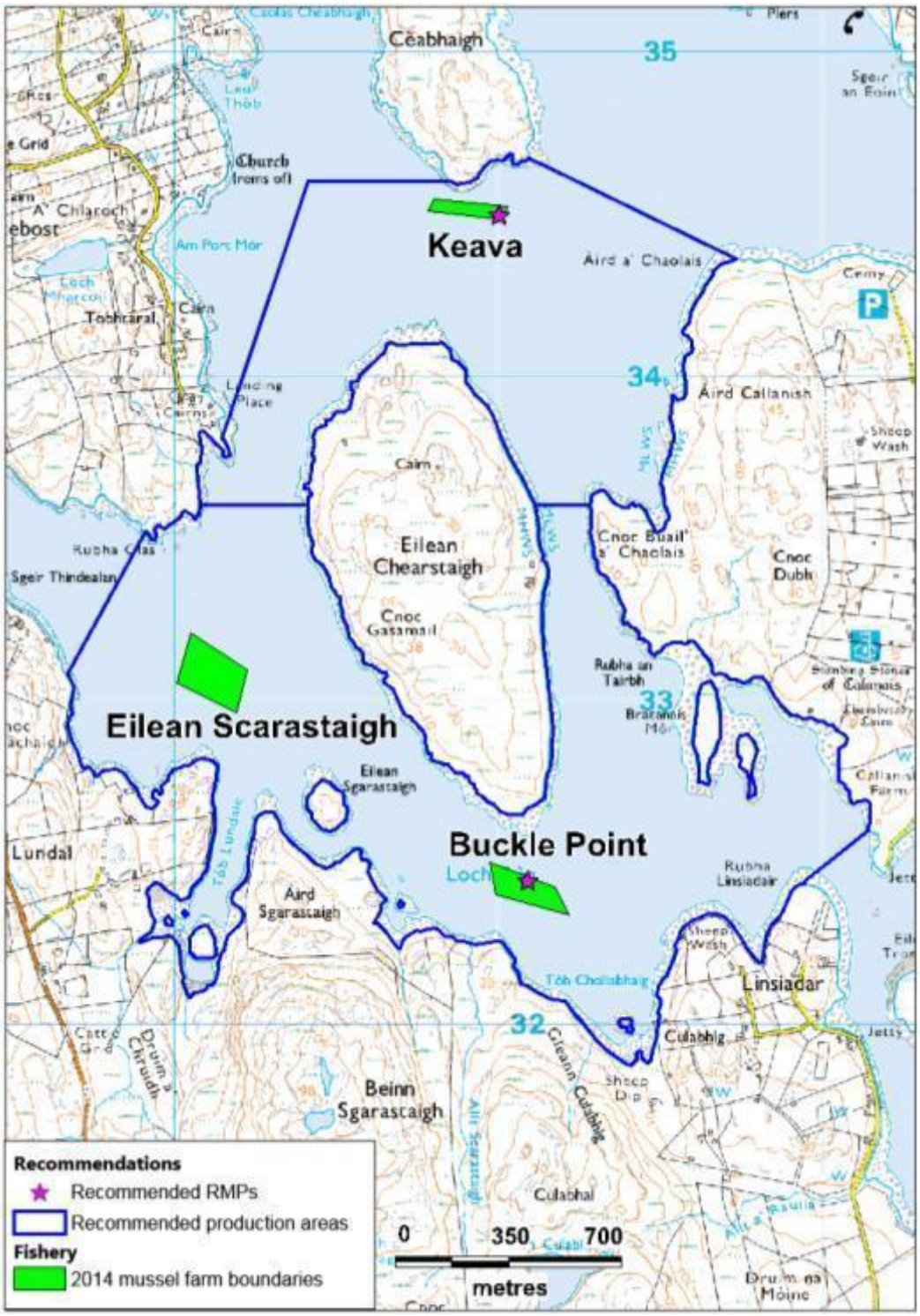

Figure 10.1 Recommended production area boundaries and RMPs for sites located in East Loch Roag

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12. List of Figures and Tables

Appendices

1. List of planning applications
2. Discharge consents from the Loch Roag: Barraglom sanitary survey report
3. Shoreline Survey Report 2014
4. CTD Data

Appendix 1

List of Planning Applications

Planning applications expected to change the human population and overall faecal loading to East Loch Roag are listed in Table 1.

Table 1 Planning applications to areas around East Loch Roag

Location	Date	Ref No	Description	Area
Breasclete	03/10/2008	08/00453/FUL	Extend Community Centre comprising kitchen, storage, multipurpose area and gym, along the east elevation	NB 2148 3512
	10/03/2009	09/00129/FUL	Erect Dwelling House	NB 2180 3551
	01/12/2009	09/00612/PPD	Erect Dwelling House	NB 2074 3390
	12/01/2011	11/00022/PPD	Erect House	NB 2159 3534
	13/12/2011	11/00603/PPD	Erect House	NB 2094 3528
	14/08/2012	12/00479/PPD	Erect house (bungalow)	NB 2209 3492
	31/10/2012	12/00658/COU	Change of use from Garage to self catering cottage including timber decked area	NB 2102 3521
	05/04/2013	13/00178/PPD	Extend Factory - works to include: the erection of a solvent wastes building, with covered tank area; tank farm building; warehouse building, cooling tower; sprinkler pump house and water tank; and perimeter fencing; the construction of additional roads, drainage and car parking spaces, installation of CCTV; landscaping and the removal of redundant generator flue.	NB 2081 3525
	13/02/2014	14/00065/PPP	Erect house	NB 2091 3559
Callanish	16/06/2008	08/00276/FUL	Erect single storey, 4 bedroom dwelling house	NB 2182 3438
	09/03/2009	09/00135/FUL	Erect two bedroom dwelling house	NB 2160 3298
	16/07/2009	09/00364/PPD	Erect Log Chalet	NB 2250 3297
	15/09/2010	10/00489/PPD	Demolish existing house and outbuilding and erect house	NB 2182 3446
	12/10/2010	10/00559/PPD	Site Portable Office Unit	NB 2120 3258
	02/05/2012	12/00231/COU	Change of use of land to create Caravan (timber pod) site with associated facilities and pathway	NB 2116 3269
	08/08/2012	12/00466/PPD	Erect house	NB 2129 3403
	21/08/2012	12/00498/COU	Siting of a residential caravan	NB 2135 3321
	03/09/2012	12/00549/PPP	Erect house	NB 2185 3312
	10/12/2012	12/00706/PPD	Erect house	NB 2176 3442

