Scottish Sanitary Survey

Sanitary Survey Review
Loch Inchard
HS 311, 312, 313, 314 and 315
December 2013

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Author	Liefy Hendrikz, Jessica Larkham, Michelle Price-Hayward	Scottish Sanitary Survey Team	20/01/2014
Checked	Michelle Price-Hayward	Senior Shellfish Hygiene Scientist	27/03/2014
Approved	Ron Lee	Principal Shellfish Hygiene Scientist	28/03/2014

Centre for Environment, Fisheries & Aquaculture Science, Weymouth Laboratory, Barrack Road, The Nothe, Weymouth DT4 8UB. Tel 01305 206 600
www.cefas.defra.gov.uk

Report Distribution – Loch Inchard

Name	Agency
Joyce Carr	Scottish Government
Hazel MacLeod	SEPA
Douglas Sinclair	SEPA
Fiona Garner	Scottish Water
Alex Adrian	Crown Estate
Anne Grant	Highland Council: Sutherland
David Forbes	Harvester
David Ross	Harvester
John Ross	Harvester
Norman Ross	Harvester

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 queries are submitted to organisations or agencies for data not freely available on the internet.

The review is intended to identify whether there have been 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. This report shall include an overall assessment as to whether the production area 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 shall be included.

A sanitary survey was undertaken at Loch Inchard in 2008. The output of this survey included a report and a sampling plan for the fishery. The 2008 sampling plan is shown on the following page alongside the amended sampling plan recommendations following findings from this review.

The present report constitutes a review and it is not intended to present detailed information relating to pollution sources that were identified in the sanitary survey report. Therefore, this review should be read in conjunction with the 2008 sanitary survey report.

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APPENDICES

Sampling Plan – Loch Inchard

	2008 recommendations	2013 review	Changes
PRODUCTION AREA	Loch Inchard		No change
SITE NAMES	Site 1, Site 2, Site 3, Site 4, Site 5		
SIN	HS 162-311-08, HS 162-312-08, HS 162-313-08, HS 162-314-08, HS 162-315-08		
SPECIES	Common mussels		
TYPE OF FISHERY	Long-line		
NGR OF RMP	NC 2474 5415	NC 2375 5552	Moved to east end of Site 1
EAST	224740	223750	
NORTH	954150	955520	
TOLERANCE (M)	40 m		Expanded from 20 m
DEPTH (M)	5 m	1 m	Depth reduced
METHOD OF SAMPLING	Hand		No change
FREQUENCY OF SAMPLING	Monthly		
LOCAL AUTHORITY	Highland Council: Sutherland		
AUTHORISED SAMPLER(S)	Anne Grant	Anne Grant	No change
RECOMMENDED PRODUCTION AREA	NC 2317 5562 and NC 2306 5522 and between NC 2400 5555 and NC 2400 5538 and between NC 2500 5428 and NC 2500 5381 and between 2482 5298 and NC 2525 5318 extending to MHWS	NC 2317 5562 and NC 2306 5522 and between NC 2400 5555 and NC 2400 5538 and between NC 2500 5428 and NC 2500 5381 and between 2482 5298 and NC 2525 5318 extending to MHWS	No change

1. Area and Fishery

Loch Inchard is located in northwest Scotland, just south of Cape Wrath. The loch is west facing and has a southward bend 1 km from the mouth of the loch. The area is remote and rugged, with no major centres of population.

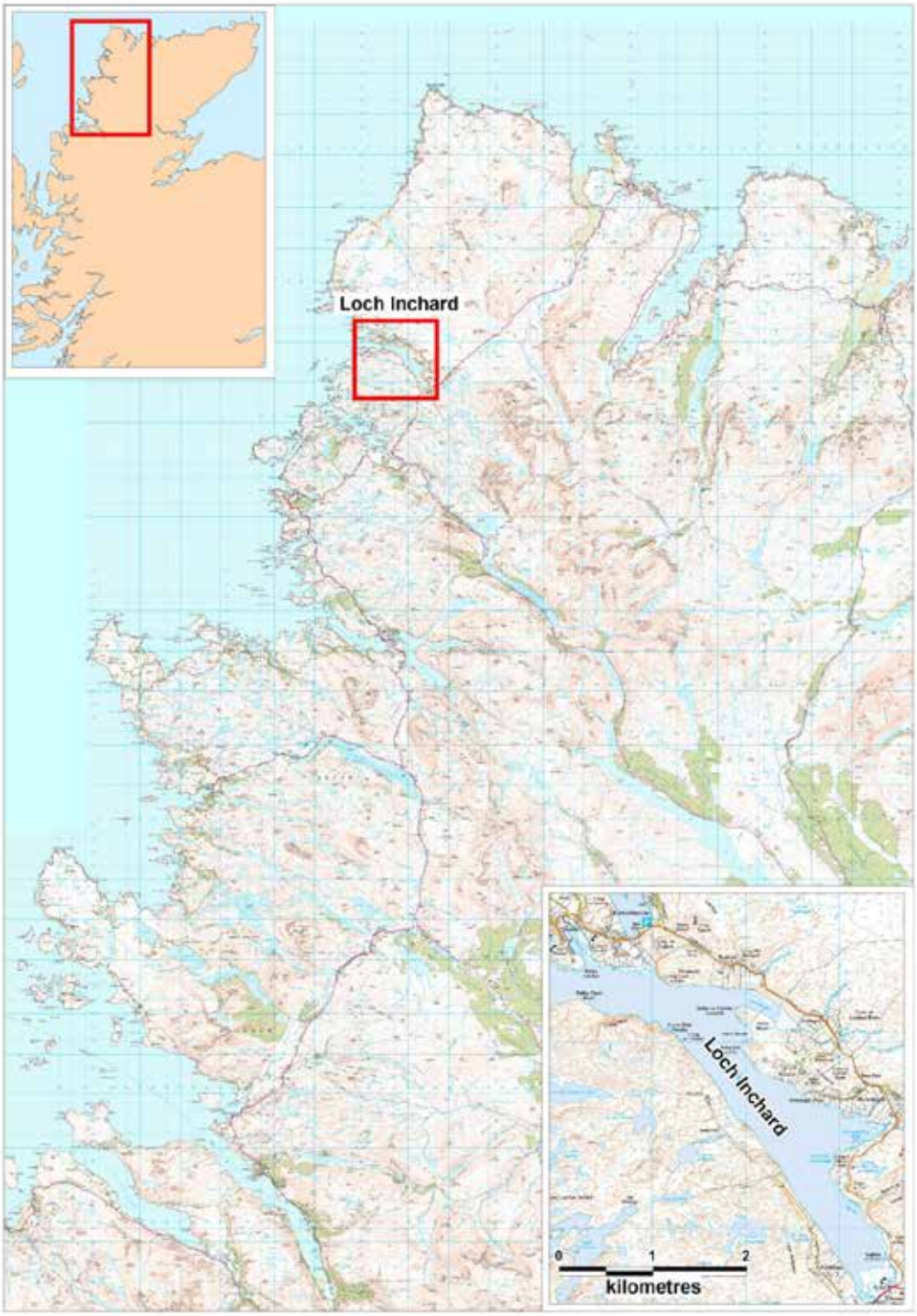

Figure 1.1 Location of Loch Inchard

The current fishery at Loch Inchard, at the time of the shoreline survey undertaken in 2013, consisted of five long-line mussel farms, details of which are listed in Table 1.1.

Table 1.1 Classified fishery at Loch Inchard

Production area	Site*	SIN*	Species	Micro RMP
Loch Inchard	Site 1 - D. Ross	HS-162-311-08	Common mussels	NC 2356 5547
	Site 2 - D. Forbes	HS-162-312-08		
	Site 3 – I. Morrison	HS-162-313-08		
	Site 4 - J. Ross	HS-162-314-08		
	Site 5 - N. Ross	HS-162-315-08		

*Taken from the FSA Scotland classification report (01 April 2013 to 31 March 2014)

The current RMP identified by FSAS is located at NC 2356 5547 and plots in Site 1. However, due to a lack of mature stock at Site 1, current monitoring samples are being taken at Site 4. The RMP at Site 1 lies approximately 1.8 km north from that recommended in the 2008 report of NC 2474 5415. These two RMPs and the RMP used prior to the 2008 report are displayed in Figure 1.2. Site boundaries obtained during the 2007 and 2013 surveys are also shown in Figure 1.2, with site names obtained during the 2013 survey. Based on information from the harvester, the site numbering has been amended from that used in the 2008 report, and the relationships are listed in Table 1.2. The names of the owners have been corrected based on a discussion with the harvester after consultation responses to the draft report were received. The corrected 2013 site numbers are used on the map in Figure 1.2.

Table 1.2 Relationship between past and present site numbering of Loch Inchard mussel farms

Site numbering 2008	Site numbering 2013	Owner (2013)
Site 1	Site 1	David Ross
Site 3	Site 2	John Ross
Site 4	Site 3	John Ross
Site 2	Site 4	David Forbes
Site 5	Site 5	Norman Ross

The 2013 survey found that all five sites observed during the 2008 survey remained in operation. No new information was provided on cultivation/ harvesting practices at any of the sites. It was noted that John Ross owns two sites (2&3) and manages the other three (Sites 1, 4 & 5) that belong to local crofters (2013 numbering system).

The production area boundaries recommended in the 2008 report and the Seabed Lease areas are displayed in Figure 1.2, together with the locations of the mussel farms and the RMPs.

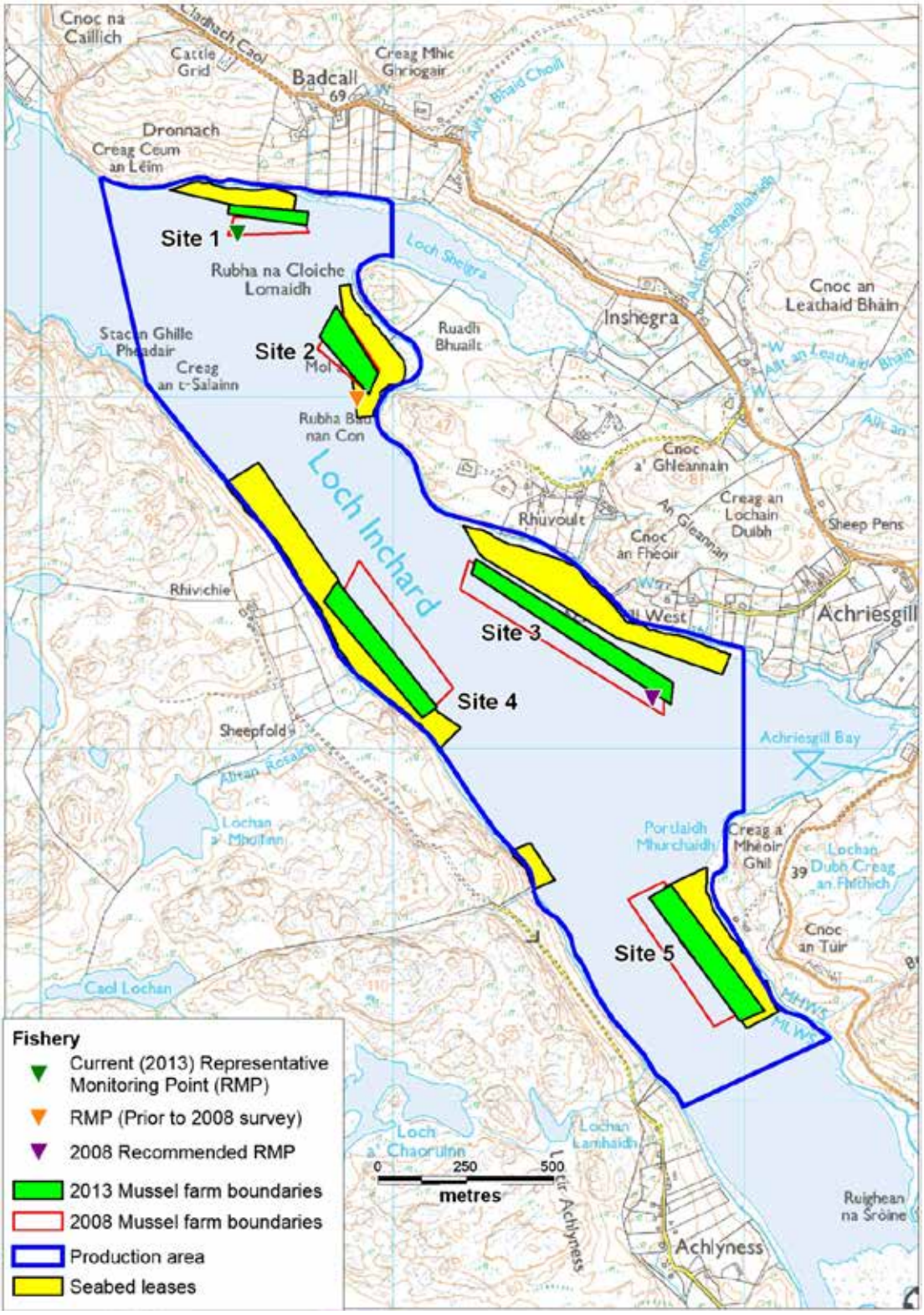

Figure 1.2 Current Loch Inchard production area and RMP, with the historical and recommended 2008 RMPs and 2008 and 2013 fishery locations

2. Population and Human Sewage Impacts

2.1 Population

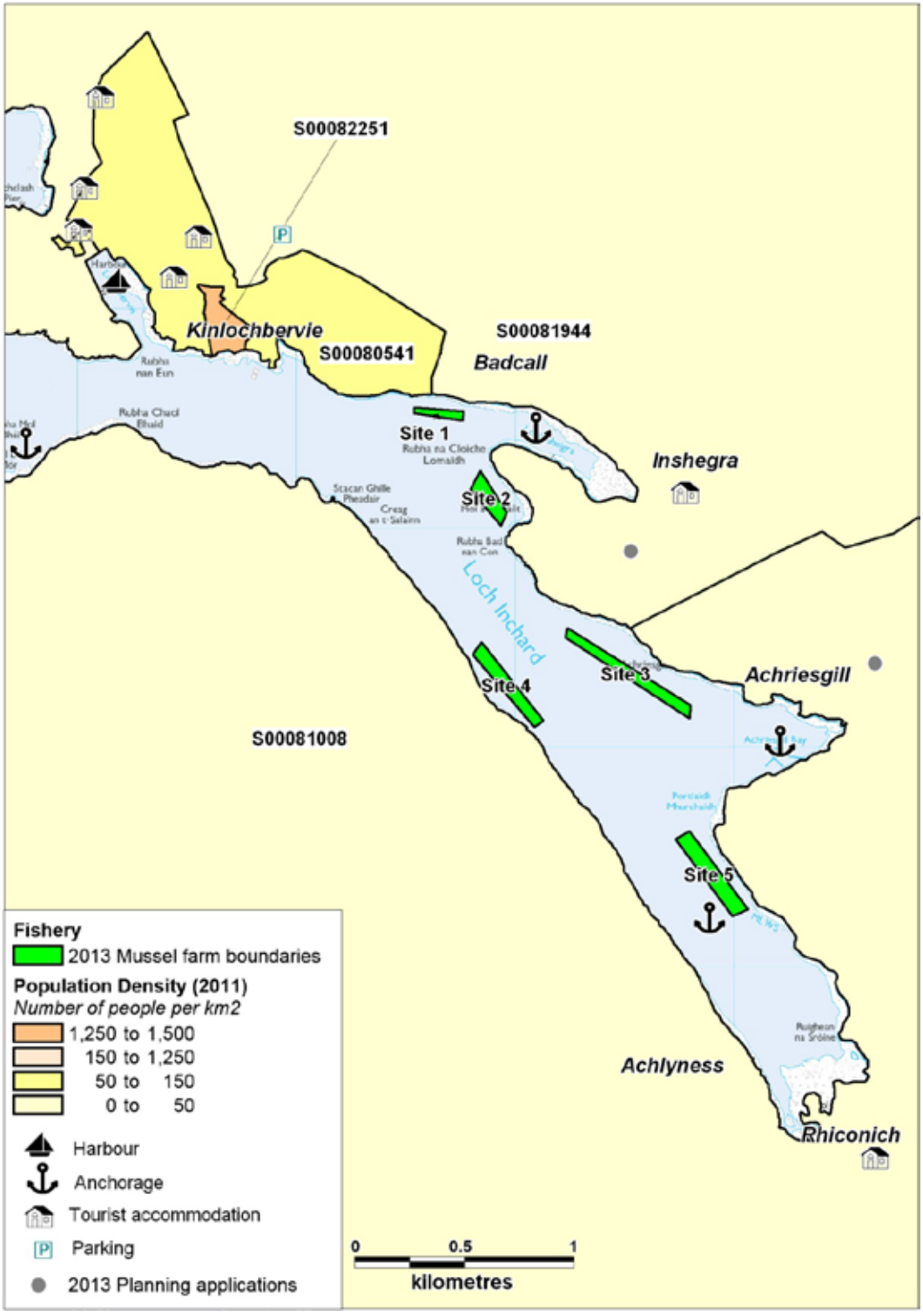

Figure 2.1 Current distribution of human population around Loch Inchard

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

2.1. Different identifiers were used for the output areas in the two censuses and one of the previous areas has been split into two. The data indicates that there has been a significant decline in the reported resident population around Loch Inchard since 2001. The greatest decrease related to the output area that relates to the area around the head of the loch and along the western shore. However, this output area covers 353 km^2 and thus it is not clear what proportion of the associated reduction related specifically to the vicinity of Loch Inchard.

