Scottish Sanitary Survey Report

Sanitary Survey Report
Kilfinichen Bay
AB-695
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Cefas

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Partner Organisations

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

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Appendices

I. Executive Summary

Under (EC) Regulation 854/2004, which sets forth specific rules for the organisation of official controls on products of animal origin intended for human consumption, sanitary surveys of production areas and their associated hydrological catchments and coastal waters are required in order to establish the appropriate representative monitoring points (RMPs) for the monitoring programme.

The purpose of the sanitary survey is to demonstrate compliance with the requirements stated in Annex II (Chapter II Paragraph 6) of Regulation (EC) 854/2004. The sanitary survey results in recommendations on the location of RMPs, the frequency of sampling for microbiological monitoring, and the boundaries of the production areas deemed to be represented by the RMPs. A sanitary survey was undertaken on the provisionally classified cockle fishery at Kilfinichen Bay on the basis recommended in the European Union Reference Laboratory publication: "Microbiological Monitoring of Bivalve Mollusc Harvesting Area Guide to Good Practice: Technical Application" (https://eurlcefas.org/media/13831/gpg_issue-5_final_all.pdf).

Kilfinichen Bay is an inlet on the north shore of Loch Scridain on the Isle of Mull, within the Argyll and Bute Council area. The bay lies on the Ardmeanach peninsula and is bordered to the east by the Aird Kilfinichen headland. The shellfishery at Kilfinichen Bay is for wild common cockles (*Cerastoderma edule*).

Although the human and farm animal populations around Kilfinichen Bay are low, the confined nature of the area means that local sources will impact on the microbiological quality of cockles within the bay. There are some small sewage discharges within, and immediately outside the bay.

In addition to direct inputs, contamination will be associated with watercourses, primarily Abhainn Bail a Mhuilinn. Sheep observed grazing around Abhainn Bail a Mhuilinn will contribute to contamination levels in that watercourse. Available information indicates that contamination will be greatest on the western side of the bay.

A short predicted transport distance over a single tidal phase means that sources closest to the shellfish bed are most likely to have an impact there. Due to the shallow nature of the bay and the low predicted transport distance, contaminants may be carried back into the bay on the incoming tide.

It is not possible to exclude those small sewage inputs that impact on the production area without markedly reducing the area available for harvest. Therefore, it is recommended that the present production area be maintained. However, it is recommended that the RMZ is moved to the west of the current position in order to reflect the higher levels of contamination seen on the western side of the bay.

II. Sampling Plan

Production Area	Kilfinichen Bay
Site Name	Kilfinichen Bay
SIN	AB-695-1507-04
Species	Common cockles
Type of Fishery	Wild harvest
BOUNDARY OF RMZ	The area bounded by lines drawn from NM 4880 2845 to NM 4890 2845 to NM 4890 2825 to NM 4880 2825 and back to NM 4880 2845
Tolerance (m)	Not applicable
Depth (m)	Not applicable
Method of Sampling	Hand gathered
Frequency of Sampling	Monthly
Local Authority	Argyll and Bute Council
Authorised Sampler(s)	Fraser Anderson William MacQuarrie Ewan McDougall Allison Hardie Heather Harley
Local Authority Liaison Officer	Fraser Anderson
Production Area	The area bounded by lines drawn between NM 4843 2800 and NM 4920 2800 extending to MHWS

III. Report

1. General Description

Kilfinichen Bay is an inlet on the north shore of Loch Scridain on the Isle of Mull, within the Argyll and Bute Council area. The bay lies on the Ardmeanach peninsula and is bordered to the east by the Aird Kilfinichen headland.

The bay is approximately 1 km wide at its mouth and is mostly intertidal. It opens to the southwest into Loch Scridain. Loch Scridain itself is oriented approximately East-West.

The area around Kilfinichen Bay, and Loch Scridain in general, is sparsely populated with no identifiable settlements, just groups of houses along the roads which border the shore.

A sanitary survey was undertaken on the classified fishery at Kilfinichen Bay on the basis recommended in the European Union Reference Laboratory publication: “Microbiological Monitoring of Bivalve Mollusc Harvesting Area Guide to Good Practice: Technical Application” (https://eurlcefas.org/media/13831/gpg_issue-5_final_all.pdf). This production area was identified for a sanitary survey on the basis of a standard track application for classification.