Location	Date	Ref No	Description	Area
	14/03/2013	13/00126/PPD	Erect house and garage (with Air Source Heat Pump)	NB 2282 3283
	17/04/2014	14/00159/PPD	Erect house and garage, and install air source heat pump	NB 2255 3294
Garynahine	25/03/2009	09/00158/OUT	Erect House	NB 2337 3197
Linshader	14/04/2009	09/00186/FUL	Erection of a new 4 bedroom family dwelling. Stabilisation and partial demolition of existing ruin to form a sheltered garden. Re-roofing of existing Agricultural Building for use as a Garage/Workshop	NB 2108 3195
	30/03/2011	11/00166/COU	Conversion of an existing delapidated outbuilding to form additional accommodation ancillary to the main dwelling house	NB 2109 3196
	30/03/2011	11/00165/LBC	Alter outbuildings to provide accommodation ancillary to existing dwelling	NB 2109 3196
Crulivig	30/11/2010	10/00638/PPP	Erect house and garage	NB 1761 3322
Kirkibost	09/02/2009	09/00062/FUL	New House and Garage and erection of small wind turbine 1.5kw	NB 1886 3522
	20/05/2009	09/00261/FUL	Temporary Accommodation Unit	NB 1834 3601
	01/06/2009	09/00282/FUL	Erect 2 bedroom bungalow, convert/restore existing stone house to Garage	NB 1891 3531
	29/06/2009	09/00333/PPP	Erect 2 No dwelling houses and form access	NB 1783 3450
	12/01/2010	10/00018/PPD	Erect house and garage	NB 1886 3522
	26/08/2010	10/00466/PPD	Erect house	NB 1886 3529
	19/10/2010	10/00573/PPD	Siting of single berth caravan to the rear of the factory for a period of five years, for residential use	NB 1830 3605
	20/12/2010	10/00670/PPD	Erect dwelling house - 3 bedroom bungalow	NB 1886 3523
	19/07/2011	11/00356/PPD	Temporary Accommodation Unit	NB 1834 3601
	11/10/2011	11/00506/COU	Change of use from Tigh Ceilidh to dwelling house	NB 1830 3429
	13/02/2012	12/00089/PPP	Erect House	NB 1831 3440

Appendix 2

SEPA discharge consents

SEPA discharges consents identified around East Loch Roag, taken from the Loch Roag: Barraglom 2013 sanitary survey report.

Table 2 Private sewage discharges along the west side of East Loch Roag

Licence Number	NGR	Site Description	Treatment Type	Discharging to	PE
CAR/L/1001793	NB 2008 3558	Greinam Island MCFF, East Loch Roag, Isle of Lewis	MCFF	-	-
CAR/L/1002198	NB 1599 3393	Hebridean Mussels Ltd, Earshader, Isle of Lewis	-	-	-
CAR/L/1004023	NB 1829 3579	Hebridean Salmon Company, Kirkibost, Isle of Lewis	-	-	-
CAR/L/1005041	NB 1930 3617	Vacasay MCFF, East Loch Roag, Isle of Lewis	MCFF	-	-
CAR/L/1009011	NB 1599 3393	Hebridean Mussels Ltd, Earshader, Isle of Lewis	-	-	-
CAR/L/1017374	NB 1806 3710	Taranaish MCFF, East Loch Roag, Isle of Lewis	MCFF	-	-
CAR/R/1023191	NB 1895 3463	Dwelling, Kirkibost, Isle of Lewis	-	-	5
CAR/R/1026488	NB 1897 3407	Dwelling, Kirkibost, Isle of Lewis	-	-	5
CAR/R/1030323	NB 1725 3454	Dwelling, Kirkibost, Berneray, Isle of Lewis	Sewage (Private) Primary	Soakaway	5
CAR/R/1040737	NB 1623 3385	Dwelling, Torranish, Earshader, Isle Of Lewis	-	-	5
CAR/R/1042604	NB 1902 3403	New house, Kirkibost, Bernera, Isle of Lewis	Sewage (Private) Primary	Soakaway	5
CAR/R/1042610	NB 1901 3390	Dwelling, Kirkibost, Isle Of Lewis	Sewage (Private) Primary	Soakaway	5
CAR/R/1042636	NB 1901 3393	Dwelling, Kirkibost, Bernera, Isle Of Lewis	-	-	6
CAR/R/1044392	NB 1648 3395	Dwelling, Earshader, Isle of Lewis,	-	-	5
CAR/R/1047054	NB 1656 3482	Dwelling, Hacklete, Isle of Lewis,	-	-	10
CAR/R/1047436	NB 1903 3421	Dwelling, Kirkibost, Bernera, Isle Of Lewis	-	-	6
CAR/R/1047661	NB 1898 3419	Dwelling, Kirkibost, Bernera, Isle Of Lewis	-	-	5
CAR/R/1049534	NB 1674 3452	Dwelling, Hacklete, Bernera, Isle of Lewis	Sewage (Private) Primary	Soakaway	5
CAR/R/1056118	NB 1873 3542	Dwelling, Kirkibost, Bernera, Isle of Lewis	-	-	7
CAR/R/1056230	NB 1880 3475	Dwelling, Kirkibost, Isle of Lewis	-	-	5
CAR/R/1056240	NB 1771 3329	Dwelling, Crulivig, Isle of Lewis	-	-	6
CAR/R/1056487	NB 1768 3336	Dwelling, Crulivig, Isle	-	-	5

Licence Number	NGR	Site Description	Treatment Type	Discharging to	PE
		of Lewis			
CAR/R/1057231	NB 1861 3218	Dwelling, Lundale, Isle of Lewis	-	-	6
CAR/R/1059561	NB 1846 3279	Dwelling, Lundale, Isle of Lewis	-	-	5
CAR/R/1059576	NB 1900 3490	Dwelling, Kirkibost, Isle of Lewis	Sewage (Private) Primary	Soakaway	5
CAR/R/1059996	NB 1682 3453	Dwelling Bernera, Isle of Lewis	-	-	6
CAR/R/1061481	NB 1689 3458	Dwelling, Isle of Lewis	Sewage (Private) Primary	Soakaway	5
CAR/R/1061687	NB 1790 3448	Dwelling, Kirkbost, Isle of Harris	Sewage (Private) Primary	Soakaway	5
CAR/R/1061950	NB 1901 3494	Dwelling, Kirkibost, Isle of Lewis	-	-	5
CAR/R/1062006	NB 1812 3452	Dwelling, Kirkibost, Isle of Lewis	Sewage (Private) Primary	Soakaway	6
CAR/R/1063347	NB 1752 3441	Dwelling, Kirkibost, Isle of Lewis	Sewage (Private) Primary	Loch Barraglom	5
CAR/R/1064030	NB 1636 3405	Dwelling, Earshader, Uig, Isle of Lewis	Sewage (Private) Primary	Sruth Iarsiadar	5
CAR/R/1066509	NB 1669 3370	Dwelling, Earshader, Isle Of Lewis	-	-	5
CAR/R/1067824	NB 1866 3511	Dwelling, Kirkibost, Isle of Lewis	Sewage (Private) Primary	Soakaway	8
CAR/R/1068128	NB 1851 3246	Dwelling, Lundale, Isle of Lewis	Sewage (Private) Primary	U/T of Tob Lundale	6
CAR/R/1068567	NB 1882 3526	Dwelling, Kirkibost, Great Bernera, Isle of Lewis	-	-	5
CAR/R/1075450	NB 1831 3397	Dwelling Kirkibost, Bernera, Isle of Lewis	Sewage (Private) Primary	Soakaway	15
CAR/R/1077617	NB 1690 3360	Dwelling, Uig, Isle of lewis	Sewage (Private) Primary	Soakaway	5
CAR/R/1087895	NB 1647 3392	New building, Earshader, Isle of Lewis	-	-	5
CAR/R/1096327	NB 1877 3549	Dwelling, Kirkibost, Isle of Lewis	-	-	5