Table 2.1 Comparison of 2001 and 2011 population census data

2001 Census data		**2011 Census data**	
Output area	Population	Output area	Population
60QT000356	160	S00081008	109
60QT000357	196	S00080541	113
		S00082251	63
60QT000358	91	S00081944	80
Total	**447**	**Total**	**365**

Population densities around the loch are generally low, but higher within the settlement of Kinlochbervie. Habitation is largely associated with crofting townships located along the B801 road that runs along the east side of the loch. A further township is located along the west side of the head of the loch. A search for planning applications since 2008 revealed only four: two in Kinlochbervie and two in the Achriesgill area on the eastern side of the loch. These applications were downloaded from the Highland Council Planning Portal in October 2013 (http://wam.highland.gov.uk/wam/), with full details listed in Appendix 1.

The two Kinlochbervie applications related to a residential caravan and five dwelling houses. Both applications indicated the properties were to be connected to the public sewerage network. The two Achriesgill applications were for private dwelling houses and are displayed in Figure 2.1. The house located northeast of Achriesgill had plans to install a private sewage treatment works with land soakaway. The application associated with a house located northwest of Achriesgill only specified a private foul drainage system. These new buildings are located at within 1 km and 500 m of Site 3 respectively.

Tourist accommodation is relatively plentiful, with most accommodation located in Kinlochbervie, with a further B&B at Inshegra and hotel at Rhiconich. Whilst it is expected that highest influxes of tourists will occur during summer months, information from conversations held with hoteliers during the 2013 survey indicates that the area is also popular with anglers, who visit the area between March and October. This suggests there is an extended influx in human population either side of the core summer months, though the number of visitors by month is not known.

In total, 21 fishing and pleasure vessels of varying sizes were observed in Kinlochbervie harbour during the 2013 survey. No other boats/moorings were noted during the 2013 survey and boat usage in the area is not expected to have changed since 2008.

2.2 Sewage Discharges

The 2008 report was provided with information from Scottish Water on five public sewage assets in the vicinity of Loch Inchard. These are listed in Table 2.2.

Table 2.2 Scottish Water Assets taken from the 2008 sanitary survey report

NGR	Discharge Name	Discharge Type	Level of Treatment	Flow (m^3/d)	PE
NC 2210 5570	Kinlochbervie Harbour	Continuous	ST	-	254
NC 2390 5580	Kinlochbervie Innis Place	Continuous	ST	-	130
NC 2200 5620	Kinlochbervie PS EO	Intermittent	6 mm screen	-	-
NC 2180 5640	Kinlochbervie Clash PS EO	Intermittent	6 mm screen	-	-
NC 2290 5658	Kinlochbervie Manse Rd PS EO	Intermittent	6 mm screen	-	-

PS – pumping station, EO – Emergency overflow, ST – septic tank and –no information provided

No information on consented discharges in the area was received from SEPA at the time that the 2008 report was finalised.

The Loch Inchard Shellfish Growing Waters (SGW) Report (SEPA 2011) identified a further four sewage assets in the Rhiconich area. Details of these four consented discharges are given in Table 2.3 and displayed in Figure 2.2.

Table 2.3 Discharges identified in SGW report for Loch Inchard

No.	Discharge Name	Type	NGR	Consent
1	Rhiconich Hotel	ST	NC 2545 5235	CAR/S/1015024
2	Rhiconich Police House and Public toilet block	ST	NC 2547 5242	CAR/R/1017728
3	Inchard House	ST	NC 2552 5266	CAR/R/1076947
4	Sutherland District Council	ST	NC 2545 5265	WPC/N/0051680

Of these, Numbers 1 and 2 were observed during the 2007 shoreline survey and Number 3 was observed in 2013. Number 4 was not identified during either shoreline survey. Other discharge-related observations made during the September 2007 survey included Kinlochbervie Harbour community ST as well as two pumping stations and six other ST, presumably private, not listed in Table 2.3. Sewage infrastructure observed during the 2013 survey is listed in Table 2.4, with the locations mapped in Figure 2.2. Further details of the 2013 survey observations can be found in the full Shoreline Survey Report in Appendix 2.

Table 2.4 Sewage discharge-related observations around Loch Inchard from the 2013 shoreline survey

No.	NGR	Description
1	NC 2217 5581	Container and manhole covered area at location marked on map as Kinlochbervie ST (Kinlochbervie harbour). No obvious outflow/discharge.
2	NC 2216 5590	Manhole cover
3	NC 2216 5594	Plastic lined pipe 50 cm diameter running in direction from septic tank. Run off from pipe with flow rate approximately 10ml/sec. No smell of sewage. Freshwater sample <1000 *E. coli* cfu/100 ml
4	NC 2200 5629	Septic tank marked on map - confined area, no access. No visible tank. Four locked metal trap doors for underground storage. Smell present, possibly sewage. No outflow or discharge visible.
5	NC 2233 5602	Pipe on shore running down below house. Pipe broken in places. Signs of historical flow. No flow at present.
6	NC 2355 5597	Location of ST marked on map, tank on private property, no access. Two access points evident from road, no pipes observed.
7	NC 2420 5572	Pipe flowing into watercourse prior to running under the road. Smell coming from watercourse, possibly sewage. Freshwater sample 150000 *E. coli* cfu/100 ml
8	NC 2547 5451	Two houses by road beside watercourse with septic tanks. No discharges visible.
9	NC 2544 5437	Three pipes protruding from below verge beside watercourse; running from direction of 4 houses above field. No flow from pipes at time of survey but historical evidence of flow. Sample taken below pipes. Width 1m. Depth 11cm. Flow 0.079m/sec. SD0.003. Freshwater sample 50 *E. coli* cfu/ 100ml
10	NC 2552 5265	Pipe running down straight to loch (low tide so pipe above water). No flow at present, Seawater sample taken beside pipe: 1700 *E. coli* cfu/100 ml. Steep rocky shore beside private residence so no further access.

Kinlochbervie Harbour ST was observed west of Rubha nan Eun. Number 4 is thought to relate to the location of the Kinlochbervie Bervie pumping station, which may be entirely underground. No outfall pipes were visible at either site. A large plastic lined pipe was observed on the west side of the harbour. A sample of the flow from the pipe returned a result <1000 *E. coli* MPN/100 ml suggesting that it did not have significant sewage content at the time.

In both the 2007 and 2013 shoreline surveys a ST was noted approximately 250 m northwest of reported Kinlochbervie Innis Place ST site. This is likely to be the actual location of the Innis Place septic tank, though this could not be confirmed.

The remaining observations related to private septic tanks and/or outlets. Pipes were noted east of Kinlochbervie Harbour, in Badcall, Achriesgill and east of Rhiconich, though most were dry at the time of the 2013 survey. The two outfall pipes discharging to the Allt Innis Sheadhairidh noted in the 2007 survey were not identified in 2013.

A water sample taken from the near the end of a discharge pipe to the Allt a Bhaid Choill in Badcall had a result of 150000 *E. coli* cfu/100 ml, indicating a high level of faecal contamination. This watercourse enters the loch approximately 500 m from Site 1.

A seawater sample was also taken adjacent to a dry pipe coming from a house east of Rhiconich. A high result of 1700 *E. coli* cfu/ 100 ml indicates significant faecal contamination in the vicinity of the pipe. This pipe corresponds to the location given for Inchard House in the 2011 Loch Inchard Shellfish Growing Water Report (SEPA, 2011). That report also identified three ST outfalls adjacent to the Rhiconich shoreline: these were referred to as Rhiconich Hotel, Rhiconich Police House & Public toilet block and Sutherland District Council.

Overall, the most significant sewage inputs to the area continue to be the community discharges in the vicinity of Kinlochbervie and Badcall. The discharge to the watercourse to the east of Site 1 may also contribute to the contamination at the eastern end of that site and the northern end of Site 2. The four private ST discharges at the southern end of the loch will also contribute significant levels of *E. coli* to the loch, which are expected to have a high impact upon the southern extent of Site 5.

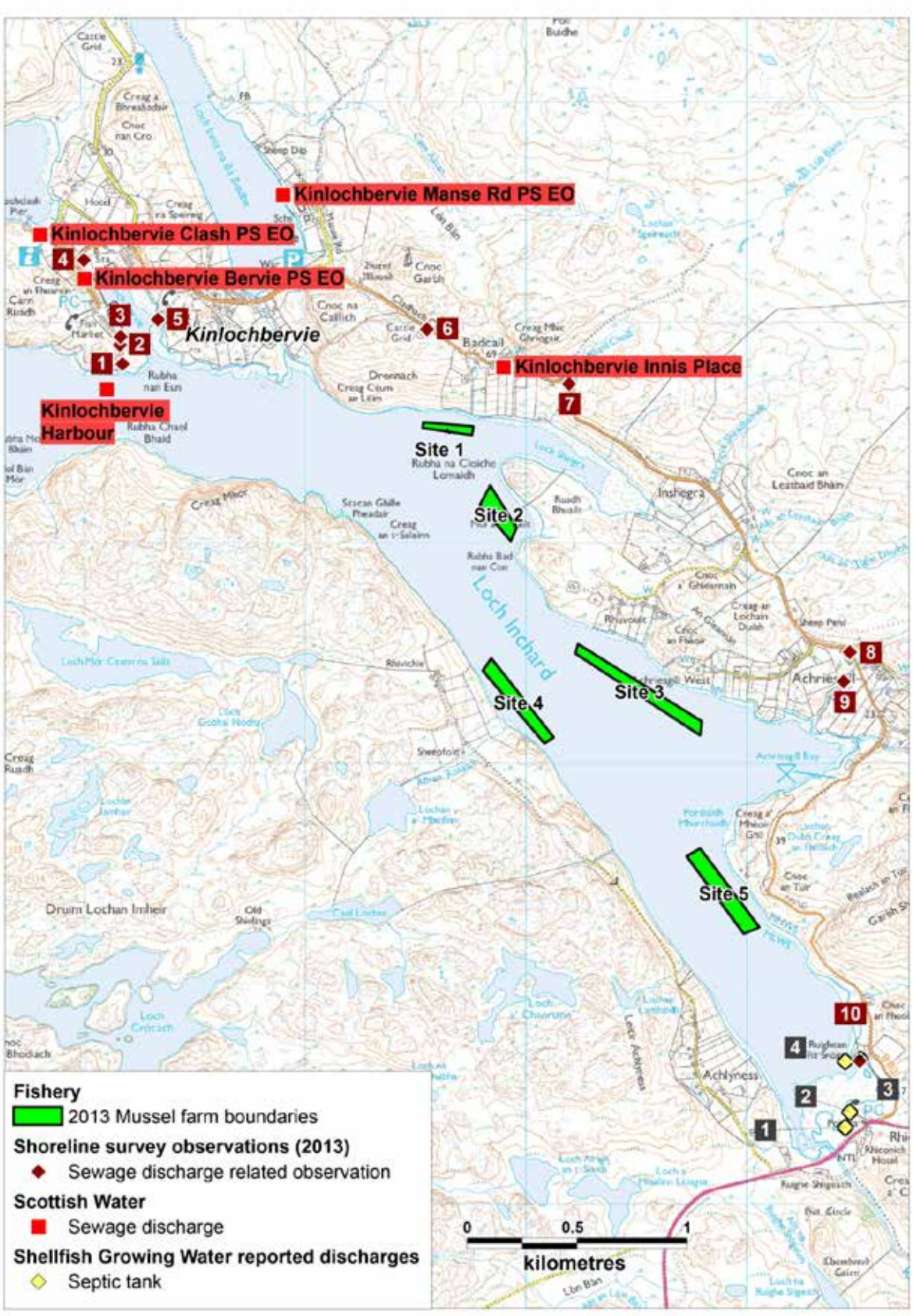

Figure 2.2 Map of original public sewage discharges and 2013 shoreline survey observations, in the vicinity of Loch Inchard

3. Livestock and Agriculture

The 2008 sanitary survey report for Loch Inchard identified that sheep were grazed on both sides of the loch, with a larger number of animals noted to be normally present on the south side of the loch (Rhivichie to Achlyness) than on the north side and mainly around the middle part of the loch.

Significant information on livestock mainly relates to that observed during the two shoreline surveys. Shoreline survey observation information relates specifically to the time of the surveys undertaken in September 2007 and on the 8th and 10th July 2013. Locations of animals observed during the 2013 survey are shown in Figure 3.1

During the September 2007 survey, 170 sheep were observed in total, with the majority seen along the east shore between Kinlochbervie and Achriesgill. Sheep were also present to the southwest at Achlyness and south at Rhiconich and were reported to graze much of the surrounding land. Conversations held with locals indicated a large number of sheep had been sent to market in the week prior to the survey, highlighting that the sheep populations changed with season.

During the 2013 survey, 87 sheep were observed in total, with the largest flock of 60 sheep seen in Achriesgill. Evidence of sheep (wool and droppings) was observed at Kinlochbervie and along the southwest shoreline. One grazing area was also noted in Kinlochbervie (north).

A simple, desk-based internet search found no additional information on farm practices or livestock numbers around Loch Inchard. A review of freely available satellite imagery (http://www.bing.com/maps/) showed sheep present on 5 fields at the farm at Rhivichie. These fields lie adjacent to the northern extent of Site 4. Sheep were seen at the southern end of the farm and on rough grazing further to the wouth during the 2007 shoreline survey, although no sheep were seen at this location during the 2013 shoreline survey.

Overall, farming practices appear not to have significantly changed, with extensive sheep rearing the main agricultural activity in the area. Fewer sheep were observed in the 2013 survey, though it remains unclear whether this reflects a decrease in the number of sheep reared in the area, spatial distribution with respect to observation points at the time of the surveys or seasonal differences between July and September. Livestock are associated with crofts in the area, mainly at Rhivichie (west of Site 4), Achriesgill (north of Site 3) and around the head of the loch (south of Site 5).