Figure 1.1 Location of Kilfinichen Bay

2. Fishery

The fishery at Kilfinichen Bay is a wild common cockle (*Cerastoderma edule*) fishery. A summary of the site is given in Table 2.1.

Table 2.1 Kilfinichen Bay site information

Production area	Site	SIN	Species
Kilfinichen Bay	Kilfinichen Bay	AB-695-1507-04	Common cockles

The area was subject to a provisional RMP assessment in December 2013. The production area recommended in that assessment was the area bounded by lines drawn between NM 4843 2800 and NM 4920 2800 extending to MHWS.

The assessment further recommended a provisional representative monitoring zone (pRMZ) within the area bounded by lines drawn from NM 4921 2849 to NM 4911 2849 to NM 4911 2823 to NM 4921 2829 and back to NM 4921 2849.

The anticipated extent of the fishery, given that harvesting is intended to be by hand-raking, is plotted in Figure 2.1.

The recommended boundaries for both the production area and the RMZ will be reassessed as part of this sanitary survey.

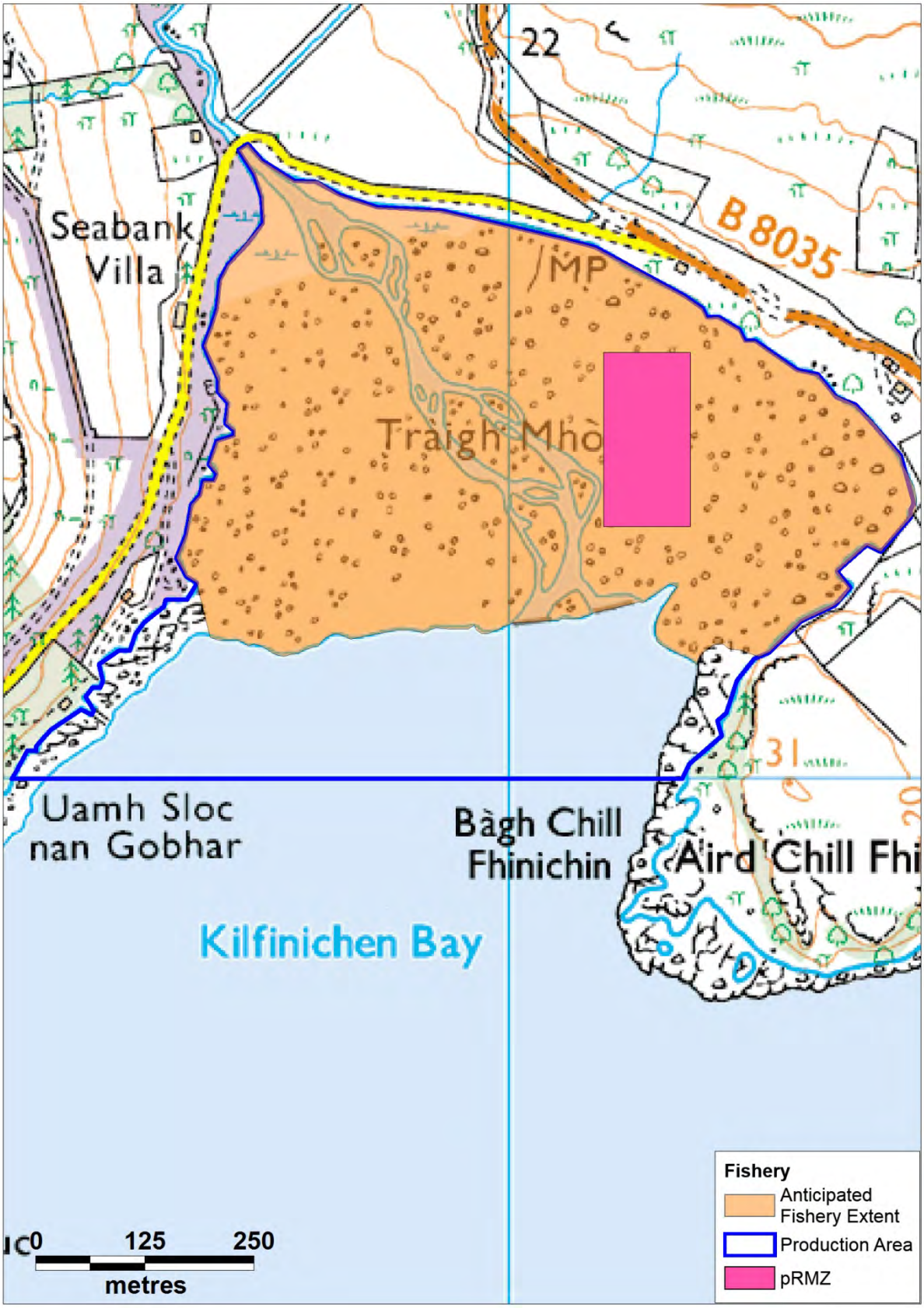

Figure 2.1 Kilfinichen Bay Fishery

3. Human Population

Information was obtained on the population within the vicinity of Kilfinichen Bay production area from the General Register Office for Scotland. The last census was undertaken in 2011. The census output area surrounding Kilfinichen Bay is shown in Figure 3.1 thematically mapped by the 2011 population density. The population density is low overall (0.46 people per km^2) within the output area bordering the fishery. However, the census output area is large and population within it will not be evenly distributed.