Appendix 3

Shoreline Survey Report

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

Document Number	B0067_Shoreline 0039

Revision History

Revision	Changes	Date
A	Draft issue for internal review	02/09/2014
B	Second issue for internal review	10/09/2014
01	First formal issue to Cefas	12/09/2014
02	Second formal issue to Cefas	29/09/2014
03	Third formal issue to Cefas	10/10/2014
04	Fourth issue with sample map correction	27/10/2014

	Name & Position	Date
Author	Lars Brunner & Peter Lamont	28/08/2014
Checked	Chris Allen	29/09/2014
Approved	Andrea Veszelovszki	27/10/2014

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

Production area:	Loch Roag: Ceabhagh Loch Roag: Chearstaigh
Site name:	Keava Buckle point Eilean Scarastaigh
SIN:	LH-381-722-08 (Keava) LH-344-791-08 (Buckle Point) LH-344-697-08 (Eilean Scarastaigh)
Species:	Mussels (*Mytilus edulis*)
Harvester:	Ruaraidh MacKay
Local Authority:	Comhairle nan Eilean: Lewis and Harris
Status:	Existing area
Date Surveyed:	25th – 26th August 2014
Surveyed by:	Peter Lamont, Lars Brunner
Existing RMP:	NB 2005 3450 (Keava) NB 2020 3240 (Buckle Point & Eilean Scarastaigh)
Area Surveyed:	**1.** The mussel cultivation sites described above **2.** An area of the east coast of Bernera from Tobhtaral To Leur Thob **3.** An area of ground around Lundal **4.** The area of coastline around Linsiadar

Weather

There were light showers in the 48hrs preceding the survey.

Monday 25th August: Bright & Sunny, clear sky, zero cloud cover, maybe 5% later in the day. Wind E-SE, f4-5. Temperature 16°C.

Tuesday 26th August: Bright & Sunny, clear sky, zero cloud cover. Wind E-SE, f4. Temperature 17°C.

Stakeholder engagement during the survey

Contact was made prior to the survey with both the harvester and the local sampling officer who provided information on access and the state of the fishery.

The harvester, Mr. Rhuraidh MacKay provided the team with access to the three sites on the morning of Monday 25th August, and was very helpful in providing information as to the current state and workings of the site, as well as future plans. It was not possible to meet Mr. Paul Tyler, the local authority sampling officer, on site due to other commitments, but the team met with him in Stornoway on Tuesday 26th August. Mr. Tyler also very helpfully provided us with information as to the fishery in Loch Roag.

Fishery

The fishery at the sites in Ceabhagh (Keava) and Eilean Chearstaigh consist of cultivation of common mussels (*Mytilus edulis*) on a longline system. All of the sites use a form of New Zealand continuous longline where the mussel rope is looped in turn for each dropper. This allows for easier handling and deployment from the farm barge (Fig. 6 – not included in Table 1). The

sampling officer later told the team that this also meant mussels could be graded without requiring to be removed from the lines.

All three areas are in production at present, although with differing ages of stock. Eilean Sgarastaigh (waypoints 1-8) is the largest of the three areas, and consisted of four longlines of mixed age stock. Buckle Point, located to the east (waypoints 9-17), consisted of two longlines running east to west, with mixed age stock present. There was a very strong tidal flow running between Eilean Chearstaigh and the main island of Lewis, which was observed by the team at the time of survey. The third site at Keava (waypoints 18-28) had two longlines, also running east to west, although at the time of survey the southernmost of the lines was partially submerged as the anchors at the eastern end had broken. The break in the line was due to be fixed imminently. Keava also had mixed age stock on site, with a large spat settlement present.

Mr Mackay confirmed that all of the sites were currently worked, and had seen investment and improvement since the site was taken over by Loch Fyne Oysters (LFO). He did not foresee any major changes to the layout or working practices on site in the near future. There was no specific seasonal pattern to harvesting, with the level being fairly constant throughout the year.

There appeared to be little other fishing activity in Loch Roag, although there were several active salmon farms in other parts of the loch. Some disused infrastructure was observed (old salmon cages) adjacent to the Keava site (Fig. 5). One other non-fishing activity observed was intertidal seaweed harvest, which used dedicated boats (waypoint 64) and storage rafts (waypoint 69).

Sewage Sources

The area around the survey site was rural, with habitation largely consisting of detached houses arranged in a crofting township style (Circebost, Calanais). In Lundal and Linsiadar there were fewer houses and some larger open farmed areas. Public facilities were few around the survey area, but a large visitor centre with parking, café & public toilet facilities was located at the Calanais standing stones at NB 2134 3277 (around 1.2km to the east of Buckle Point).

Pipes with active discharge were noted in the Circebost area at waypoints 31 & 34 with other pipes, either inactive or not currently discharging, noted in the shoreline observations in table 1.

During survey, a large factory was observed in the village of Breascleit (Fig 5.). Although the factory was outside the survey area, it was only around 1km from the Keava site. It was not possible to ascertain the activity at the factory during the survey.

Seasonal Population

There were no hotels present in the survey area, although some B&B's and self-catering properties were observed (but not separately waypointed). While

no campsites were noted on the survey route three camping pods were noted (Fig. 14) on the shoreline adjacent to the Calanais Stones Visitor Centre.

Boats/Shipping

Small launching points were noted at Circebost (waypoint 33) and at Linsiadar (waypoint 57 & 69). The only vessel observed working on Loch Roag was the harvesting craft from the mussel farm. Several smaller vessels were observed at moorings around the loch, including a small yacht at waypoint 36, a small workboat and RIB at waypoint 57, and a 6m RIB at waypoint 67.

Farming and Livestock

Three cows were noted at the start of the shoreline survey in Circebost (waypoint 31), and sheep were noted at several points during the survey (eighteen sheep at waypoint 37, thirty three sheep at waypoint 46, six at waypoint 50, and another six sheep at waypoint 60). In the Linsiadar area, some of the fields were improved grassland and had recently been harvested for silage.

Land Use

Land use in the survey area consisted primarily of small scale crofting plots, with some upland and unimproved areas being used for sheep grazing. No large scale industry was noted other than the mussel farm sites themselves and the factory noted at waypoint 22.