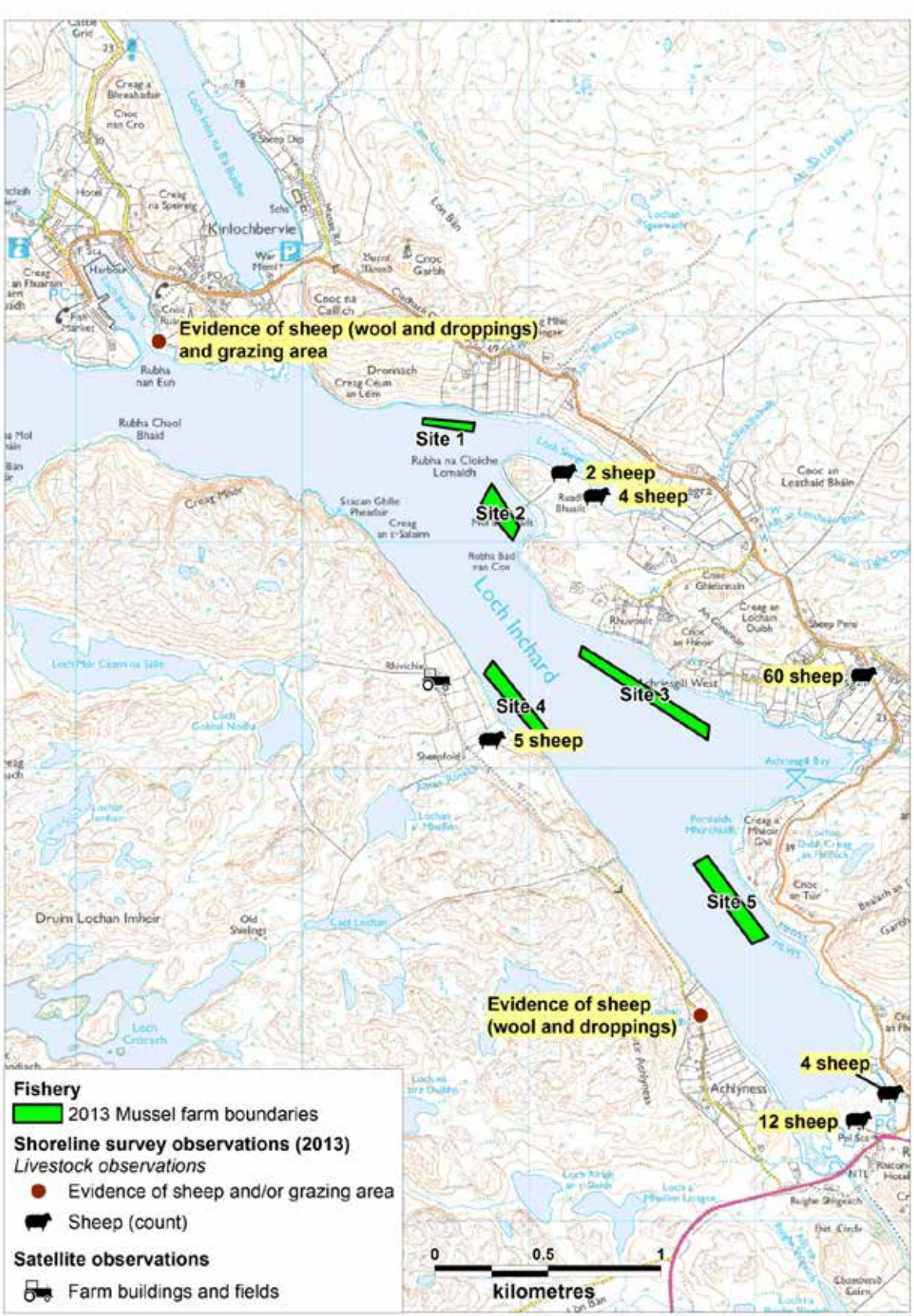

Figure 3.1 Map of farm animals and associated observations made during the 2013 shoreline survey

4. Wildlife

The 2008 sanitary survey report identified that there was little in the way of specific information on wildlife numbers present on and around the loch, with only a few birds and two seals seen during the shoreline survey.

Information on potential wildlife sources of faecal contamination has been obtained through surveys conducted in 2007 and 2013, and through a desk-based internet search undertaken for this review. Shoreline survey observation information only relates to the time of the surveys undertaken in September 2007 and on the 8th and 10th July 2013. Wildlife observations are displayed in Figure 4.1.

Seals

Two seals were observed in Kinlochbervie Harbour during the 2007 survey. None were seen during the 2013 survey. Seals are reported to be regularly seen in Kinlochbervie Harbour. There are also anecdotal accounts of seals around Rhiconich, at the head of Loch Inchard (http://www.rhiconichhotel.co.uk/Rhiconich_-_Wildlife.html).

In a report by the Sea Mammal Research Unit (SMRU) published in 2012, Cape Wrath (approximately 19 km northeast of Loch Inchard) was noted to support a significant colony of grey seals, with 100-150 seals observed, compared to just 10-50 harbour seals seen in the same area. Harbour seals and grey seal populations in the area are also reported to be in a stable condition. Grey seals may travel great distances (SCOS, 2012) and it is anticipated that they will use much of the west coast of Scotland, including Loch Inchard.

Cetaceans

No cetaceans were noted during the 2007 or the 2013 surveys. In the Loch Inchard Aquaculture Framework Plan (2001), it was stated that SNH had reported occasional sightings of porpoise, dolphins, and minke whales in Loch Inchard.

Seabirds

No birds were noted during the September 2007 shoreline survey. Seabird 2000 data for the northwest coast of Sutherland was presented in the 2008 report (Mitchell *et al*., 2004). Four records plotted at Loch Inchard. The first is a record for black guillemots on land that is noted as relating to survey subsite Kinlochbervie to Am Meal. The given coordinates plot in Kinlochbervie Harbour, though the actual location should be somewhere to the northwest of this location. The other three related to survey subsite Cnoc na h-Eannaiche within Loch Laxford and therefore are presumed to have been given incorrect coordinates.

Therefore, breeding seabirds are expected to have little impact on water quality within Loch Inchard.

The Loch Inchard Aquaculture Framework Plan (2001) identified that a large number of eider ducks visit the loch and that the large concentration of mussel farms would attract these birds to the area. However, it did not identify how many birds normally visit the area nor at what time of year.

During the 2013 shoreline survey, birds were the most common wildlife observed, with geese being most numerous. Other species included eider ducks, oystercatchers, sand pipers and mallard ducks.

Deer

No deer were noted during the 2007 shoreline survey. During the 2013 shoreline survey, two red deer were observed east of Kinlochbervie harbour. There are anecdotal accounts of red deer around Loch Inchard that inhabit the surrounding mountains during the summer and migrate to sea level during the winter (http://www.rhiconichhotel.co.uk/Rhiconich - Wildlife.html). Foinaven Special Area of Conservation (SAC), located at the head of Loch Inchard, supports red deer in its woodland areas (Dayton and O'Hanrahan, 2011). The report also highlighted that these deer migrated to the shoreline around Rhiconich from time to time.

Otters

Foinaven SAC is designated for important freshwater habitats and associated vegetation, but is also recognised as important for the Eurasian otter (*Lutra lutra*) (http://jncc.defra.gov.uk/protectedsites/sacselection/sac.asp?Eucode=UK0013141). Anecdotal accounts also highlight that otters use the Rhiconich area, in particular to build their holts (http://www.rhiconichhotel.co.uk/Rhiconich - Wildlife.html). No otters were observed during the 2007 or 2013 shoreline surveys and population data was not available at the time of writing this review.

Overall, impacts from wildlife-source faecal contamination are not expected to have changed significantly since the 2008 report. Relatively low numbers of birds were observed during the 2013 shoreline survey.

Deer are reported to be found around the loch, particularly around Rhiconich, and are expected to contribute to contamination levels in the water courses nearer the loch in winter, when they are present at lower altitudes. New information also highlights that otters may be present in suitable habitat around the head of the loch. However, this is not expected to lead to significant faecal contamination in the area. No individual site experienced higher contamination inputs from wildlife, than another.

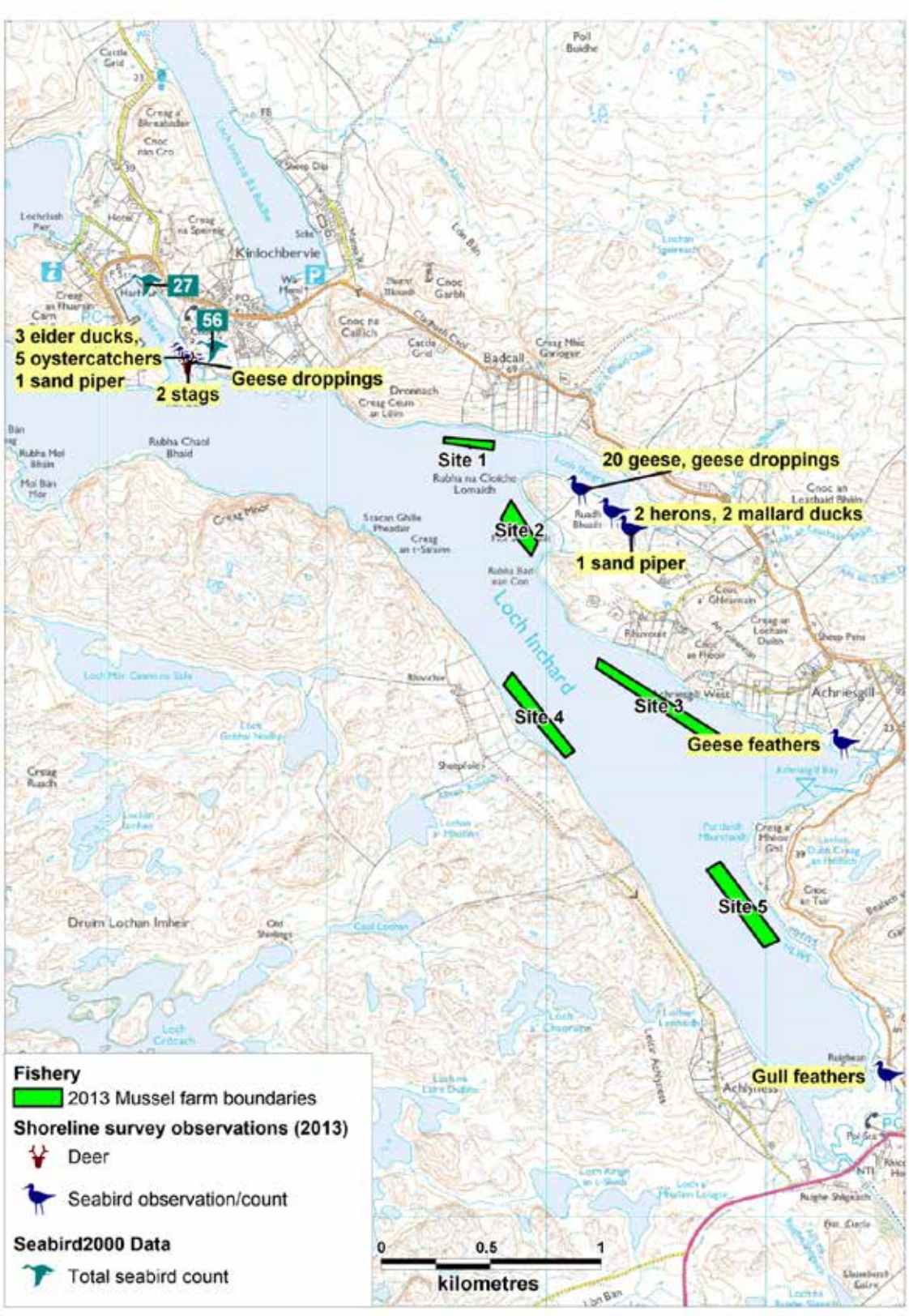

Figure 4.1 Map of wildlife around Loch Inchard, including observations made during the 2013 shoreline survey

5. Watercourses

There are no river gauging stations on watercourses discharging to Loch Inchard. Watercourse observations were made during the two shoreline survey periods, which occurred under slightly different weather conditions. The 2007 survey was undertaken in dry conditions, whilst light rain was recorded prior to the second survey day in 2013.

A comparison of watercourse loadings estimated on the basis of the 2007 and 2013 shoreline survey measurements and *E. coli* concentrations is shown in Table 5.1. Sample loadings calculated from the 2013 survey are displayed in Figure 5.1. In total nine watercourses were measured and sampled in the 2007 survey, eight of which were re-sampled in the 2013 survey. Five additional freshwater inputs were measured and sampled in the 2013 survey. A full list of recorded flow measurements and sample results from the full 2013 shoreline survey can be found in Appendix 2.

Table 5.1 Watercourse loadings to Loch Inchard taken during the 2007 and 2013 surveys

No.	Description	NGR	2007 Loading (*E. coli* / day)	2013 Loading (*E. coli* / day)
1	Unnamed Watercourse	NC 2233 5609	$<1.4x10^{7}$ *	$<4.3x10^{4}$*
2	Flow from Loch Innis na Ba Buidhe	NC 2291 5585	$7.2x10^{11}$	$1.3x10^{10}$
3	Allt a Bhaid Choill	NC 2420 5572	**	$8.4x10^{11}$
4	Unnamed Watercourse	NC 2440 5548	**	$<5.2x10^{4}$*
5	Altan na Lamhaidh	NC 2468 5305	**	$<3.4x10^{8}$*
6	Allt an Rosaich	NC 2390 5415	$<3.0x10^{9}$ *	$4.2x10^{7}$
7	Allt an Tighe Dubh	NC 2454 5513	$1.2x10^{10}$	$1.2x10^{8}$
8	Allt Innis Shreadhairidh	NC 2456 5518	$1.4x10^{10}$	$1.4x10^{8}$
9	Achriesgill Water (General's Loch)	NC 2557 5412	$<6.0x10^{11}$ *	$1.9x10^{10}$
10	Allt an Fheorain	NC 2544 5437	$<5.6x10^{10}$ *	$3.8x10^{8}$
11	Allt Ruidhean na Sroine	NC 2560 5256	**	$4.0x10^{10}$
12	Allt Glas	NC 2559 5253	**	$1.8x10^{10}$
13	Rhiconich River	NC 2546 5214	$<1.2x10^{12}$ *	$<2.8x10^{10}$ *
14	Allt na Ruighe Shligeich	NC 2520 5228	**	$9.3x10^{7}$
15	Unnamed Watercourse	NC 2434 5356	$<1.9x10^{8}$*	**

*where a sample result was reported as <100 *E. coli*, the loading is calculated using 100 *E. coli* and identified as a 'less than' value.

** Not recorded and/or sampled during the shoreline survey.

Loadings calculated from the 2007 shoreline survey measurements were higher for all watercourses that were re-sampled in the 2013 survey. During the 2007 shoreline survey, the flow from Loch Innis na Ba Buidhe had a significantly elevated loading. In 2013, this loading was an order of magnitude lower. Much of the difference is

attributable to the *E. coli* concentration, which was 500 E. coli cfu/100 ml in 2007 and 70 cfu/100 ml in 2013.

Loadings for the Rhiconich River and Achriesgill Water appeared high, but because the actual water sample result was below the limit of detection of the test used, the actual loading could have been anywhere between 0 and 1 below the number stated.

Comparison of loadings where results were below the limit of detection in both years can give an idea of the hydrological state of the watercourses at the time of sampling. Despite the recorded dry conditions in 2007, both unnamed watercourse No 1 and the Rhiconich River had considerably lower flows during the 2013 survey.

During the 2013 survey, these three watercourses were only shown to contain moderate loadings of contamination. The highest loading was shown to come from Allt a Bhaid Choill, which was not sampled during the 2007 survey. This watercourse was noted to have a pipe discharging suspected sewage effluent directly into the flow (see sewage discharge section for further details). This watercourse is located <500 m east of Site 1 and may therefore have a significant impact on the contamination levels on the eastern extent of the fishery.

Overall, contamination carried via watercourses is expected to impact principally on Site 1 and the southern end of Site 5 although the other sites may also be impacted to a lesser extent by local watercourses.