Table 3.1 Census output area and population – Kilfinichen Bay

Census Output Area ID	Population	Area (km^2)
S00069230	129	283

The B8035 road runs adjacent to the north eastern shoreline of the bay then joins to a smaller road which runs along the remainder of the northern and western shoreline of the bay. The small settlement of Tiroran lies inland to the west of the mouth of the bay: there is a hotel and restaurant as well as two self-catering cottages at Tiroran. Kilfinichen Estate covers the majority of the land surrounding the fishery and includes a farm, two self-catering cottages and several residential dwellings all located northeast of the bay. There is a pier with a boat house north of Eilean na h-Ordaig. During the shoreline survey, a pier and slipway were also observed on the western shoreline of the bay at Uam nan Gobhar. North of that location, there were also an informal beach slipway and two moorings occupied by small pleasure craft. Two empty moorings were present on the shore south of the hotel at Tiroran. An anchorage is present on the west side of the bay (Clyde Cruising Club, 2007).

Overall, the local population surrounding the bay is low and sparsely distributed. However, in relation to the fishery, the far eastern and western sides of the shellfish bed are likely to be more impacted by human-related sources due to the presence nearby of dwellings at Tiroran and Kilnifinchen Estate, tourist accommodation, the anchorage and moorings. The presence of tourist accommodation, moorings and anchorage suggests that there is likely to be significant seasonal variation in human population around the bay.