Land Cover

The predominant land cover in the areas of habitation was a mixture of improved and unimproved grassland based around small crofting units. Out with these townships there were large areas of heathland and unimproved grassland. The area around Linsiadar had an increased amount of improved grassland, some of it used for grazing and silage production. No woodland was observed on the survey route.

Watercourses

The watercourses present in the survey area were mostly small streams, the largest of which was the Lundale River (waypoint 47), followed by the Allt Scarastaigh (waypoint 52) and the Allt a Raulla (waypoint 70). Several smaller watercourses were observed, and these are referred to in the shoreline observation table (Table 1).

Wildlife/Birds

Birds were observed at various points during the survey, including;

- 10 gulls at waypoint 8;
- 6 immature gulls using the surface buoys as resting points at the Buckle Point site (waypoint 12);
- Three crows in filed above shoreline at waypoint 31;
- 2 rock doves at waypoint 32;
- 1 wren at waypoint 34;
- 2 hooded crows at waypoint 42

In addition a rabbit was observed at waypoint 49, and a female Atlantic grey seal observed offshore at waypoint 40.

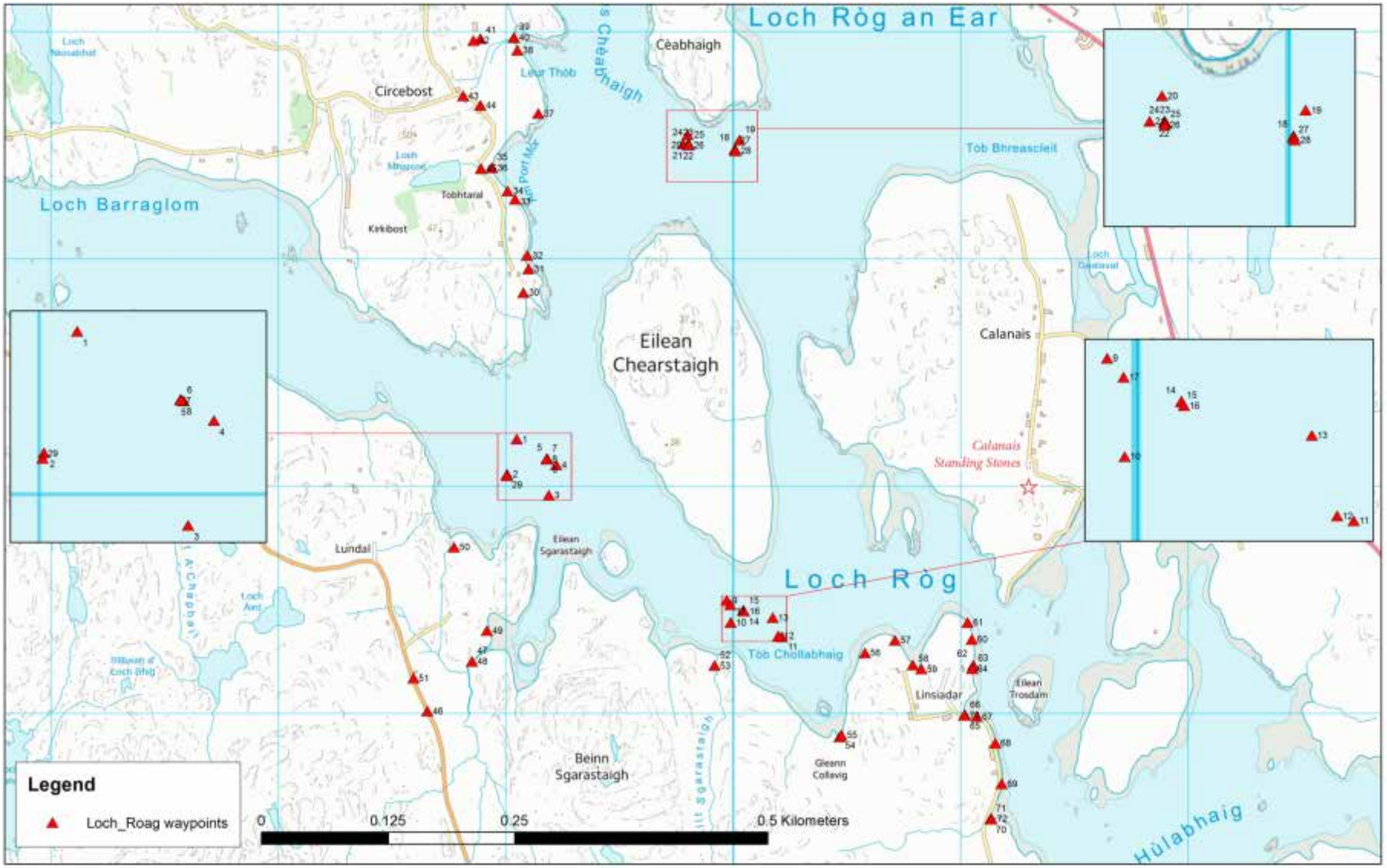

Figure 1. Loch Roag waypoints

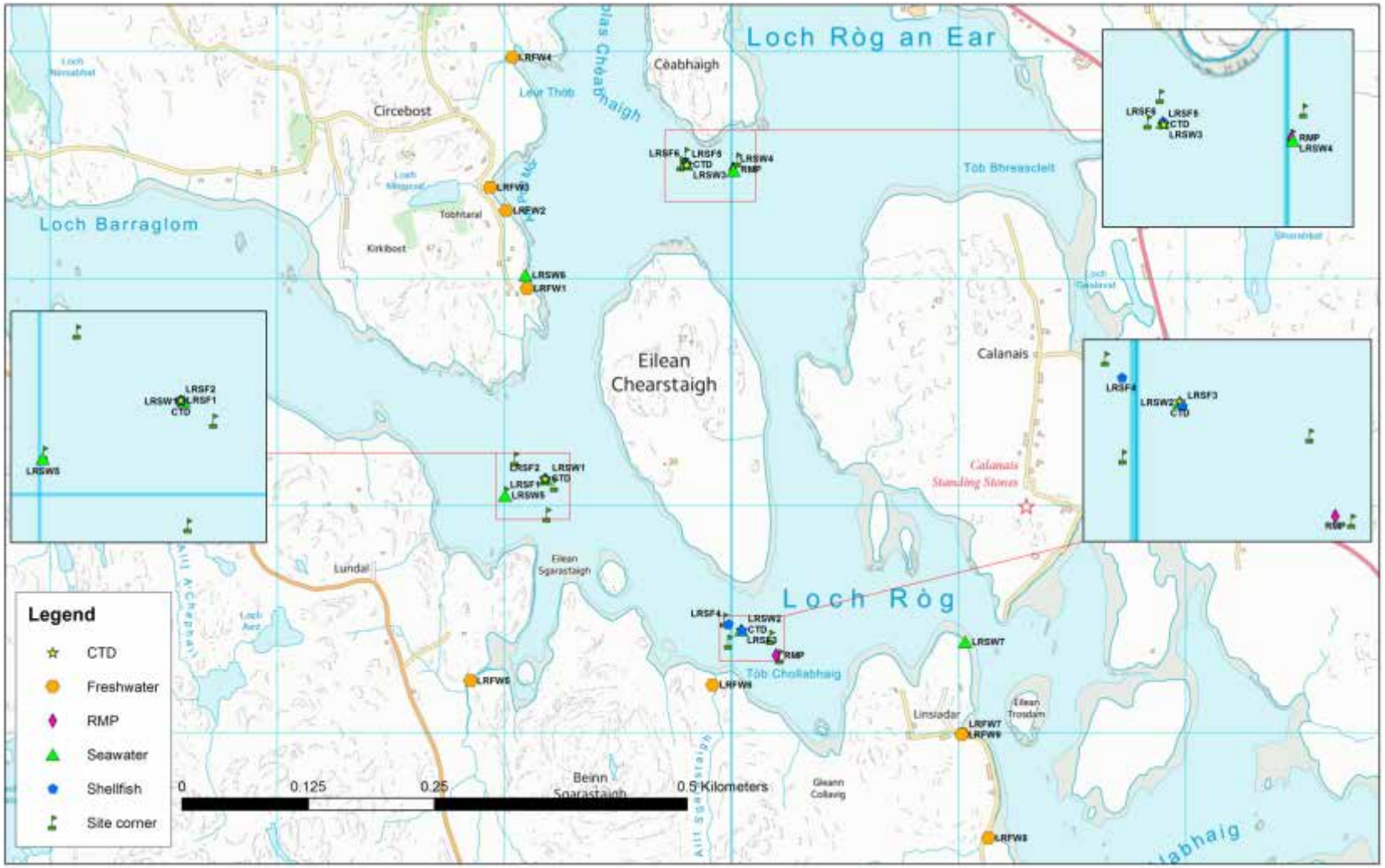

Figure 2. Loch Roag samples

Table 1. Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	25/08/2014	9:13	NB 19047 33207	119048	933207			Start of survey day 1, survey area 1; Eilean Sgarastaigh NW point of mussel array.
2	25/08/2014	9:14	NB 19005 33053	119006	933053			SW corner of mussel array.
3	25/08/2014	9:15	NB 19188 32960	119189	932961	Fig. 3		SE corner of mussel array.
4	25/08/2014	9:16	NB 19221 33094	119221	933094			NE corner of mussel array.
5	25/08/2014	9:18	NB 19183 33118	119183	933119		LRSW1	Seawater sample: Harvester mentions there is a lot of freshwater in the loch at the time of the survey.
6	25/08/2014	9:20	NB 19180 33119	119180	933120		LRSF1	Mussel sample from surface. Mussels are about two years old.
7	25/08/2014	9:24	NB 19178 33120	119179	933120		LRSF2	Mussel sample from about 6 metres depth on the line (8 m droppers).
8	25/08/2014	9:25	NB 19179 33120	119179	933120		CTD	CTD cast. Ten gulls present nearby.
9	25/08/2014	9:36	NB 19971 32497	119971	932498			NW corner of mussel array at Buckle Point.
10	25/08/2014	9:37	NB 19988 32400	119988	932400			SW corner of mussel array.
11	25/08/2014	9:38	NB 20214 32336	120215	932337	Fig. 4		SE corner of mussel array.
12	25/08/2014	9:38	NB 20198 32341	120198	932342			RMP position of mussel array. Six immature gulls present, appearing to spend time on the buoys
13	25/08/2014	9:40	NB 20173 32421	120173	932421			NE corner of mussel array.
14	25/08/2014	9:42	NB 20044 32454	120045	932455		LRSW2	Planned seawater sample.
15	25/08/2014	9:43	NB 20044 32455	120044	932455		CTD	CTD cast - delayed slightly.
16	25/08/2014	9:49	NB 20046 32450	120047	932451		LRSF3	Mussel sample from surface.