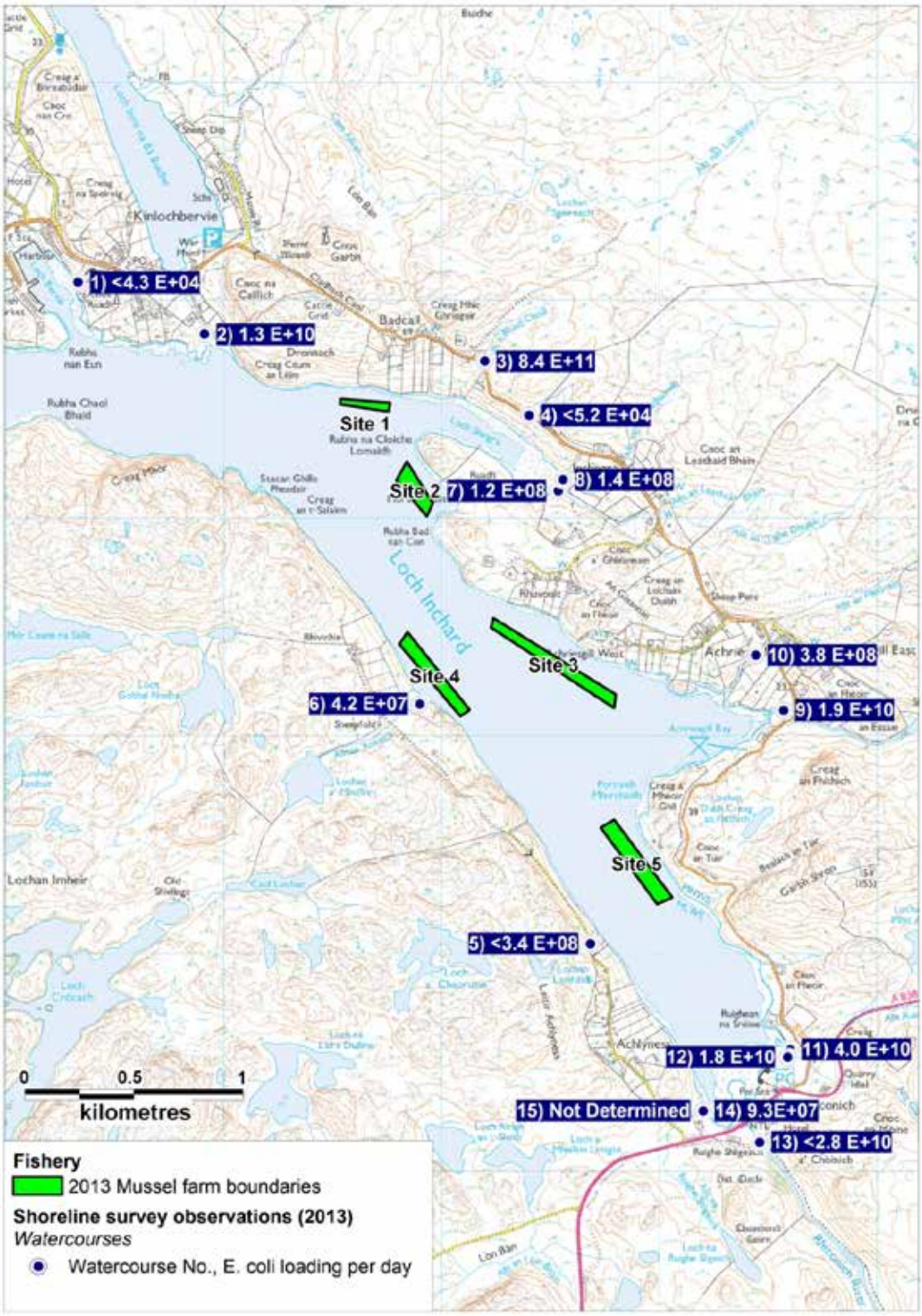

Figure 5.1 Watercourse loadings into Loch Inchard, measured during the 2013 shoreline survey

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 – 31/12/2007 for the analyses undertaken for the 2008 Loch Inchard Sanitary Survey Report: rainfall box-plots and wind roses for 2003-2007 period are presented in that report and have not been reproduced here.

Meteorological data for the Achfary weather station (15 km SSE of Loch Inchard) was purchased from the Meteorological Office in April 2013 for the period 01/01/2008 – 31/12/2012. Rainfall data from Achfary was available for 98% of the survey days.

Wind roses were taken from the Stornoway Airport weather station, which lies approximately 25 km west of the Loch Inchard production area.

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 and Morgan, 2003).

The Achfary weather station rainfall dataset for 2008-2012 is presented by year in Figure 6.1 and by month in Figure 6.2.

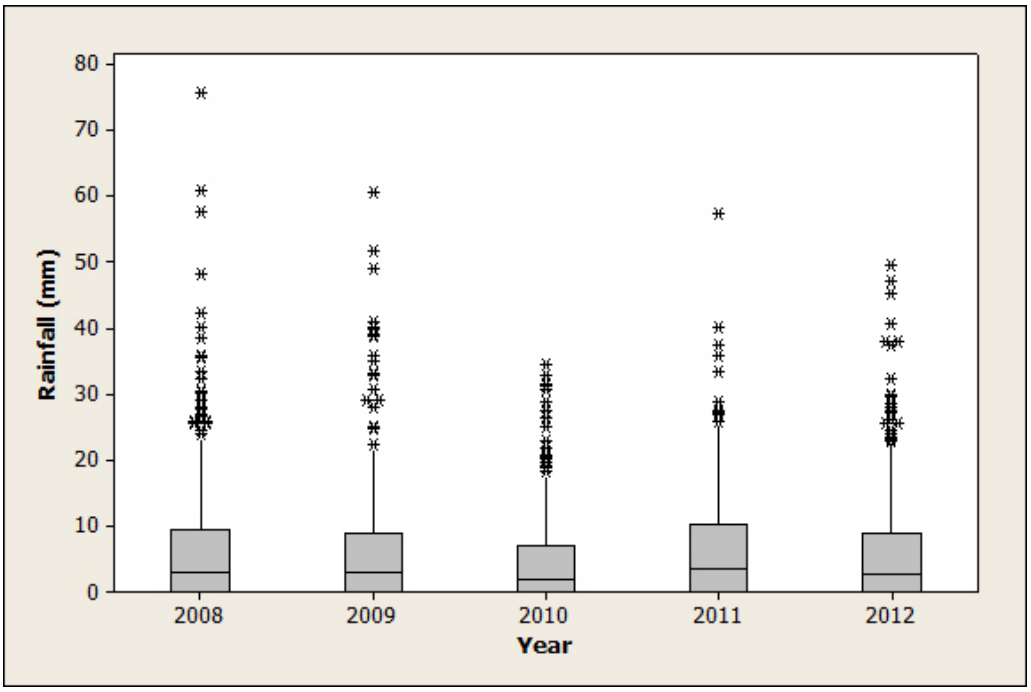

Figure 6.1 Boxplot of daily rainfall at Achfary by year (2008-2012)

The bulk of the observations are below 10 mm rainfall/day. In the period 2008-2012 there were both wetter and drier years than occurred during the previous period

2003-2007: 2011 was generally wetter and 2010 was drier. The number of rainfall events exceeding 50 mm/day occurred in all years, with an extreme rainfall event of greater than 70 mm/d seen in 2008.

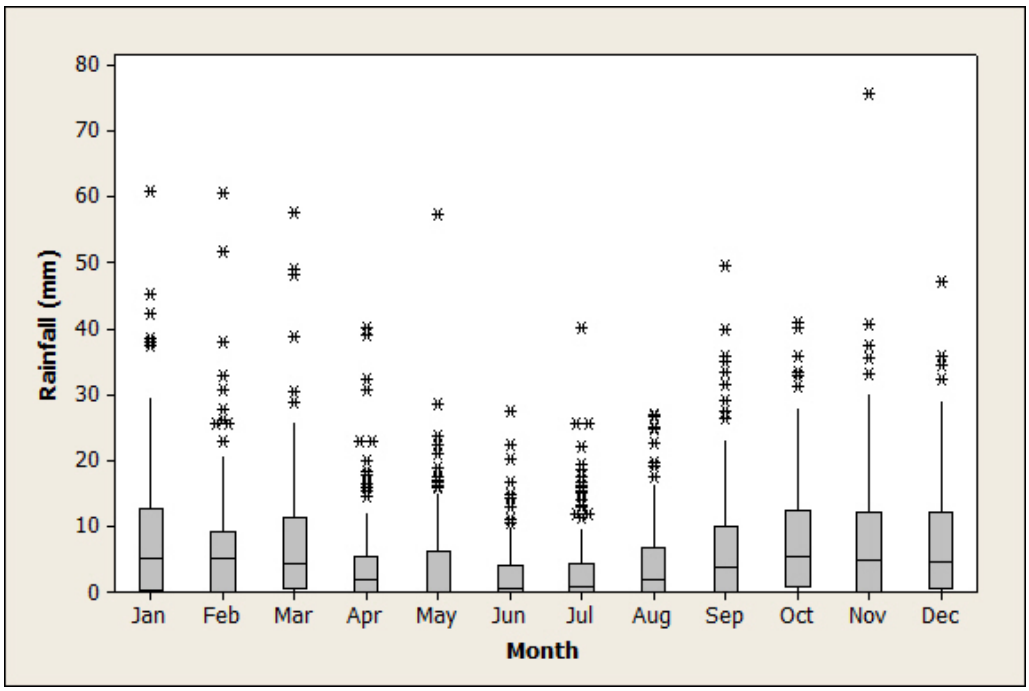

Figure 6.2 Boxplot of daily rainfall at Achfary by month (2008-2012)

Figure 6.2 presents a boxplot of daily rainfall values by month for the 2008-2012 dataset. The period 2003-2006 had shown a marked difference in rainfall with season, with September to January the wettest months and June and July the driest. A similar trend was seen in data from the period 2007-2012, with September to January and March representing the wettest months, and June and July the driest.

Rainfall events greater than 50 mm day were recorded in all months but June, July and December across the data set. Three events with greater than 70 mm rain/day occurred in April, August and October in the 2003-2007 dataset compared with only one, in November, in 2008-2012 dataset.

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 Airport for the period 2002-2011 while Figure 6.4 shows the annual wind rose for the same period. The local topography and direction of Loch Inchard is likely to cause a variation in wind patterns to those shown in the wind roses (Stornoway is on the east coast of the Outer Hebrides, whilst Loch Inchard is on the west coast of the mainland Scotland).

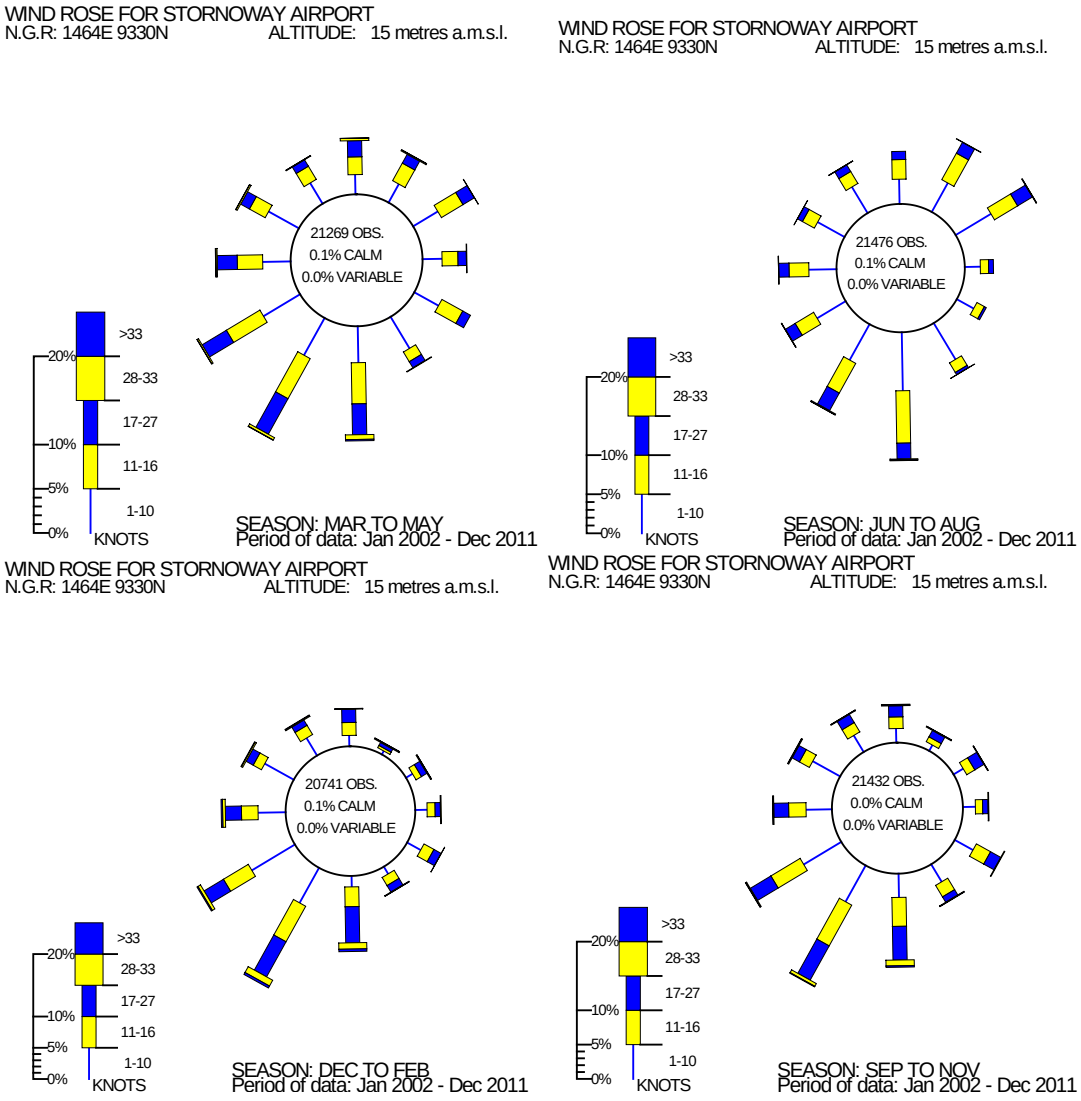

Figure 6.3 Seasonal wind roses for Stornoway Airport (2002-2011)

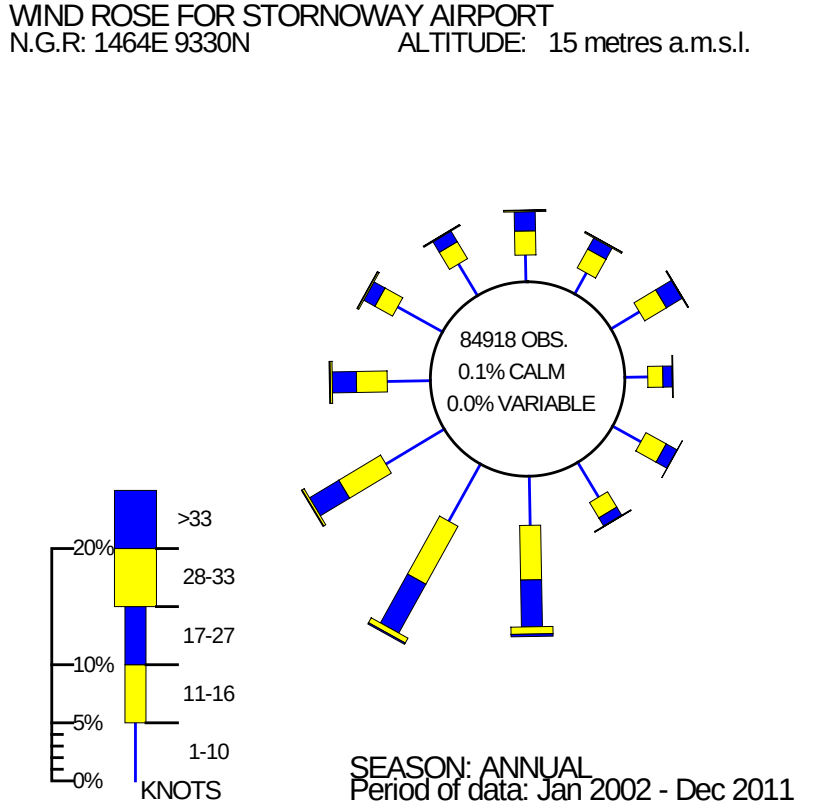

Figure 6.4 Annual wind rose for Stornoway Airport (2002-2011)

The wind rose in Figure 6.4 shows that the overall prevailing annual wind direction is from the south and west. Winds are generally lighter during the summer months and strongest in the winter, though strong southerly winds were also common in the summer months.