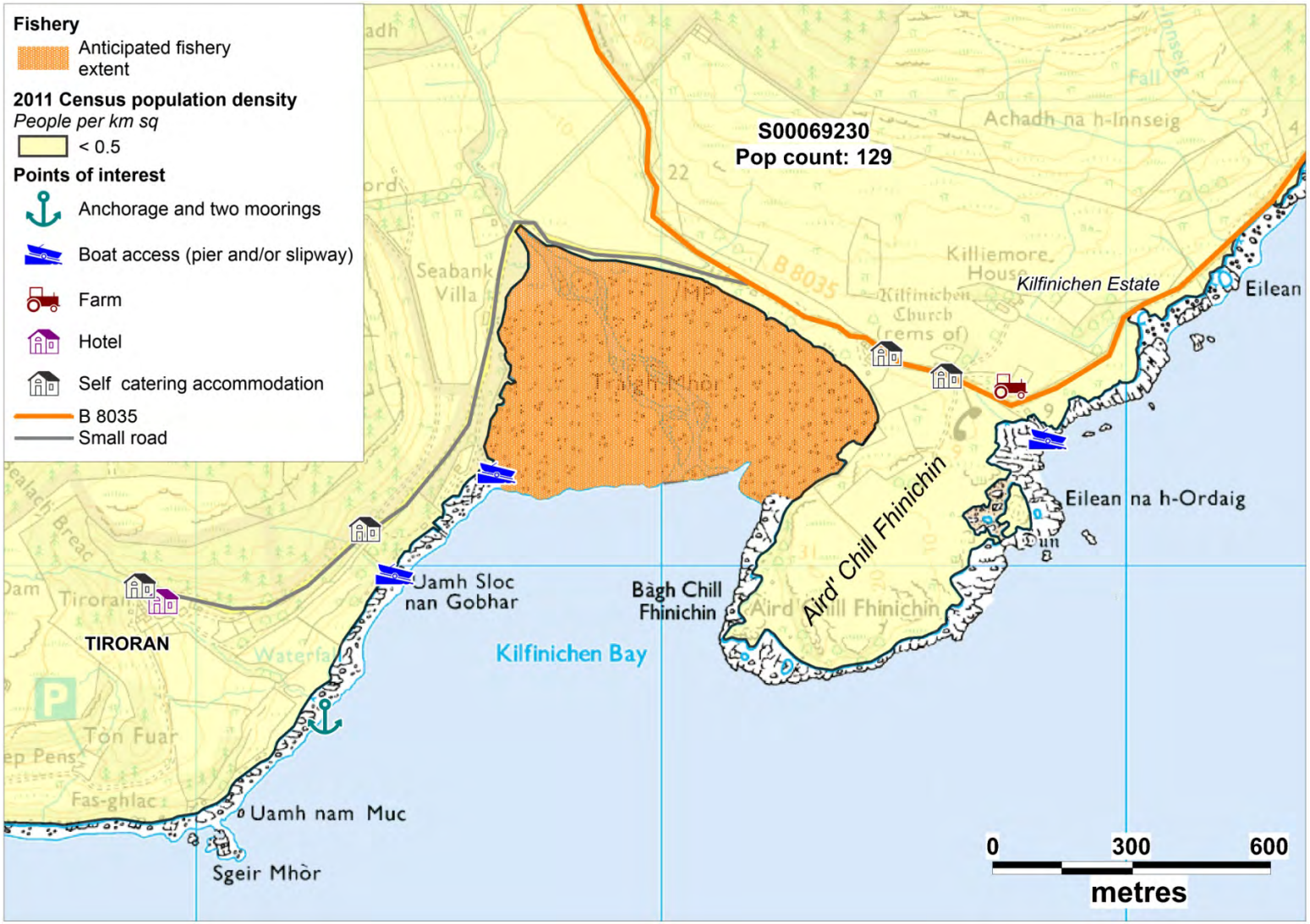

Figure 3.1 Population map for the area around Kilfinichen Bay

4. Sewage Discharges

Information on sewage discharges within an area 6.5 km around the point NM 4900 2700, located in the middle of Loch Scridain to the south of Kilfinichen Bay, was sought from Scottish Water and the Scottish Environment Protection Agency (SEPA). Data requested included the name, location, type, size (in either flow or population equivalent), level of treatment, sanitary or bacteriological data, spill frequency, discharge destination (to land, watercourse or sea), any available dispersion or dilution modelling studies, and whether improvements were in work or planned. No information was provided on sanitary or bacteriological content, spill frequency, dispersion or dilution modelling studies, or whether improvements were in work or planned

4.1 Community Discharges

Scottish Water and SEPA did not report any community discharges affecting the assessment area.

4.2 Consented Private Discharges - SEPA

SEPA provided information regarding consented discharges within the request area identified. Discharges relating to abstraction or engineering works have been excluded from assessment, as they should not contribute faecal input to the area.

SEPA provided information on 23 sewage discharge consents within the area requested. These discharges are centred somewhat around Kilfinichen Bay and to its east, and on the small settlement of Pennyghael.

Registration is required for all new properties and upon sale of existing properties. Information provided by SEPA is considered to be correct at the time of writing, however there may be additional discharges that have not yet been registered with SEPA.

The consented discharges assessed in this report are listed in Table 4.1. Those located in the close vicinity of Kilfinichen Bay are shown in Figure 4.1. The full set of consented discharges are shown on a map in the Loch Scridain East sanitary survey review.

Of the 23 discharges reported by SEPA, six discharge within 1 km of the bay. One, CAR/R/1100348, discharges at the mouth of Kilfinichen Bay and has a PE of 5. The remaining four; CAR/R/1013638, CAR/R/1038955, CAR/R/1009214 and CAR/R/1100347, are recorded as discharging to land or soakaway. CAR/R/1009214, while recorded as discharging to land, plots in the intertidal zone. This may mean that it effectively discharges to sea, rather than to soakaway with its associated benefits.

The effectiveness of soakaway systems depends on location and maintenance, and SEPA have identified previously that in remote areas, consents originally registered as discharging to land may have been diverted to sea or watercourses upon failure of the soakaway fields.

Table 4.1 Discharges to Loch Scridain and adjacent watercourses.