17	25/08/2014	9:54	NB 19987 32478	119987	932479		LRSF4	Mussel sample additional from surface. Weight of line prevents depth sample being obtained.
18	25/08/2014	10:06	NB 20007 34483	120008	934483			SE corner of mussel array at Keava.
19	25/08/2014	10:07	NB 20027 34523	120027	934524			NE corner of mussel array.
20	25/08/2014	10:08	NB 19799 34546	119799	934547			NW corner of mussel array.
21	25/08/2014	10:08	NB 19779 34506	119779	934507			SW corner of mussel array.
22	25/08/2014	10:11	NB 19802 34505	119802	934505	Fig. 5	LRSW3	Planned seawater sample 3. Photograph of mussel lines at Keava with disused fish farm cages and a shore factory in the distance.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
23	25/08/2014	10:12	NB 19803 34506	119803	934506		LRSF5	Mussel sample from surface.
24	25/08/2014	10:17	NB 19803 34505	119804	934506		LRSF6	Mussel sample from about 7 metres depth.
25	25/08/2014	10:22	NB 19803 34502	119804	934502		CTD	CTD cast.
26	25/08/2014	10:24	NB 19802 34500	119803	934501			Extra waypoint.
27	25/08/2014	10:27	NB 20007 34480	120007	934480			RMP position of mussel array.
28	25/08/2014	10:28	NB 20009 34476	120010	934477		LRSW4	Seawater sample, planned.
29	25/08/2014	10:32	NB 19003 33045	119004	933046		LRSW5	Seawater sample, planned.
30	25/08/2014	11:23	NB 19077 33852	119077	933852			Start of shore survey section 2. New drainage ditch dug.
31	25/08/2014	11:28	NB 19100 33955	119100	933956	Fig. 7	LRFW1	Freshwater sample, unplanned, contaminated. Septic tank above shoreline with 10 cm plastic outfall pipe with discharge. Three cows in field above. Flow from pipe 3.3ml/second
32	25/08/2014	11:35	NB 19093 34015	119094	934015		LRSW6	Seawater sample, planned. Two rock doves disturbed.
33	25/08/2014	11:45	NB 19040 34262	119041	934263			Abandoned slipway or wall.
34	25/08/2014	11:48	NB 19008 34299	119008	934300	Fig. 8	LRFW2	Freshwater sample, unplanned, contaminated. No septic tank visible above shoreline. Smell present at 10 cm diameter plastic discharge pipe. Flow rate 13ml/second. One wren seen.
35	25/08/2014	11:54	NB 18938 34401	118938	934402		LRFW3	Freshwater sample, planned. Sample associated with waypoint (WP) 36.
36	25/08/2014	11:54	NB 18938 34401	118938	934402			Flow 0.186 m/s SD 0.006, depth 9 cm, width 20 cm. One yacht moored in bay.
37	25/08/2014	12:18	NB 19143 34639	119143	934640	Fig. 9		Eighteen sheep in field. Moved off when disturbed, into neighbouring field.
38	25/08/2014	12:26	NB 19050 34918	119051	934919			Dwelling but no discharge or pipe visible.
39	25/08/2014	12:29	NB 19035 34974	119035	934975		LRFW4	Freshwater sample, planned. Sample associated with WP 40.
40	25/08/2014	12:29	NB 19034 34975	119035	934975			Flow 0.040 m/s SD 0.005, depth 4 cm, width 20 cm. One sunken work vessel in bay (<10 m length). Female Atlantic grey seal nearby.
41	25/08/2014	12:40	NB 18888 34968	118888	934969			Plastic soil pipe 10 cm diameter apparently running into soak-away in marshy ground. No end visible in field or on shoreline