Loch Inchard is located on the west coast of northern mainland Scotland. The loch is mostly exposed to northwesterly winds, with the inner loch much more sheltered than the outer loch due to its orientation. Wind is likely to be responsible for driving currents in the loch, with the local hydrodynamics of the site also adding to this effect.

7. Historical *E. coli* Data

Results for all sites assigned against the Loch Inchard production area between 01/01/2008 and 27/06/2013 were extracted from the FSAS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. Data was extracted from the database in October 2013. Historical *E. coli* data used in the 2008 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 <20 were reassigned a value of 10 *E. coli* MPN /100 g for the purposes of statistical evaluation and graphical representation.

Of the initial 63 sample results returned, five were recorded as rejected and were omitted from further analysis. A further sample had no result recorded and was also omitted. Eighteen results from years 2010 and 2011 had NGRs recorded 18 km south of Loch Inchard at Loch Glencoul and one sample was recorded 5.8 km to the southwest of the production area. These 19 samples were omitted from the analyses. All remaining 38 samples arrived at the laboratory within 48 hours of collection and all except one sample had recorded box temperatures of <8^{o}C. Twelve samples had results of <20 *E. coli* MPN /100 g.

7.1 Summary of microbiological results

Summary results are displayed for the Loch Inchard production area in Table 7.1, with the classification history shown for Loch Inchard common mussel fisheries in Table 7.2.

Table 7.1 Sampling summary results for Loch Inchard common mussel fishery between 2001 and 2013

Sampling Summary				
Production area	Loch Inchard			
Site	Sites 1-5			
Species	common mussels			
SIN	HS-162			
Location	Various			
Years	2001-2007		2008-2013	
Total no. Of samples	99		38	
	2001	8	2008	8
	2002	13	2009	10
	2003	20	2010	5
	2004	23	2011	-
	2005	14	2012	7
	2006	12	2013	8
	2007	9		
Results Summary				
Minimum	<20		<20	
Maximum	5400		16000	
Median	40		35	
Geometric mean	48		56	
90 Percentile	500		800	
95 Percentile	1300		9540	
No. Exceeding 230/100g	15 (15%)		7 (18%)	
No. Exceeding 1000/100g	6 (6%)		3 (8%)	
No. Exceeding 4600/100g	1 (1%)		2 (5%)	
No. Exceeding 18000/100g	0		0	

Significantly more samples were taken between 2001 and 2007 than between 2008 and 2013. Until 2006, the sample location was rotated amongst the 5 mussel farms and in some cases two sites were sampled during the same month. In 2007, samples were taken from only two of the sites, with duplicate sampling occuring in one month. From 2008 onward, only one site was sampled in any given month. All samples taken in 2011 were omitted due to incorrect NGRs.

The maximum result observed during 2008-13 was higher than that observed during 2001-2007. Two results during the 2008-2013 period exceeded 4600 *E. coli* MPN /100 g compared to one during 2001-2007, despite the fact that markedly fewer samples were taken during the more recent period.

Table 7.2 Classification history for Loch Inchard common mussel fishery between 2008 and 2014

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

Classification at Loch Inchard has improved since 2008, with class A given for all months since 2012. In the past class B months have mostly been between September and December.

7.2 Geographical patterns of results

One sample taken in 2013 was identified in SHS as unverified and did not include NGR information; it was therefore not included in the geographical analysis. The remaining 37 samples are plotted below in Figure 7.1. Samples were attributed to Sites 1, 4 and 5. However, the grid references given plot at or near Sites 1 and 4 only. Samples appear to have been taken across much of the length of Site 1, with all samples recorded within 200 m of the current RMP (NC 2356 5547). Samples taken at Site 4 plotted within a 40 m radius of one other.

Samples taken at the current RMP were sampled between 2008 and 2010. Sampling was moved to Site 4 in 2012 due to a lack of mature stock at Site 1. All of these samples were attributed to Site 1 and ten of the samples taken at Site 1 prior to 2012 were attributed to Site 4. No samples have been taken at the 2008 recommended RMP (NC 2474 5415) or the at the nominal RMP assigned prior to the 2008 report.

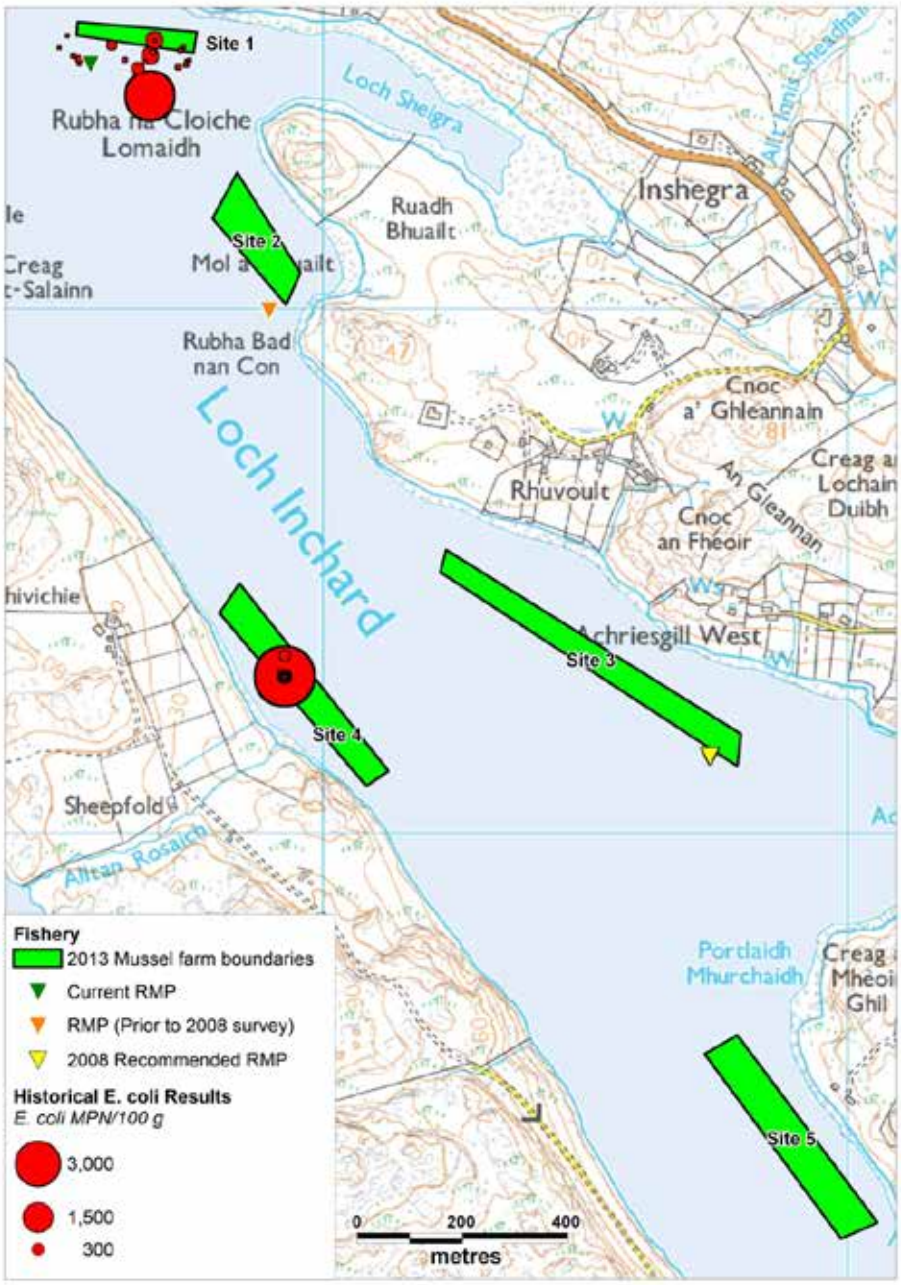

Figure 7.1 Sample results and locations of Loch Inchard common mussel fishery

Sample results at Site 4 ranged from <20 to 16000 *E. coli* MPN /100 g, whilst those at Site 1 ranged from <20 and 3500 *E. coli* MPN /100 g. The majority of samples (23) came from Site 1, while fewer samples (14) were taken at Site 4. The two locations were not sampled concurrently, however.

7.3 Temporal patterns of results

Temporal trends are displayed in Figure 7.2, followed by results from the statistical analyses.

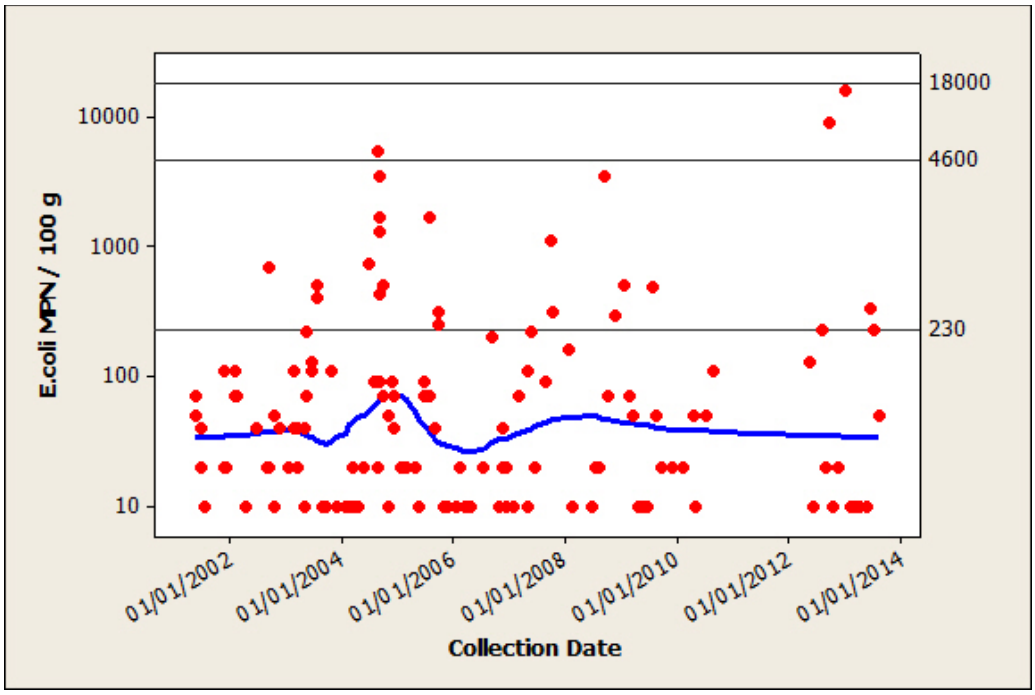

Figure 7.2 Scatterplot of common mussel *E. coli* results by date (2001-2013), with a lowess line

A comparison of *E. coli* results from all sites in Loch Inchard was undertaken for the periods 2001-2007 and 2008-2013.

The following statistical analyses were carried out on the statistical software package Minitab Version 15:

1. A two sample t-test (using $\log_{10}$ transformed *E. coli* data) to determine whether there was a statistically significant difference in average ($\log_{10}$-transformed) *E. coli* results between the two sampling periods.

2. A Chi-squared test, to test for significant difference in observed and expected *E. coli* results above 230 *E. coli* MPN /100 g from both periods.

3. A Fisher's Exact Test to test for significant difference in the observed and expected *E. coli* results above 1000 *E. coli* MPN /100 g from both periods. This was conducted because two cells had expected counts of less than five, thereby contraindicating use of the Chi-squared test.

No significant difference was found between Loch Inchard common mussel $\log_{10}$-transformed *E. coli* results from the two survey periods (Two sample t-test, t = -0.46, DF = 55, p = 0.645).

The number of results exceeding 230 and 1000 *E. coli* MPN /100 g is shown in Table 7.3.

Table 7.3 Number of results greater than and less than or equal to 230 *E. coli* MPN /100 g and greater than and less than or equal to 1000 *E. coli* MPN /100 g for Loch Inchard common mussel *E. coli* results

		***E. coli* MPN/100g**			***E. coli* MPN/100g**		
		≤230	>230	**Total**	≤1000	>1000	**Total**
2001-2007	Observed	84	15	99	93	6	99
2008-2013	Observed	31	7	38	35	3	38
	Total	115	22	137	128	9	137

No statistically significant difference was found in the proportion of results ≤230 *E. coli* MPN /100 g and >230 *E. coli* MPN /100 g between sampling periods (Chi-square test, $X^2 = 0.218$, DF = 1, p = 0.641).

No statistically significant difference was found in the proportion of results ≤1000 and >1000 *E. coli* MPN /100 g between sampling periods (Fisher's Exact Test, p = 0.707).

8. Movement of contaminants

The main conclusions of the 2008 sanitary survey report with respect to movement of contaminants were as follows:

- Tidal velocities were weak and therefore wind and density driven flows were expected to be the main contributors to net transport
- Low mixing is expected within the loch
- It is expected that where freshwater enters the loch, a freshwater stratified layer will sit as the top layer of the water column, until slowly mixed

No additional information was obtained to suggest any changes to what was reported in 2008 survey. The hydrographic analysis in the report identified that wind-driven circulation was likely to set up gyres or circulation cells within the loch, the likely result of which was that local sources would be most likely to have the greatest impact at each individual mussel farm which could operate in opposite directions depending on wind direction and strength. Freshwater inputs to the loch were predicted to create a persistent, generally seaward movement of surface water. Dilution calculations for the loch suggested that water quality across the entire loch could fail to meet standards sufficient to support A classification at times.

However, it is important to note that due to the paucity of recorded field data on water movement within Loch Inchard, the confidence level that can be ascribed to the analysis in the original survey is low.

9. Overall Assessment

This assessment considers the information obtained since the 2008 Report and the potential changes in extent and location of faecal contamination.

Human sewage Impacts

The resident human population was reported to have decreased significantly since 2008. Despite the overall reduction in population, four planning applications have been made since 2008, two of which had specific plans for private sewage discharges.

Spatially, these additional applications do not represent a significant change in the distribution of human population and potential sewage input around the loch. Site 1 lies nearest to the identified sewage discharges around Kinlochbervie. The eastern extent of Site 1 may also receive contamination from pipe observed discharging into Allt a Bhaid Choill (<500 m east of Site 1), though it lies some distance away. The watercourse near the outflow from this pipe was found to contain significant levels of faecal contamination (150000 *E. coli* cfu/100 ml). There are four discharges at the head of the loch, near Rhiconich. This area may also be subject to low mixing and it is therefore the southern extent of Site 5 may be impacted by these sources. Houses on private septic systems in Achriesgill are also expected to impact Site 3, which lies <700 m to the west of it.

Agricultural impacts

Sheep continue to be reared extensively on the land around Loch Inchard, though fewer animals were seen during the 2013 survey. It is not clear whether this represents an actual decrease in the numbers of livestock kept in the area, or the spatial distribution of the sheep visible to the surveyors on the survey days. Sheep are still concentrated around the crofted areas at Achriesgill and along the west shore from Rhivichie southward.

Wildlife Impacts

Information suggests that large numbers of eider ducks may be present around the mussel farms, but it is not clear how many or at what times of year. New information also highlights deer are likely to be a source of contamination along the southern shores at Rhiconich during the winter months and that otters may also be present at Rhiconich. However, no information on numbers of animals was available and the total likely impact is therefore unknown.

Seasonal Variation

The classification at Loch Inchard fishery is now class A year round. Seasonal variations are however likely in human population, with summer influxes of

tourists/anglers, and in livestock, as well as in rainfall. No information was found to suggest any change to the findings in the original survey report that there was significant seasonal variation in *E. coli* sampling results.