Licence Number	National Grid Reference	Site Description	Treatment Type	Discharging to	PE
CAR/R/1009214	NM 48662 28523	Dwelling, Tiroran, Isle of Mull	Sewage (Private) Primary	Land	15
CAR/R/1013638	NM 48700 29340	Dwelling, Tiroran, Isle of Mull	Sewage (Private) Primary	Land	7
CAR/R/1017505	NM 51886 26415	Pennyghael Community Hall & School House Mull	Sewage (Private) Primary	Leidle River	11
CAR/R/1018620	NM 47980 27810	Dwelling, Tiroran, Isle of Mull	Sewage (Private) Primary	Land	5
CAR/R/1033085	NM 42740 26750	Dwelling ,Burg,Tiroran,Isle Of Mull	Sewage (Private) Primary	Soakaway	15
CAR/R/1033369	NM 52871 24487	Dwelling, Glen Leidle, Carsaig, Pennyghael	Sewage (Private) Primary	Leidle River	9
CAR/R/1038125	NM 48580 25392	Dwelling, Pennyghael, Isle of Mull	Sewage (Private) Primary	Soakaway	5
CAR/R/1038410	NM 52950 28010	Dwelling, Pennyghael, Isle of Mull	Sewage (Private) Primary	Loch Scridain	5
CAR/R/1038446	NM 53490 28480	Dwelling, Pennyghael, Isle of Mull	Sewage (Private) Primary	Loch Scridain	6
CAR/R/1038669	NM 46869 27218	Dwelling, Tiroran, Isle of Mull	Sewage (Private) Primary	Soakaway	5
CAR/R/1038952	NM 50379 26045	Dwelling, Pennyghael, Isle of Mull	Sewage (Private) Primary	Soakaway	5
CAR/R/1038955	NM 48810 29315	Dwelling, Balevulin, Tiroran, Isle of Mull	Sewage (Private) Primary	Soakaway	5
CAR/R/1039682	NM 51550 29680	Dwelling, Dererach, Pennyghael,Isle of Mull	Sewage (Private) Primary	Loch Scridain	5
CAR/R/1041564	NM 46770 24390	Dwelling, Isle Of Mull	Sewage (Private) Primary	Soakaway	5
CAR/R/1042230	NM 47248 27439	Dwelling, Tiroran, Isle of Mull	Sewage (Private) Primary	Underground watercourse	5
CAR/R/1049233	NM 51795 26412	Dwelling, Pennyghael, Isle Of Mull	Sewage (Private) Primary	Loch Scridain	5
CAR/R/1063060	NM 54150 28000	Dwelling, Pennyghael, Isle of Mull	Sewage (Private) Primary	Soakaway	14
CAR/R/1076821	NM 47230 27374	Dwelling, Tiroran, Isle of Mull	Sewage (Private) Secondary	Unnamed watercourse	6
CAR/R/1087216	NM 51679 26371	Dwelling, Pennyghael, Isle of Mull	Sewage (Private) Secondary	Unnamed watercourse	6
CAR/R/1100347	NM 48400 28020	Dwelling, Tiroran, Isle of Mull	Sewage (Private) Primary	Soakaway	5
CAR/R/1100348	NM 48540 28040	Dwelling, Tiroran, Isle of Mull	Sewage (Private) Primary	Loch Scridain	5
CAR/R/1115317	NM 52140 26730	Dwelling, Tigh Na Habhan, Pennyghael, Mull	Sewage (Private) Primary	Soakaway	10
CAR/R/1119446	NM 51504 26382	2 Dwellings, Pennyghael, Mull	Sewage (Private) Secondary	Unnamed watercourse	10

Shoreline Survey Discharge Observations

Four observation of sewage discharges or infrastructure were recorded during the shoreline survey and are shown in Table 4.2 below.

Table 4.2 Discharge-associated observations made during the shoreline survey

No.	Date	NGR	Associated Photograph (Appendix 4)	*E. coli* (cfu/100ml)	Description
1	13/08/2014	NM 48263 27738	Fig. 10	>10000000	Unplanned freshwater sample - Contaminated. 11cm diameter PVC pipe. Flow 1cm deep at centre of pipe.
2	13/08/2014	NM 48515 28106	Fig. 8		Large fibreglass septic tank next to shed. 10cm diameter PVC pipe running out into ground, re-appears alongside side of pier. No discharge present.
3	13/08/2014	NM 48650 28514			Concrete septic tank. No outflow. Large (12-13cm) metal pipe coming out shore side of tank, but running directly into ground. Searched for end of pipe, could not be seen.
4	13/08/2014	NM 49180 28569	Fig. 5		10cm PVC pipe running to high tide mark from property. Exit blocked by reeds. No discharge. No sign of septic tank in garden above.