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
42	25/08/2014	12:42	NB 18858 34962	118858	934962			End of survey section 2: Septic tank by road below abandoned house. Not in use at the time of the visit as the house was clearly uninhabited. No further tanks seen on walk back. Two hooded crows.
43	25/08/2014	12:48	NB 18812 34718	118812	934718			Pipework and new septic tank by cottage renovation on site of consented private discharge. Observed in transit between sections 2 and 3 of the shore walk.
44	25/08/2014	12:50	NB 18888 34675	118888	934676	Fig. 10		Large plastic septic tank below road, partially uncovered. Observed in transit between sections 2 and 3 of the shore walk.
45	25/08/2014	12:55	NB 18890 34398	118891	934398	Fig. 11		Open plastic ex-commercial fish tank below road about 3.5 m diameter by 1 m high. Observed in transit between sections 2 and 3 of the shore walk. Water draining in from pipe and outflow at low level with little in tank. Shore below already sampled twice.
46	25/08/2014	13:29	NB 18654 32010	118655	932011			Start of shore section 3. Field below road with 33 sheep.
47	25/08/2014	13:38	NB 18851 32229	118851	932230	Fig. 12	LRFW5	Freshwater sample, planned. Isolated position. Sample associated with observations in WP48.
48	25/08/2014	13:38	NB 18851 32229	118851	932229			Flow 0.100 m/s SD 0.008, depth 25 cm; 0.135 m/s SD 0.047, depth 25 cm. Total width 2.45 m.
49	25/08/2014	13:51	NB 18917 32365	118918	932365	Fig. 13		Septic tank at house above shore. No outflow observed. One rabbit seen.
50	25/08/2014	14:07	NB 18771 32732	118772	932732			Many sheep droppings and six sheep in field above shore.
51	25/08/2014	14:18	NB 18593 32155	118594	932156			End of shore survey section 3. Dwelling by road. No septic tank observed.
52	25/08/2014	14:58	NB 19918 32211	119918	932211		LRFW6	Freshwater sample, isolated position, planned. Sample associated with WP53.
53	25/08/2014	14:58	NB 19918 32211	119918	932211			Flow 0.397 m/s SD 0.003, depth 14 cm, width 10 cm. Measurement in cleft rock channel with V section.
54	25/08/2014	15:15	NB 20468 31898	120468	931898			Start of shore survey section 4.
55	25/08/2014	15:15	NB 20475 31905	120476	931906			Small burn not sampled.
56	25/08/2014	15:25	NB 20578 32267	120579	932267			Sheep fank.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
57	25/08/2014	15:29	NB 20711 32322	120712	932323	Fig. 14, 15		On the opposite shore the Calanais Stones Visitor Centre is visible from this waypoint with three camping pods below, close to shore. Fig 14 only shows two of these. Two small craft on mooring. Small pier on shore (Fig. 15).
58	25/08/2014	15:33	NB 20789 32213	120790	932214			End of survey day 1.
59	26/08/2014	9:01	NB 20827 32195	120828	932196			Start of survey day 2. Field with 29 sheep adjacent to west of the bay.
60	26/08/2014	9:11	NB 21048 32326	121049	932326			Field with six sheep. Droppings plentiful. Area previously used for grazing, better ground.
61	26/08/2014	9:14	NB 21030 32400	121030	932401		LRSW7	Seawater sample, planned.
62	26/08/2014	9:20	NB 21054 32212	121055	932213	Fig. 16		Ceramic 15 cm diameter pipe running down foreshore. End not visible due to tide level. Section broken near to high water mark, no flow visible.
63	26/08/2014	9:23	NB 21051 32197	121052	932198	Fig. 17		Standard 10 cm diameter plastic soil pipe plus one metal 5 cm diameter pie ending on upper foreshore. No discharge in either. Ground above inspected for septic tank but none observed.
64	26/08/2014	9:23	NB 21050 32197	121050	932198	Fig. 18		Workboat at mooring. Seaweed harvesting vessel.
65	26/08/2014	9:31	NB 21017 31994	121017	931995		LRFW7	Freshwater sample, planned. Sample associated with WP66.
66	26/08/2014	9:31	NB 21017 31994	121017	931995			Flow 0.140 m/s SD 0.006, depth 2 cm, width 14 cm.
67	26/08/2014	9:38	NB 21070 31986	121071	931987			Three moorings, one occupied with a 6 m RIB.
68	26/08/2014	9:41	NB 21151 31870	121152	931870	Fig. 19		Large covered septic tank on shore with one 10 cm plastic pipe inlet. No sign of discharge pipe to shore below. Discharge pipe present on upper side of tank, with no active discharge.
69	26/08/2014	9:51	NB 21180 31690	121181	931691	Fig. 20		Caged storage area on intertidal for harvested seaweed. Silage bales in field above road.
70	26/08/2014	9:55	NB 21131 31536	121132	931537		LRFW8	Freshwater sample, planned. Sample associated with WP71.
71	26/08/2014	9:55	NB 21131 31536	121132	931537			Flow 0.215 m/s SD 0.002, depth 4 cm, width 26 cm.
72	26/08/2014	10:00	NB 21136 31535	121137	931536			End of survey section 4. End of Loch Roag shore surveys.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
73	26/08/2014	10:32	NB 21014 31992	121015	931992		LRFW9	Freshwater sample, unplanned. Extra sample taken classed as contaminated to cover possible high result recorded before for this watercourse. Paired sample (LRFW7, waypoint 65) was counted as clean.

Photographs referenced in the table can be found attached as Figures 3-19.

Sampling

Sampling proceeded according to plan on the 25th & 26th August.

Water samples were collected at the sites marked on the Loch Roag samples map shown in Figure 2.

All the samples were transferred to a Biotherm 30 box (25th August) and a Biotherm 10 box (26th August) with ice packs and posted to the Glasgow Scientific Services (GSS) for *E.coli* analysis. All the samples were posted on the day of collection with all of the samples being received the following day. The sample temperatures on arrival at the laboratory were recorded as 6.5°C (26th August) and 4.0 °C (27th August).