Watercourses

During the 2013 shoreline survey, the highest level of contamination associated with watercourses was from Allt a Bhaid Choill, located near Badcall, <500 m east of Site 1. Here a private discharge pipe was noted to enter the watercourse, which is expected to be a significant contributor to the high contamination loading of this watercourse. Other freshwater loadings were low-moderate, with a large number of inputs continuing to enter from the south around Rhiconich.

Movement of contaminants

No updated hydrographic information was found for Loch Inchard. It is therefore presumed that movement of contaminants remains largely the same.

Analysis of Results

Historical *E. coli* results

There has been considerable variation in sampling location, with sampling rotated around the five sites prior to 2008 and then taken from around Site 1 until 2012 when sampling was moved to Site 4. The site identified for each sample in the SHS record did not correspond with the NGR location. The two highest sample results were recorded at Site 4 in September 2012 and January 2013. The majority of results were <230 *E. coli* MPN/100 g. No statistically significant differences were found in $\log_{10}$ *E. coli* results between the two survey periods, nor in the proportion of results exceeding either 230 or 1000 *E. coli* MPN/100 g between the two periods.

Shoreline Survey results

Nine seawater samples were taken in total. Seawater samples taken at the mussel farms returned low results. Six of the nine samples had results between 0-5 *E. coli* cfu/100 ml. The highest seawater result (1700 *E. coli* cfu/100 ml) came from a sample taken adjacent to a pipe coming from Inchard House, near Rhiconich. One of the two other elevated samples (both at 200 *E. coli* cfu/100ml) came from Kinlochbervie Harbour and the other adjacent to four houses and associated ST at Rhiconich.

Eight common mussel samples were taken, with all returning low *E. coli* results (<100 *E. coli* MPN/100 g.). No samples were taken at Site 4. Results were slightly higher at Site 1 than at Sites 2, 3 or 5. There was no consistent variation in result with depth.

Conclusions

The conclusions from the 2008 Report indicated that the following were the main potential sources of faecal contamination to the fishery at Loch Inchard:

- Continuous discharges from Kinlochbervie Harbour ST and Kinlochbervie Innis Place ST which are expected to acutely impact Sites 1 and 3 (presently sites 1 and 2)
- Private discharges from outfalls at Rhiconich and from a B&B in Inshegra
- Land runoff associated with sheep reared on the land, particularly during the spring-summer lambing season
- Freshwater inputs, in particular from those feeding into Kinlochbervie harbour and one into Loch Sheigra (east shore at Inshegra). Allt an Rosaich was also a potentially important input source to Site 2 (presently Site 4)
- Low mixing within the loch

The 2013 survey has found two additional private septic tanks associated with planning permits on the north side of the loch, as well as:

- A pipe discharging to Allt a Bhaid Choill that was found to contain significant faecal contamination.
- A possible additional outfall at the head of the loch near Rhiconich that was listed in the shellfish growing water site report, though not seen on the shore.
- At the time of the 2013 shoreline survey, Allt a Bhaid Choill posed the most significant freshwater contamination input.

Agricultural sources of faecal contamination have remained essentially the same, though a smaller number of livestock were recorded during the second shoreline survey.

Sampling has been variable, and no sampling was undertaken at the RMP recommended after the sanitary survey. A review of all information, including the most recent sampling results, suggests that the recommended RMP should be relocated to the western end of Site 1 in order to better reflect the risk from human-source contamination sources at the northern end of the loch.

10. Recommendations

This review has found a slight change to the assessment of spatial distribution of faecal contamination sources entering into Loch Inchard. Recommended changes are summarised below. The recommended RMP is shown together with the mussel farm locations and production area in Figure 10.1

Production area

No changes are recommended to the production area boundaries identified by the 2008 report, and as currently identified in the classification document. This is the area bounded by lines drawn between NC 2317 5562 and NC 2306 5522 and between NC 2400 5555 and NC 2400 5538 and between NC 2500 5428 and NC 2500 5381 and between 2482 5298 and NC 2525 5318 extending to MHWS.

RMP

It is recommended that, in order to better reflect the risk from human-source contamination sources at the northern end of the loch, the RMP be relocated to NC 2375 5552. This lies nearer to septic tanks and watercourses at Badcall and Inshegra.

Tolerance

The recommended sampling tolerance should be amended to 40 metres to allow for some movement of the mussel lines. It is further recommended that bagged shellfish be placed at the sampling location to ensure that stock of suitable maturity for sampling is consistently available within the tolerance zone. Shellfish used for this purpose should be in place for at least 14 days prior to sampling to ensure that they reflect water quality at the RMP.

Depth

It is recommended that the sampling depth at this location be amended to 1 metre to reflect contamination sources that are likely to be more concentrated in the surface layer.

Frequency

Monthly

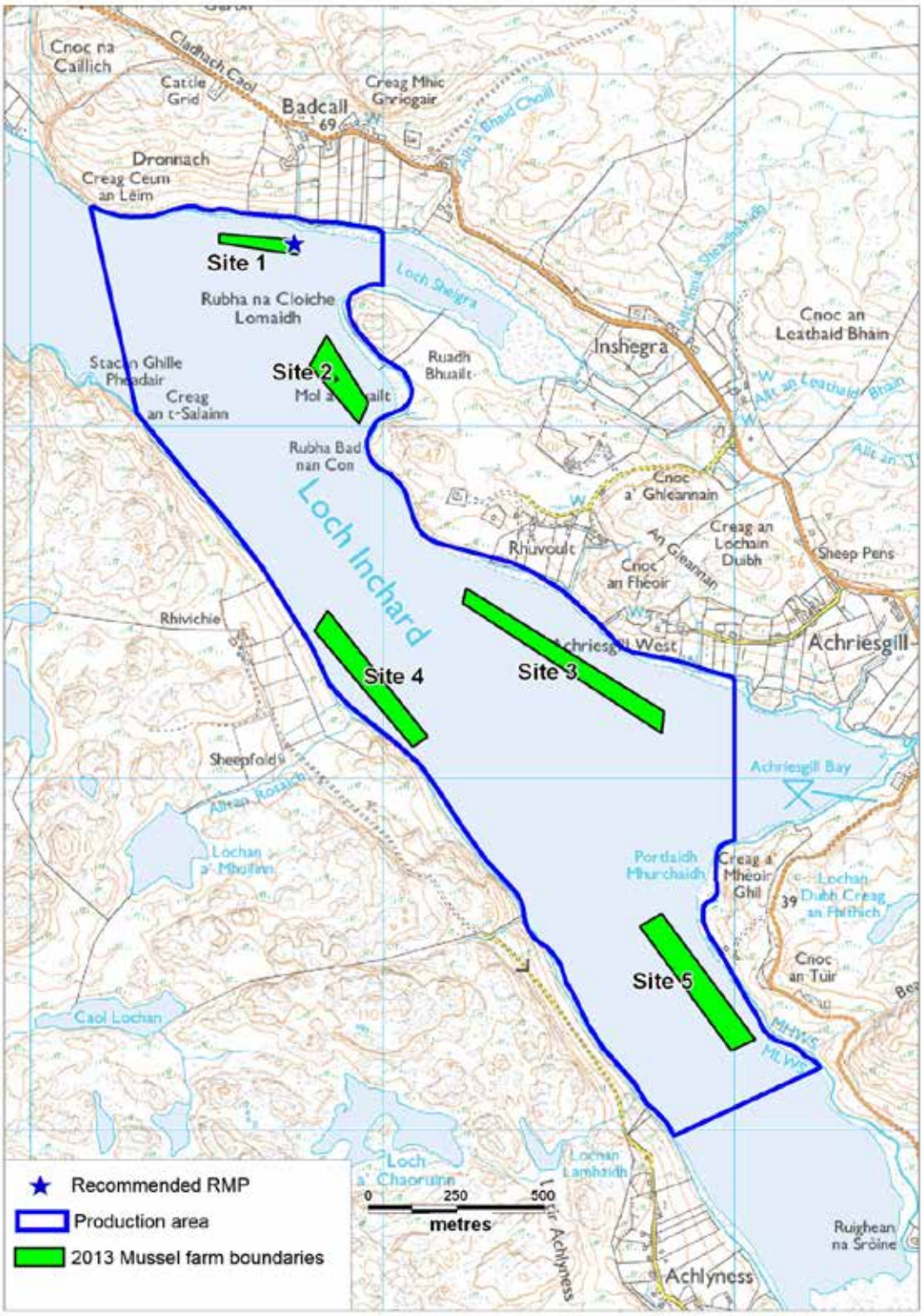

Figure 10.1 Recommendations for Loch Inchard

11. References

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12. List of Figures and Tables

Appendices

1. List of planning applications
2. Shoreline Survey Report 2013

Appendix 1 Planning Applications

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

Table 1 Planning applications to areas Kinlochbervie and Achriesgill respectively

Area	Date	Ref no.	Description	Location
Kinlochbervie	Sep 2013	13/03343/FUL	To site a residential caravan. Connecting to public drainage network	Land 30M North Of Free Church Kinlochbervie
	Mar 2010	10/01194/PIP	Proposed private 5 apt. dwelling house providing accommodation for proprietors. Connecting to public drainage network and public sewer	Land North Of Kinlochbervie Hotel Kinlochbervie
Achriesgill	Aug 2011	11/03070/MSC	Erection of house & garage (re-submission for amended design); installation of private sewage treatment system. Septic Tank or Treatment Plant discharging to land soakaway, both located outwith site curtilage with landowners consent; percolation value submitted with outline planning application	Land East Of 96 Achriesgill Rhiconich Lairg
	Sep 2009	09/00391/FULSU	Erection of house & garage, installation of private foul drainage system & upgrade of existing access (Detail)	Land Between 110 And 111 Rhuvoult Rhiconich Lairg

Appendix 2 Shoreline Survey Report

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

Document Number	B0067_Shoreline 0015

Revision History

Revision	Changes	Date
A	Issue for internal review	18/07/2013
01	First formal issue to CEFAS	02/08/2013
02	Second issue to CEFAS incorporating comments at Rev 01	20/08/2013
03	Clarification on harvester supplied information	22/08/2013

	Name & Position	Date
Author	Colin Abernethy	15/07/2013
Checked	Andrea Veszelovszki	22/08/2013
Approved	John Hausrath	22/08/2013

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

Shoreline Survey Report

Production area:	Loch Inchard	
Site name:	Loch Inchard sites 1-5	
SIN:	Site 1 - D. Ross	HS-162-311-08,
	Site 2 - J. Ross	HS-162-312-08,
	Site 3 - J. Ross	HS-162-314-08,
	Site 4 - N. Ross	HS-162-313-08
	Site 5 - D. Forbes	HS-162-315-08
Species:	Common Mussels	
Harvester:	John Ross	
Local Authority:	Highland Council: Sutherland	
Status:	Existing Area	
Date Surveyed:	8th and 10th July 2013	
Surveyed by:	Debra Brennan, Colin Abernethy	
Existing RMP:	NC 2356 5547	

Area Surveyed: Four separate areas around the shoreline of the loch were surveyed over two days: (1) The shoreline surrounding Kinlochbervie harbour; (2) The south and eastern shoreline of Loch Sheigra (Inshegra Bay) west of Inshegra; (3) The north-eastern shoreline of Achriesgill Bay and the watercourse which runs down to it south-west from the road at Achriesgill; (4) The south-western shore of Loch Inchard at Rhiconich, including Rhiconich River.

Weather

There was no rainfall recorded in the 48 hours prior to the survey.

08/07/2013:

At the start of the survey there was a 1.29 metres per second (m/s) south-easterly wind with a temperature of 13°C. Sea state 1(calm, rippled). Cloud cover was 100% for entirety of survey period with it clearing to 30% with sunshine later in the day.

10/07/2013:

There was light precipitation from about 14:00 on the previous day, which was intermittent throughout the day, until around 22:00. At the start of the survey there was a 2.19m/s south wind with a temperature of 11°C.

Sea state 0, (flat calm, glassy). Cloud cover was around 85% for the survey period.

Stakeholder engagement during the survey

Both the harvester (site manager) Mr John Ross and sampling officer (Mrs Anne Grant) were very helpful and cooperative during pre-survey arrangements. The harvester's representative (Mr Alex Ross) who took the survey team to the mussel farm on the Monday morning was also very co-operative and helpful both with sampling and with providing additional information on the fishery and surrounding area.

Fishery

There are five sites based on Loch Inchard all cultivating common mussels (Mytilus edulis).The sites are owned by different stakeholders. Two are owned by Mr John Ross (Site 2 and 3) and he manages the three remaining sites which belong to local crofters. Two of the sites are at the mouth of Inshegra Bay, two sites just north-west of Achriesgill bay, and one site lying north of Rhiconich at the mouth of the bay. The mussels are grown on long lines. Mr Ross provided information on the extent of the five sites after the survey, based on measurements he had taken just prior to the survey.

The sampling officer Anne Grant informed us that the loch had been closed earlier in the year for paralytic shellfish poisoning(PSP), due to harmful algal bloom. The loch was open at the time of the survey.

Sewage Sources

There are two public septic tanks in the survey area, one in Kinlochbervie harbour and one on the road north of Inshegra Bay. The land surrounding Loch Inchard is sparsely populated with private residences using septic tanks. During the survey, pipes were found at five locations:

50cm pipe running from a septic tank (Kinlochbervie harbour) at NC 22164 55937 (waypoint 29 and Figure 6),

A pipe on the shore below a house with signs of historical flow at NC 22333 56015 (waypoint 37 and Figure 10),

A pipe flowing into a watercourse at NC 24198 55723 (waypoint 44 and Figure 13),

Three pipes directed into a water course, running from the direction of four houses above at NC 25442 54373 (waypoint 66 and Figure 16),

A pipe running straight into the loch (Inchard) at NC 25515 52652 (waypoint 71 and Figure 18).

Seasonal Population

The majority of the residences surrounding Loch Inchard are crofts (with much of the land used for grazing of animals), or provide housing near the harbour for fishermen. There is a hotel just north of the Kinlochbervie harbour and a B&B to the east of the harbour. There is a hotel at Rhiconich, and a holiday home situated just north-east of the hotel.

Holiday accommodation will exhibit a seasonal flux in the area, with an increase in visitors likely to coincide with the start of the angling season. Through conversations with a local hotel proprietor it was established that the area was very popular with anglers from March to October, with the majority of their guests being anglers in that season.

Boats/Shipping

Twenty-one boats were seen moored around the harbour at Kinlochbervie; these were a mixture of fishing and pleasure vessels of varying sizes. No other vessels were encountered during the survey.

Farming and Livestock

The only livestock encountered during the survey were sheep. They were observed at several locations during the survey, with the majority encountered at farmland at Achriesgill, close to a watercourse running down into the Loch.

A cattle grid was observed approximately 1km north of the harbour at Kinlochbervie, and one about 0.4km north-west of Badcall. No evidence of cattle was found during the survey.

Land Use

The majority of the land around Loch Inchard is utilised for grazing of animals. There are croft houses sporadically surrounding the loch, with accommodation and services in Kinlochbervie surrounding the harbour.

Land Cover

The land cover surrounding large areas of Loch Inchard is steep grassy banks leading down to a rocky shoreline. There are hills to the north and south of Loch Inchard, with several small lochs.

Watercourses

Thirteen watercourses were observed entering Loch Inchard during the survey, all of which were flowing and sampled.

The larger watercourses were:

Achriesgill River (entering the most eastern point of Achriesgill Bay), WPs 60 & 61. A fast running river, 10m wide,

Allt na Ruidhean na Sroine, WPs 72 & 73, 15m wide,

Allt Glas, WPs 75 & 76, 17m wide,

The Rhiconich river (entering the bay at Rhiconich), WPs 80 & 81, 15m wide.