Observation 1 relates to a pipe discharging to the shore. A sample taken from this returned a value of greater than 10000000 *E.coli cfu*/100 ml. This value is typical of primary treated effluent. The flow rate of effluent was not recorded during the sanitary survey.

Observation 2 relates to a fibreglass septic tank with the outfall pipe observed alongside a concrete pier. No discharge was observed. This septic tank relates to CAR/R/1100348, which plots next to a small pier on the map.

Observation 3 relates to a concrete septic tank with a pipe coming out into the ground. The end of this pipe goes into the ground and no outlet was observed. The location of this corresponds with the location given for CAR/R/1009214: the output from that septic tank is consented to discharge to soakaway. Due to the close proximity to the shoreline the soakaway may not be fully effective.

Observation 4 relates to a pipe running to shore from a house. The pipe appeared silted up with the exit blocked by reeds.

Two additional sewage discharge-related observations were made during the shoreline survey undertaken in 2014 for the Loch Scridain East review. However, given that these related to small discharges located more than 3 km from Kilfinichen

Bay, they have not been included in Figure 4.1. Details can be found in the report associated with that review.

Summary

As there are no community discharges to the area, the main human faecal inputs come from small private discharges located around Loch Scridain. One discharge (CAR/R/1100348) to Kilfinichen Bay itself was reported by SEPA with another (CAR/R/1009214) discharging extremely close to the shore line. The shoreline survey also recorded a small number of septic tanks or outfall pipes. A sample taken from one discharge returned a very high *E. coli* result. That discharge lies approximately 1 km from the estimated fishery extent.

List of Acronyms

MDF=	Mean daily flow	DWF=	Dry weather flow
PE=	Population Equivalent	ST=	Septic Tank
WWTW=	Wastewater Treatment Work	CSO=	Combined Sewer Overflow