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

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

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	*E. coli* (cfu/100ml)	Salinity (ppt)
1	25/08/14	LRSW1	NB 19183 33118	Seawater	2	29.63
2	25/08/14	LRSW2	NB 20044 32454	Seawater	2	30.53
3	25/08/14	LRSW3	NB 19802 34505	Seawater	3	32.52
4	25/08/14	LRSW4	NB 20009 34476	Seawater	4	32.34
5	25/08/14	LRSW5	NB 19003 33045	Seawater	5	30.35
6	25/08/14	LRSW6	NB 19093 34015	Seawater	62	29.63
7	26/08/14	LRSW7	NB 21030 32400	Seawater	47	27.64
8	25/08/14	LRFW1	NB 19100 33955	Freshwater contaminated	200,000	
9	25/08/14	LRFW2	NB 19008 34299	Freshwater contaminated	1,400,000	
10	25/08/14	LRFW3	NB 18938 34401	Freshwater	60	
11	25/08/14	LRFW4	NB 19035 34974	Freshwater	40,000	
12	25/08/14	LRFW5	NB 18851 32229	Freshwater	40	
13	25/08/14	LRFW6	NB 19918 32211	Freshwater	<10	
14	26/08/14	LRFW7	NB 21017 31994	Freshwater	70	
15	26/08/14	LRFW8	NB 21131 31536	Freshwater	110	
16	26/08/14	LRFW9	NB 21014 31992	Freshwater contaminated	<1000	

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	*Sample depth (m)*	*E. coli* (MPN/100g)
1	25/08/14	LRSF1	NB 19180 33119	Mussel	Surface	330
2	25/08/14	LRSF2	NB 19178 33120	Mussel	6m	130
3	25/08/14	LRSF3	NB 20046 32450	Mussel	Surface	45
4	25/08/14	LRSF4	NB 19987 32478	Mussel	Surface	330
5	25/08/14	LRSF5	NB 19803 34506	Mussel	Surface	45
6	25/08/14	LRSF6	NB 19803 34505	Mussel	7m	<18

Salinity Profiles

CTD profiles were taken at three locations in the production area, at each sampling point around the mussel lines (refer to Figure 2 for map locations). The gathered data will be sent to the client as a separate document.

Photographs –

Fig 3: Longlines at Eilean Sgarastaigh (WP3, looking north)

Fig 4: Longlines at Buckle point, showing fouling and birds present (WP 11)

Fig 5: Longlines at Keava, with disused salmon cages (not associated with the mussel farm) highlighted with red arrow. Factory located in village of Breascleit is highlighted with green arrow. Photo taken from point to SW of WP22, looking NE.

Fig 6: Aluminium mussel farm harvesting vessel – photo taken on passage in Loch Barraglom on return to shore base.

Fig 7: House at Tobhtaral with septic tank and active discharge, associated with unplanned freshwater sample LRFW1,WP 31.

Fig 8: Pipe with active discharge on shoreline at Tobhtaral associated with unplanned freshwater sample LRFW2 (WP 34).

Fig 9: Bay at Tobhtaral, looking S from WP 37. Sheep observed in this area were behind camera.

Fig 10: Septic tank situated below road at Circebost, WP 44.

Fig 11: Large, open tank below public road, with pipe and inflow running in. Waypoint 45.

Fig 12: Lundale River, site of planned freshwater sample LRFW5 from WP 47.

Fig 13: Isolated house at Lundal with septic tank (highlighted with red arrow) but no evidence of discharge onto shore. WP49.

Fig 14: Two of three camping pods located across water from survey route, adjacent to (west of) Calanais standing stones. Photo taken from WP57, looking NE.

Fig 15: Launching site, with work boat & RIB moored offshore. WP 57.

Fig 16: Pipe running from foreshore into bay with end below sea level, WP62. No flow observed at broken section on upper shore.

Fig 17: Further pipes running onto foreshore, WP 63. No flow present.

Fig 18: Seaweed harvesting vessel at mooring. WP 64.

Fig 19: Septic tank on foreshore WP 68.

Fig 20: Storage raft with harvested seaweed moored on foreshore. WP 69.

Appendix 4

Loch Roag Ceabhagh and Eilean Cheastaigh CTD data

Data obtained during the shoreline survey. The locations of the casts are shown in Figure A8.1.

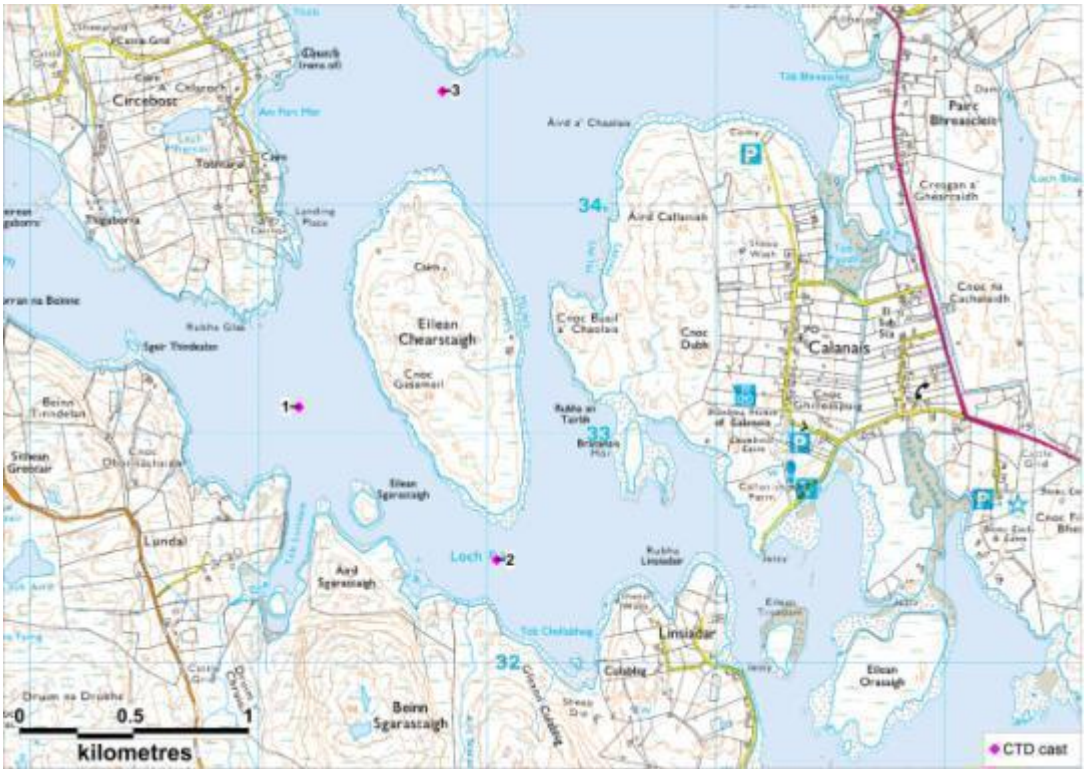

Figure A8.1 Location of CTD cast

CAST 1

Data Header

% Device	10G100653
% File name	10G100653_20140825_082539
% Cast time (local)	25/08/2014 09:25
% Sample type	Cast
% Cast data	Down & up
% Location source	GPS
% Start latitude	58.1971319
% Start longitude	-6.7812262
% Start GPS horizontal error(Meter)	1.919999957
% Start GPS vertical error(Meter)	2.789999962
% Start GPS number of satellites	6
% Cast duration (Seconds)	111
% Samples per second	5
Calibration Date	March 2013
Calibration offset for Temperature	-0.033
Calibration offset for Salinity	0.029