With the remaining being quite smaller:

Loch Innis na ba buidhe (east of Kinlochbervie harbour), Waypoints (WP) 40 & 41, 2.5m wide,

Allt a bhaid choill (south-east of Badcall), WPs 43 & 44, 0.5m wide,

An unnamed watercourse north-west of Inshegra, WPs 45 & 46, 0.4m wide,

Allt Innis Shead, WPs 56 & 57, 2m wide,

Allt an Tighe Dubh (east of Inshegra and entering into Inshegra Bay), WPs 58 & 59, 0.7m wide,

Allt an Fheorain (running down through farmland in Achriesgill to Loch Inchard), WPs 65 & 66, 1m wide,

Allt na Ruighe Shligeich which joins with the Rhiconich river on its western bank before entering Loch Inchard, WPs 82, 83 & 84, 0.4m wide,

Altan na Lamhaidh, WPs 47 & 48, 1m wide,

Alltan Rosaich WPs 51 & 52 on the western side of the Loch at 1.5m wide.

Wildlife/Birds

Several species of birds were noted over the two days including Eider ducks, Oyster catchers, Common Sand Pipers, pink footed geese and Mallard ducks.

Two stags were also seen east of Kinlochbervie harbour.

Shoreline Survey Maps

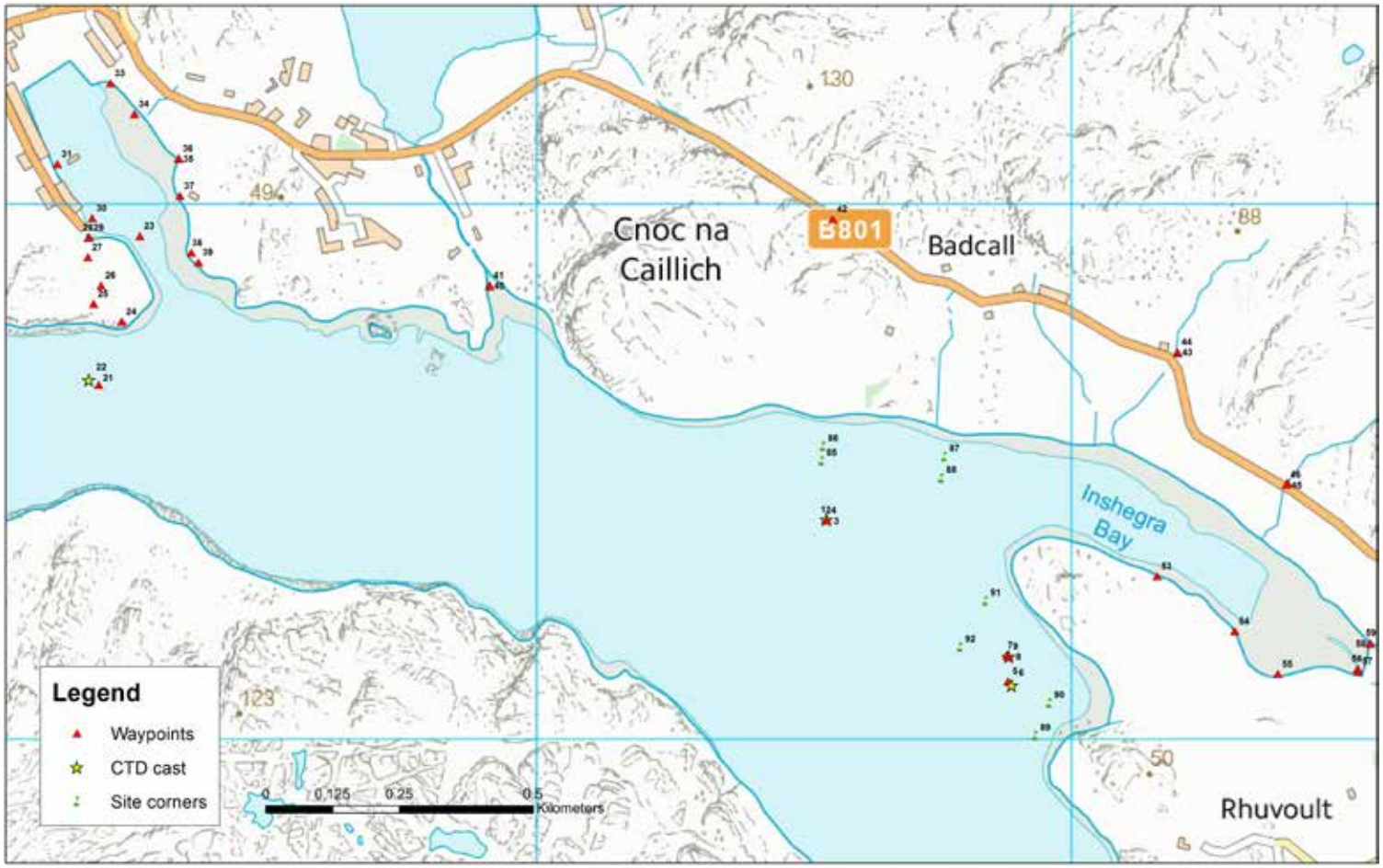

Figure 1. Loch Inchard Waypoints - north.