CTD data (calibration offsets applied)

Depth (Meter)	Temperature (Celsius)	Salinity (Practical Salinity Scale)
0.149541502	13.39098192	29.07447094
0.448604339	13.38952063	29.09320851
0.747665402	13.3931656	29.14008293
1.046703297	13.41254922	29.3010801
1.345645974	13.45589048	29.99613118
1.644468419	13.51710267	30.38974859
1.943218322	13.49367844	30.64578308
2.241913351	13.47109524	30.86157698
2.540551259	13.44550572	31.13709937
2.839104825	13.37911302	31.58328313
3.137568732	13.34564436	31.90414172
3.435970494	13.3103227	32.11425303
3.734299948	13.26424104	32.52226424
4.032534894	13.21363809	32.92573131
4.330694358	13.16238992	33.1636015
4.628801541	13.12831679	33.36530859
4.926863688	13.07025123	33.53712792
5.224882203	13.02451963	33.72339252
5.522853933	12.99322867	33.93019009
5.820788245	12.96766356	34.03842636
6.118703072	12.95765284	34.09128529
6.416608065	12.95164849	34.11876543
6.714505234	12.94174378	34.15380374
7.012393346	12.929112	34.19051616
7.310272978	12.91767694	34.22005351
7.608142035	12.90033613	34.27418785
7.905996907	12.88443011	34.33466123
8.203842234	12.87477804	34.34953835
8.501684511	12.87073127	34.35529622
8.799523889	12.8674062	34.37045072
9.097357746	12.85988732	34.39865453
9.395184773	12.8447944	34.42240167
9.693008233	12.84110033	34.42259491
9.99082923	12.82914156	34.43732476
10.28378274	12.8235595	34.44365385

CAST 2

Data Header

% Device	10G100653
% File name	10G100653_20140825_084954
% Cast time (local)	25/08/2014 09:49
% Sample type	Cast
% Cast data	Processed
% Location source	GPS
% Start latitude	58.1917148
% Start longitude	-6.7657473
% Start GPS horizontal error(Meter)	1.889999986
% Start GPS vertical error(Meter)	3.930000067
% Start GPS number of satellites	5
% Cast duration (Seconds)	74.2
% Samples per second	5
Calibration Date	March 2013
Calibration offset for Temperature	-0.033
Calibration offset for Salinity	0.029

CTD data (calibration offsets applied)

Depth (Meter)	Temperature (Celsius)	Salinity (Practical Salinity Scale)
0.149498644	13.29362764	29.43103116
0.448469266	13.30325213	29.50399097
0.747423223	13.30620615	29.6331396
1.046346421	13.30892941	29.77476345
1.345221436	13.30697454	30.05704549
1.644035106	13.30420236	30.31399504
1.942797939	13.30710975	30.50453054
2.241518372	13.30390746	30.68669748
2.540200832	13.29848795	30.83596209
2.838851989	13.2965402	30.95935884
3.137475435	13.28940339	31.07638253
3.436061452	13.27651394	31.28322232
3.734581828	13.26186805	31.64863941
4.033001686	13.23565726	32.16177089
4.331342875	13.21863706	32.33284143
4.629651436	13.2105629	32.44205699
4.927942594	13.20461556	32.48079375
5.226159984	13.18653303	33.08814562
5.524255381	13.15730153	33.54947524
5.82228831	13.14589944	33.62986252
6.120301219	13.12737045	33.7167424
6.418298891	13.12059996	33.75581389
6.716282499	13.10677545	33.83349494
7.014249993	13.08006983	33.88562775
7.312202858	13.04616808	33.94495535
7.610137342	13.01506899	34.02930843
7.908049857	12.99585461	34.12435451
8.205942215	12.97935773	34.19636811
8.503820069	12.96644152	34.24277506
8.801690137	12.95865029	34.25729691
9.099555581	12.95684985	34.27846889
9.397416563	12.94896294	34.29151508
9.60708498	12.94893836	34.29376928
0.149498644	13.29362764	29.43103116
0.448469266	13.30325213	29.50399097

CAST 3

Data Header

% Device	10G100653
% File name	10G100653_20140825_092342
% Cast time (local)	25/08/2014 10:23
% Sample type	Cast
% Cast data	Processed
% Location source	GPS
% Start latitude	58.209879
% Start longitude	-6.7722434
% Start GPS horizontal error(Meter)	4.360000134
% Start GPS vertical error(Meter)	6.090000153
% Start GPS number of satellites	7
% Cast duration (Seconds)	178.6
% Samples per second	5
Calibration Date	March 2013
Calibration offset for Temperature	-0.033
Calibration offset for Salinity	0.029

CTD data (calibration offsets applied)

Depth (Meter)	Temperature (Celsius)	Salinity (Practical Salinity Scale)
0.149215122	13.45206843	31.9818996
0.447624009	13.44304557	32.00885228
0.746030674	13.42276198	32.04377962
1.044406119	13.37371128	32.26519542
1.342719591	13.32270127	32.56534703
1.640938761	13.26290362	33.07129813
1.939044016	13.22407147	33.54910889
2.237069723	13.15962469	33.74865561
2.535051788	13.1109636	33.90484405
2.833000584	13.05266878	34.01383609
3.130928797	13.02498084	34.06267636
3.428843165	13.01012654	34.12299077
3.726742101	12.99402604	34.18894165
4.024624035	12.97824603	34.26297974
4.322491414	12.9645454	34.30780697
4.620350227	12.95944018	34.33134008
4.918199796	12.94667849	34.38244103
5.216036296	12.93186918	34.43748507
5.513859553	12.91528071	34.48916716
5.811672325	12.89753819	34.51892386
6.109476954	12.87901813	34.5492887
6.407274482	12.86173004	34.56990278
6.705067285	12.849338	34.58071001
7.002857388	12.84362644	34.58630736
7.300646827	12.83927955	34.58106972
7.598435216	12.83518421	34.59051242
7.896221342	12.82798257	34.59532768
8.232961692	12.82934763	34.59662602