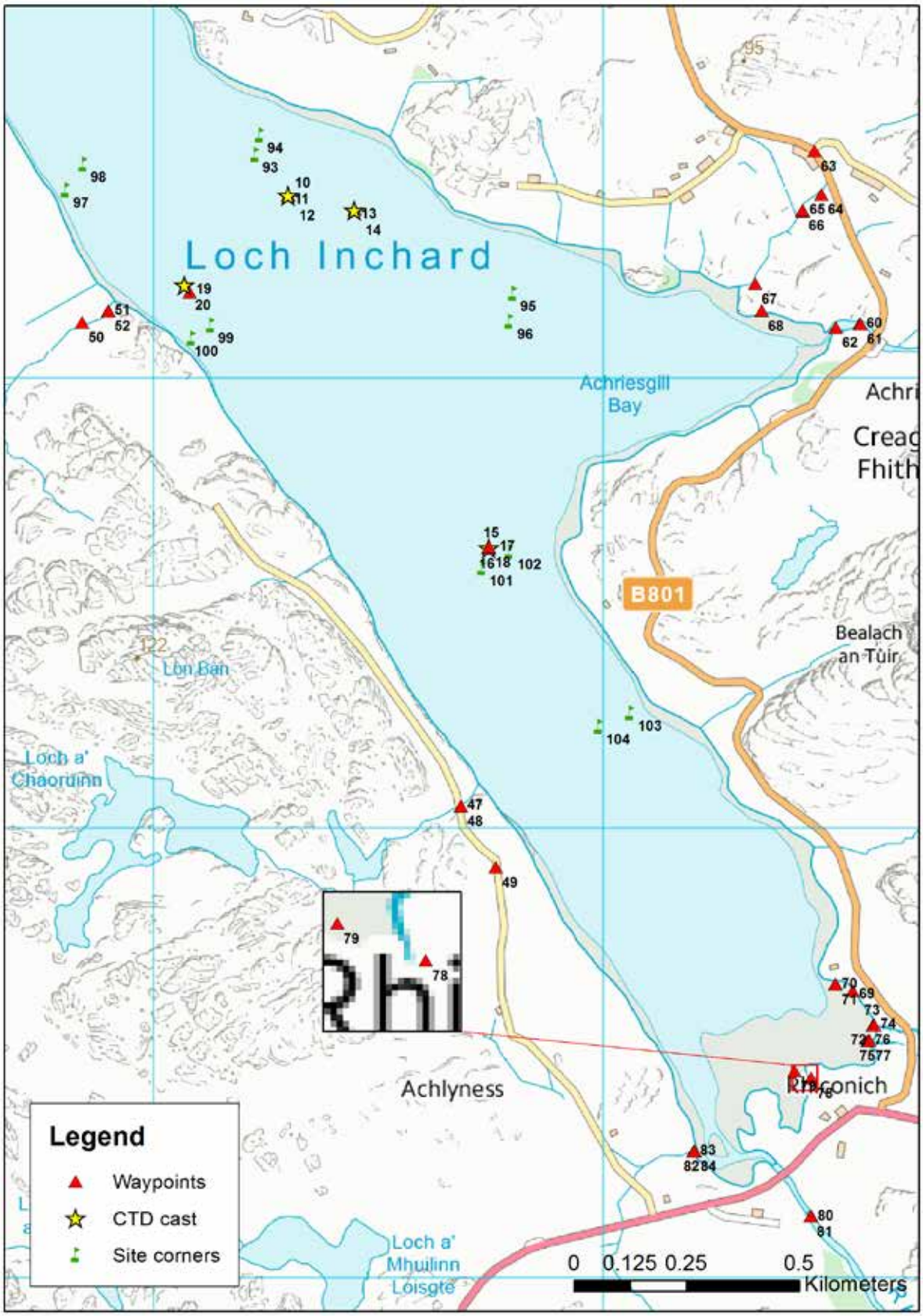

Figure 2. Loch Inchard Waypoints - south

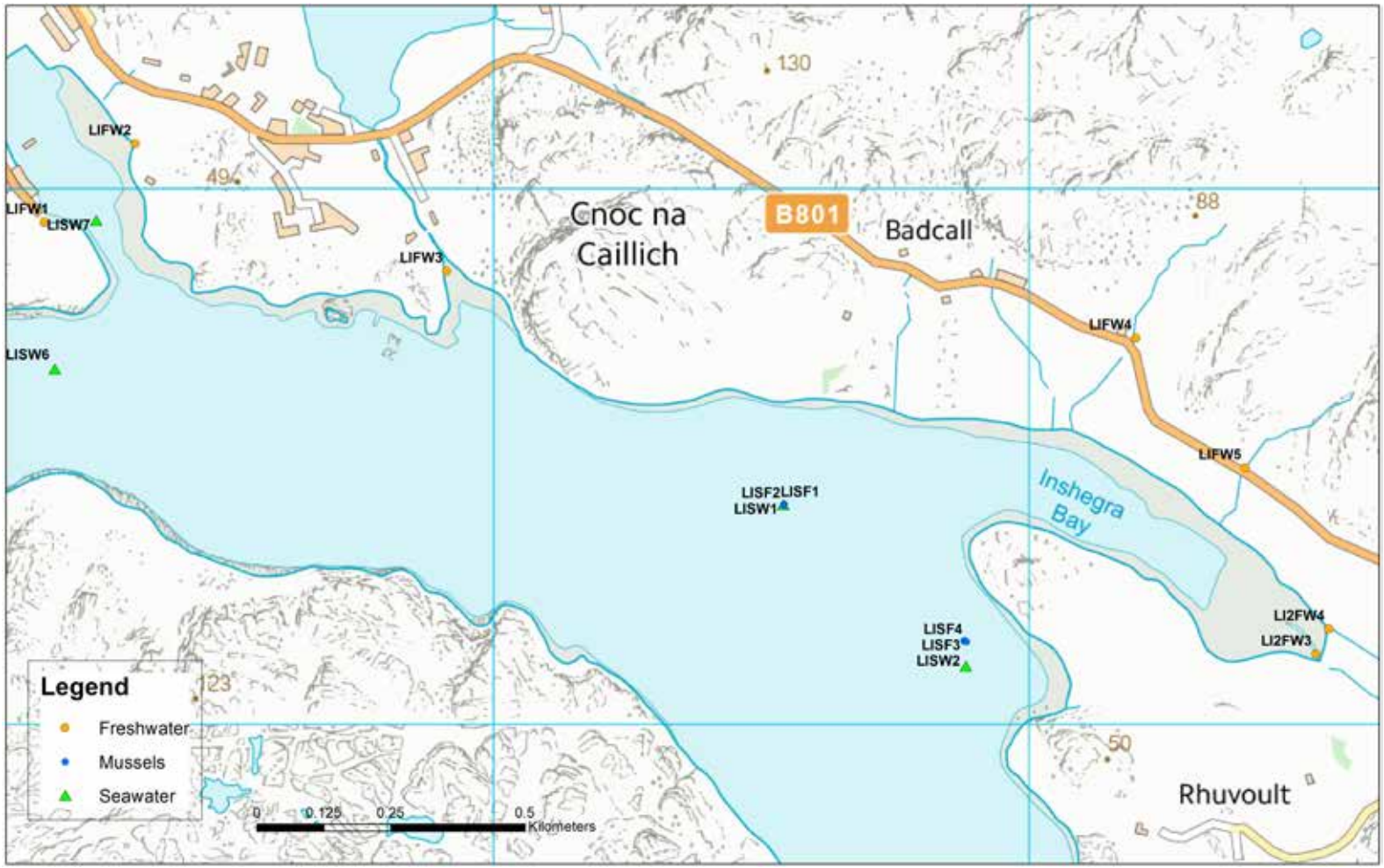

Figure 3. Loch Inchard Samples - north

Figure 4. Map 2 of Loch Inchard samples

Table 1 Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	08/07/2013	8:46	NC 23542 55411	223542	955411		LISF1	Shellfish sample.
2	08/07/2013	8:48	NC 23541 55410	223541	955410		LISW1	Planned seawater sample.
3	08/07/2013	8:53	NC 23541 55410	223542	955411			CTD cast 1.
4	08/07/2013	8:55	NC 23542 55409	223542	955409		LISF2	Shellfish sample.
5	08/07/2013	8:59	NC 23881 55108	223882	955109		LISW2	Planned seawater sample.
6	08/07/2013	9:00	NC 23887 55100	223888	955101			No sample taken, no surface mussels.
7	08/07/2013	9:01	NC 23878 55157	223879	955157		LISF3	Shellfish sample.
8	08/07/2013	9:03	NC 23882 55154	223882	955155			CTD cast 2.
9	08/07/2013	9:06	NC 23882 55155	223882	955155		LISF4	Shellfish sample.
10	08/07/2013	9:15	NC 24300 54406	224300	954406		LISW3	Planned seawater sample.
11	08/07/2013	9:15	NC 24299 54406	224299	954407		LISF5	Shellfish sample.
12	08/07/2013	9:17	NC 24299 54406	224300	954406			CTD cast 3.
13	08/07/2013	9:25	NC 24447 54375	224448	954375		LISF6	Shellfish sample.
14	08/07/2013	9:27	NC 24446 54373	224447	954373			CTD cast 4.
15	08/07/2013	9:33	NC 24745 53622	224746	953623		LISW4	Planned seawater sample.
16	08/07/2013	9:35	NC 24744 53622	224745	953622		LISF7	Shellfish sample.
17	08/07/2013	9:35	NC 24745 53622	224745	953623			CTD cast 5.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
18	08/07/2013	9:38	NC 24745 53625	224745	953625		LISF8	Shellfish Sample.
19	08/07/2013	9:50	NC 24080 54191	224080	954192		LISW5	Planned seawater sample.
20	08/07/2013	9:50	NC 24069 54206	224069	954206			CTD cast 6.
21	08/07/2013	10:07	NC 22181 55663	222181	955663		LISW6	Planned seawater sample.
22	08/07/2013	10:08	NC 22162 55671	222163	955671			CTD cast 7.
23	08/07/2013	10:12	NC 22258 55940	222258	955941		LISW7	Planned seawater sample.
24	08/07/2013	10:47	NC 22224 55780	222225	955781			Start of shore survey. Helipad area, restricted, no access. Shoreline steep and very rocky.
25	08/07/2013	10:53	NC 22171 55813	222172	955814	Figure 5		Container and manhole covered area at location marked on map as Kinlochbervie septic tank (Kinlochbervie harbour). No obvious outflow/discharge.
26	08/07/2013	10:56	NC 22185 55848	222185	955848			Oil drum containers close to slipway with release valve beside them.
27	08/07/2013	10:58	NC 22161 55900	222161	955901			Manhole cover.
28	08/07/2013	11:01	NC 22161 55937	222162	955938		LIFW1	Planned freshwater sample, associated with Waypoint 29.
29	08/07/2013	11:01	NC 22164 55937	222164	955938	Figure 6		Plastic lined pipe 50cm diameter running in direction from septic tank. Run off from pipe with flow rate approximately 10ml/sec, calculated using graduated sample container and wrist watch. Flow rate estimated due to sampling point being unsuitable for flow meter use. No smell of sewage.
30	08/07/2013	11:07	NC 22168 55974	222169	955974	Figure 7		On western side of pier, 13 boats of varying use and size moored (a mix of fishing and pleasure). No outflow pipes visible around this area.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
31	08/07/2013	11:11	NC 22104 56075	222104	956075			Eastern side of pier: 8 boats moored both fishing and pleasure vessels.
32	08/07/2013	11:19	NC 21996 56285	221997	956285	Figure 8		Septic tank marked on map (confined area, no access). No visible tank. Four locked metal trap doors for underground storage. Smell present, possibly sewage. No outflow or discharge visible.
33	08/07/2013	11:28	NC 22203 56225	222203	956226			Three houses above shore, no obvious outflow pipes from them which would have been evident due to low tide.
34	08/07/2013	11:31	NC 22247 56168	222248	956169			Common mussel shells on beach.
35	08/07/2013	11:34	NC 22331 56084	222332	956084		LIFW2	Planned freshwater sample , associated with waypoint.
36	08/07/2013	11:34	NC 22330 56085	222331	956086	Figure 9		Watercourse filled with seaweed and debris. Small flow entering stagnant pool on shore. White oily substance in pool. Depth 1cm. Width 0.5m 5ml/second approximate flow calculated using graduated sample container and wrist watch. Flow rate estimated due to sampling point being unsuitable for flow meter use.
37	08/07/2013	11:39	NC 22333 56015	222333	956016	Figure 10		Pipe on shore running down below house. Pipe broken in places. Signs of historical flow, through water marks on the pipe. No flow present at time of survey.
38	08/07/2013	11:43	NC 22354 55909	222354	955909			Three eider ducks, five oyster catchers and one common sand piper; all on the loch.
39	08/07/2013	11:44	NC 22367 55891	222368	955891			Goose droppings on grass above shore. Rocky, steep shore with barbed wire fence above it marking boundary of grazing land. Evidence of sheep via wool and droppings on ground. Two stags on nearby hill.
40	08/07/2013	12:05	NC 22912 55846	222913	955847		LIFW3	Planned freshwater sample associated with waypoint 41.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
41	08/07/2013	12:06	NC 22911 55848	222912	955848	Figure 11		Fast running watercourse with broken pipe lying beside it. 2.5m width. Depth 32cm. Flow rate 0.260 m/sec, SD 0.017
42	08/07/2013	13:10	NC 23553 55972	223554	955972	Figure 12		Location of Septic tank marked on map, tank on private property, no access. Two access points evident from the road. No pipes observed.
43	08/07/2013	13:14	NC 24199 55721	224199	955722		LIFW4	Planned fresh water sample associated with waypoint 44.
44	08/07/2013	13:15	NC 24198 55723	224198	955724	Figure 13		Width 0.5m. Depth 15cm. Flow 0.086m/sec, SD 0.012. Pipe flowing into watercourse prior to running under the road. Smell coming from watercourse, possibly sewage.
45	08/07/2013	13:26	NC 24403 55479	224403	955479		LIFW5	Planned fresh water sample associated with waypoint 46.
46	08/07/2013	13:26	NC 24401 55476	224402	955476			Width 0.4m. Depth 2cm. Flow approximately 6ml/sec. Planned watercourse sample, running downhill then under the road.
47	10/07/2013	8:30	NC 24684 53049	224684	953049		LI2FW1	Planned freshwater sample associated with waypoint 48.
48	10/07/2013	8:31	NC 24683 53049	224684	953050	Figure 14		Watercourse running down hill and sampled higher up hill near road due to inaccessibility to the shore (steep hill, overgrown ferns). No houses around or below the sampling point. Width 1m. Depth 17cm. Flow 0.228m/sec, SD0.013.
49	10/07/2013	8:41	NC 24760 52912	224761	952913			Evidence of sheep, wool and droppings. Appeared to be grazing area around road.
50	10/07/2013	8:54	NC 23841 54124	223842	954125			Five sheep in field beside watercourse.
51	10/07/2013	8:56	NC 23900 54151	223900	954151		LI2FW2	Planned freshwater sample associated with waypoint 52.
52	10/07/2013	8:56	NC 23900 54150	223900	954150			Width 1.5m. Depth 5cm. Flow 0.065m/sec, SD0.005. No outflows at water course.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
53	10/07/2013	9:53	NC 24160 55305	224160	955305			Surveying started beside fence with no further access to the shore. Twenty pink footed geese on water and two sheep by the shore. Geese droppings present. No apparent outflows from 2 houses onshore across from this waypoint.
54	10/07/2013	9:59	NC 24305 55202	224305	955202			Two Herons in the water, four sheep and two mallard ducks on shore.
55	10/07/2013	10:03	NC 24386 55122	224386	955122			One common sandpiper on shore.
56	10/07/2013	10:06	NC 24535 55132	224535	955132		LI2FW3	Planned freshwater sample associated with waypoint 57.
57	10/07/2013	10:07	NC 24535 55127	224536	955128			Width 2m. Depth 10cm. Flow 0.071m/sec. SD0.007.
58	10/07/2013	10:11	NC 24559 55178	224559	955179		LI2FW4	Planned freshwater sample associated with waypoint 59.
59	10/07/2013	10:11	NC 24558 55180	224558	955180			Width 0.7m. Depth 4cm. Flow 0.098m/sec. SD 0.011.
60	10/07/2013	10:36	NC 25570 54121	225571	954121		LI2FW5	Planned freshwater sample associated with waypoint 61.
61	10/07/2013	10:36	NC 25571 54120	225572	954121	Figure 15		Fast-running wide river flowing under the road directly into the loch. Width 10m. Depth 1 34cm. Flow 1 0.767. SD0.074. Depth 2 38cm. Flow 2 0.469m/sec. SD0.076.
62	10/07/2013	10:45	NC 25516 54113	225517	954113			River too wide and fast-flowing to cross safely.
63	10/07/2013	10:51	NC 25469 54505	225470	954506			Two houses by road beside watercourse with septic tanks. No discharges visible.
64	10/07/2013	10:54	NC 25485 54409	225485	954409			Approximately 60 sheep in field by watercourse.
65	10/07/2013	10:56	NC 25443 54371	225444	954372		LI2FW6	Freshwater sample associated with waypoint 66.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
66	10/07/2013	10:58	NC 25442 54373	225443	954374	Figure 16		Three pipes protruding from below verge beside watercourse; running from direction of 4 houses above field. No flow from pipes at time of survey but historical evidence of flow, through water marks on the pipes. Sample taken below pipes. Width 1m. Depth 11cm. Flow 0.079m/sec. SD0.003.
67	10/07/2013	11:07	NC 25338 54210	225338	954211	Figure 17		Steep banks leading down to loch resulting in no sample being taken at this watercourse.
68	10/07/2013	11:09	NC 25352 54150	225353	954151			Car engine debris on shore, signs of geese (feathers).
69	10/07/2013	11:30	NC 25554 52638	225555	952639			Seagull feathers on shore.
70	10/07/2013	11:36	NC 25515 52653	225516	952654		LI2SW1	Unplanned seawater sample associated with waypoint 71.
71	10/07/2013	11:36	NC 25515 52652	225515	952653	Figure 18,19		Pipe running down straight to loch (low tide so pipe above water). No flow at time of survey. Sea water sample taken beside pipe. Steep rocky shore beside private residence so no further access.
72	10/07/2013	11:45	NC 25600 52562	225600	952562		LI2FW7	Planned freshwater sample associated with waypoint 73.
73	10/07/2013	11:45	NC 25600 52561	225601	952562			Width 15m. Depth 1 6cm .Flow 1 0.179m/sec. SD0.009. Depth 2 8cm.Flow 2 0.040. SD0.006.
74	10/07/2013	11:50	NC 25602 52562	225602	952562			Four sheep on shore.
75	10/07/2013	11:52	NC 25587 52527	225588	952528		LI2FW8	Planned freshwater sample associated with waypoints 76 & 77.
76	10/07/2013	11:54	NC 25589 52527	225589	952528	Figure 20		Stream Width 17m. Depth 1 5cm. Flow 1 0.080m/sec. SD0.052. Depth 2 5cm. Flow 2 0.200m/sec. SD0.005.
77	10/07/2013	11:55	NC 25591 52527	225591	952528			Stream running down onto shore. Very rocky stream, shallow and spread out over wide area.
78	10/07/2013	12:02	NC 25461 52444	225461	952445			12 sheep on shore.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
79	10/07/2013	12:05	NC 25425 52459	225425	952460		LI2SW2	Planned seawater sample taken below 4 houses above shore.
80	10/07/2013	12:21	NC 25462 52136	225463	952137		LI2FW9	Planned freshwater sample associated with waypoint 81.
81	10/07/2013	12:22	NC 25461 52136	225461	952137	Figure 21		Sampling point beside arch bridge set back from main road. Width 15m. Depth 1 34cm. Flow 1 0.6888m/sec. SD0.071. Depth2 41cm. Flow 2 0.459m/sec. SD0.018.
82	10/07/2013	12:36	NC 25202 52282	225203	952282		LI2FW10	Planned freshwater sample associated with waypoint 83.
83	10/07/2013	12:38	NC 25200 52281	225201	952281			Width 0.4m. Depth 6cm. Flow 0.112m/sec. SD0.004.
84	10/07/2013	12:39	NC 25201 52281	225202	952282			Burn running onto shore. 1 house higher up the hill above shoreline, no obvious outflow pipes running from it.
85	End of June 2013		NC 23532 55520	223533	955521			Harvester provided coordinates, taken just prior to the survey. Coordinates not taken by team during the survey due to operational issues. Those provided align with the locations observed by the survey team, including coordinates taken for CTD casts, seawater and shellfish samples. Site locations: Site 1.
86	End of June 2013		NC 23535 55547	223535	955547			Site locations: Site 1.
87	End of June 2013		NC 23762 55528	223762	955528			Site locations: Site 1.
88	End of June 2013		NC 23756 55488	223756	955488			Site locations: Site 1.
89	End of June 2013		NC 23931 55007	223932	955007			Site locations: Site 2.
90	End of June 2013		NC 23958 55067	223959	955068			Site locations: Site 2.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
91	End of June 2013		NC 23838 55258	223839	955259			Site locations: Site 2.
92	End of June 2013		NC 23791 55172	223792	955172			Site locations: Site 2.
93	End of June 2013		NC 24226 54496	224226	954497			Site locations: Site 3.
94	End of June 2013		NC 24236 54540	224237	954540			Site locations: Site 3.
95	End of June 2013		NC 24798 54188	224799	954189			Site locations: Site 3.
96	End of June 2013		NC 24791 54126	224792	954127			Site locations: Site 3.
97	End of June 2013		NC 23805 54418	223805	954419			Site locations: Site 4.
98	End of June 2013		NC 23843 54475	223843	954476			Site locations: Site 4.
99	End of June 2013		NC 24127 54117	224127	954118			Site locations: Site 4.
100	End of June 2013		NC 24084 54088	224085	954089			Site locations: Site 4.
101	End of June 2013		NC 24729 53578	224730	953578			Site locations: Site 5.
102	End of June 2013		NC 24791 53614	224792	953614			Site locations: Site 5.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
103	End of June 2013		NC 25059 53255	225059	953256			Site locations: Site 5.
104	End of June 2013		NC 24989 53225	224989	953226			Site locations: Site 5.

Photographs referenced in the table can be found attached as Figures 5-21.

Sampling

Water samples were collected at the sites marked on the Loch Inchard sample maps shown in Figures 3 & 4.

All the samples were transferred to a Biotherm 30 box with ice packs and posted to Glasgow Scientific Services (GSS) for *E.coli* analysis. All the samples were posted on the day of collection and all the samples were received the following day. The sample temperatures on arrival at the laboratory were 3.4°C.

LI2FW6 was a planned sample which was taken further from the shore due to steep banks leading down to the watercourse, which didn't allow for a safe approach.

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:

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

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	*E. coli* (cfu/100ml)	Salinity (ppt)
1	08/07/2013	LISW1	NC 23541 55410	Seawater	0	31.25
2	08/07/2013	LISW2	NC 23881 55108	Seawater	0	30.53
3	08/07/2013	LISW3	NC 24300 54406	Seawater	1	31.62
4	08/07/2013	LISW4	NC 24745 53622	Seawater	0	32.34
5	08/07/2013	LISW5	NC 24080 54191	Seawater	0	31.62
6	08/07/2013	LISW6	NC 22181 55663	Seawater	5	32.34
7	08/07/2013	LISW7	NC 22258 55940	Seawater	200	33.06
8	08/07/2013	LIFW1	NC 22161 55937	Freshwater	<1000	
9	08/07/2013	LIFW2	NC 22331 56084	Freshwater	<10	
10	08/07/2013	LIFW3	NC 22912 55846	Freshwater	70	
11	08/07/2013	LIFW4	NC 24199 55721	Freshwater	150000	
12	08/07/2013	LIFW5	NC 24403 55479	Freshwater	<10	
13	10/07/2013	LI2FW1	NC 24684 53049	Freshwater	<10	
14	10/07/2013	LI2FW2	NC 23900 54151	Freshwater	10	

15	10/07/2013	LI2FW3	NC 24535 55132	Freshwater	10	
16	10/07/2013	LI2FW4	NC 24559 55178	Freshwater	60	
17	10/07/2013	LI2FW5	NC 25570 54121	Freshwater	10	
18	10/07/2013	LI2FW6	NC 25443 54371	Freshwater	50	
19	10/07/2013	LI2SW1	NC 25515 52653	Seawater	1700	
20	10/07/2013	LI2FW7	NC 25600 52562	Freshwater	400	
21	10/07/2013	LI2FW8	NC 25587 52527	Freshwater	170	
22	10/07/2013	LI2SW2	NC 25425 52459	Seawater	200	
23	10/07/2013	LI2FW9	NC 25462 52136	Freshwater	<10	
24	10/07/2013	LI2FW10	NC 25202 52282	Freshwater	40	

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	Sample depth (m)	*E. coli* (MPN/100g)
1	08/07/2013	LISF1	NC 23542 55411	Mussels	2	70
2	08/07/2013	LISF2	NC 23542 55409	Mussels	6	50
3	08/07/2013	LISF3	NC 23878 55157	Mussels	0.5	<20
4	08/07/2013	LISF4	NC 23882 55155	Mussels	2	20
5	08/07/2013	LISF5	NC 24299 54406	Mussels	6	50
6	08/07/2013	LISF6	NC 24447 54375	Mussels	2	20
7	08/07/2013	LISF7	NC 24744 53622	Mussels	10	20
8	08/07/2013	LISF8	NC 24745 53625	Mussels	2	<20

Salinity Profiles

Salinity profiles were taken at seven locations in the production area, at each sampling points around the mussel lines (Refer to Figures 1 & 2 for map locations). The gathered data will be sent to client as a separate document.

Photographs

Figure 5. Container and manhole covered area at location marked on map as Kinlochbervie septic tank. Waypoint 25.

Figure 6. Sewage outfall pipe, location of water sample LIFW1. Waypoints 28 & 29.

Figure 7. Boats moored at pier. Waypoint 30.

Figure 8. Septic tank storage area. Waypoint 32.

Figure 9. Planned water sample LIFW2. Waypoints 35 & 36.

Figure 10. Pipe running to shore below house. Waypoint 37.

Figure 11. Planned water sample LIFW3. Waypoints 40 & 41.

Figure 12. Septic tanks. Waypoint 42.

Figure 13. Planned water sample LIFW4. Waypoints 43 & 44.

Figure 14. No access to shore. Waypoint 48.

Figure 15. Planned water sample LI2FW5. Waypoint 60 & 61.

Figure 16. Pipes running into watercourse, Sample LI2FW6. Waypoint 65 & 66.

Figure 17. Steep bank beside water course. Waypoint 67.

Figure 18. Pipe running to shore from house, Unplanned Seawater Sample LI2SW1. Waypoint 70 & 71.

Figure 19. Rocky steep shore. Waypoint 71.

Figure 20. Wide shallow sampling point LI2FW8. Waypoint 76.

Figure 21. Planned sampling point LI2FW9. Waypoint 81.