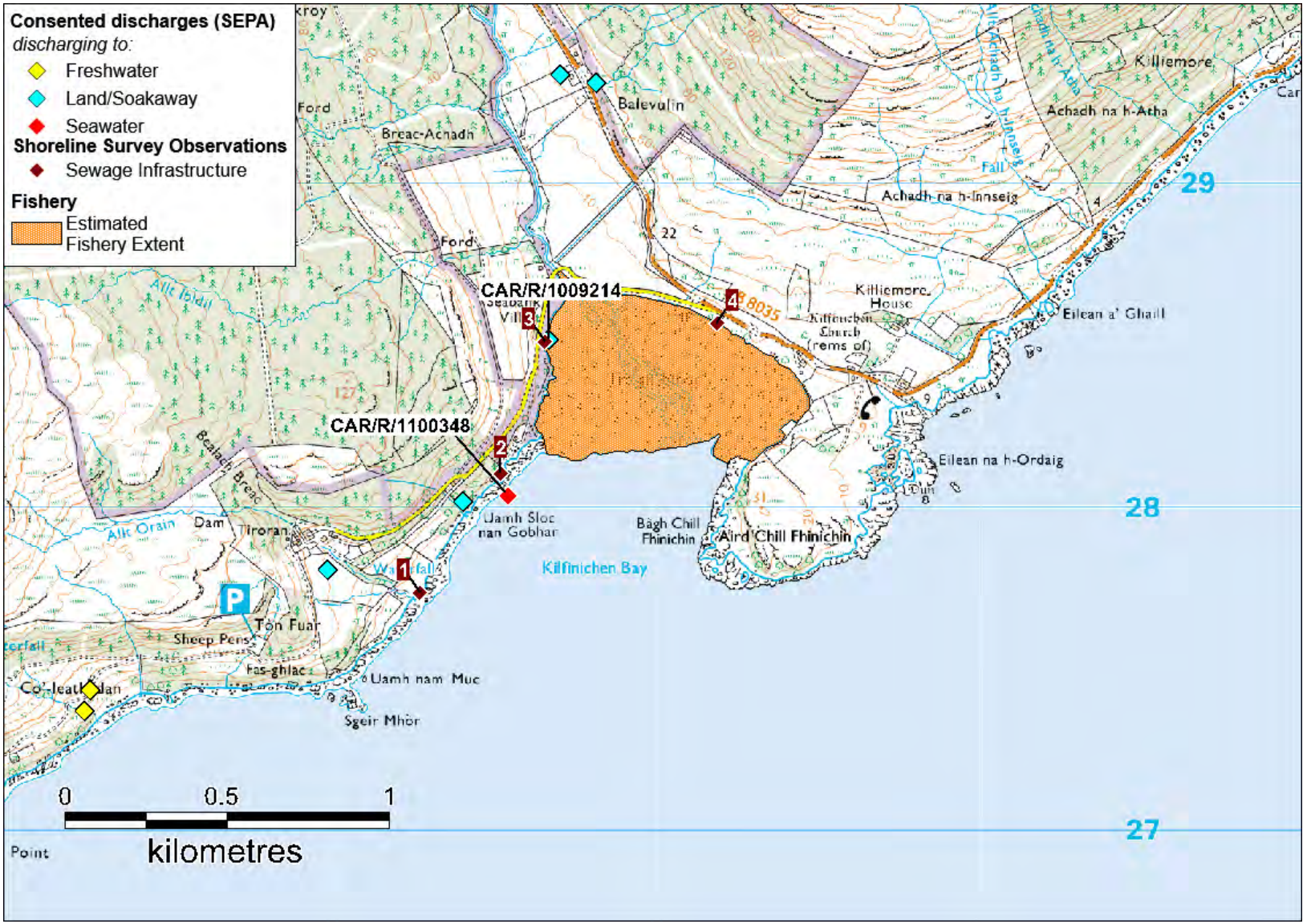

Figure 4.1 Map of discharges for Kilfinichen Bay

5. Agriculture

Information on the spatial distribution of animals on land adjacent to or near the fishery can provide an indication of the potential amount of organic pollution from livestock entering the shellfish farm area. Agricultural census data to parish level was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the Kilfinichen and Kilvickeon parish. Reported livestock populations for the parish in 2013 are listed in Table 5.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data. Any entries which relate to fewer than five holdings, or where two or fewer holdings account for 85% or more of the information, are replaced with an asterisk.

Table 5.1 Livestock numbers in the Kilfinichen and Kilvickeon agricultural parish 2013

	Kilfinichen and Kilvickeon	
	247 km^2	
	Holdings	Numbers
Pigs	*	*
Poultry	24	388
Cattle	27	980
Sheep	38	14215
Horses used in Agriculture	0	-
Other horses and ponies	8	26

* data withheld

The livestock census numbers for Kilfinichen and Kilvickeon relate to a very large parish area, therefore it is not possible to determine the spatial distribution of the livestock on the shoreline adjacent to the bay or to identify how many animals are likely to impact the catchment around the shellfish farm. Although the figures are of little use in assessing the potential impact of livestock contamination to the shellfishery they do give an idea of the total numbers of livestock over the broader area. Poultry, cattle and other horses and ponies were kept in small numbers and sheep were kept in moderate numbers. No pigs were reported for the parish due the small number of holdings. There were no reported horses used in agriculture.

A source of spatially relevant information on livestock population in the area was the shoreline survey (see Appendix 4) which only relates to the time of the site visit on the 13th August 2014. Observations made during the survey are dependent upon the viewpoint of the observer some animals may have been obscured by the terrain.

During the shoreline survey, sheep were observed grazing on the shorelines to the east, north and west of the bay. A feeding station was also observed close to the north west corner of the bay and four cattle were observed on the western shoreline.

Review of publicly available aerial images shows that areas of improved pasture are located along the majority of the coastline of the bay apart from where there are wooded extents to the west (Bing Maps, accessed 03/10/2014 (imaging date Apr-May 2012, http://mvexel.dev.openstreetmap.org/bing/)). Areas identified from the aerial images as likely improved pasture are shown in Figure 5.1. The 1:25,000 Ordnance Survey map identified sheep pens south of Tiroran as shown in Figure 5.1. A sheep and cattle farm is also reported to be located on the Kilfinichen Estate north east of the fishery (Kilfinichen Estate, 2014).

Numbers of sheep are expected to be approximately double during the spring and summer months when lambs are present. Any contributions of faecal contamination from livestock are expected to be low to moderate, with livestock grazing on the improved pasture surrounding the fishery potentially affecting all cockles on the shellfish bed.

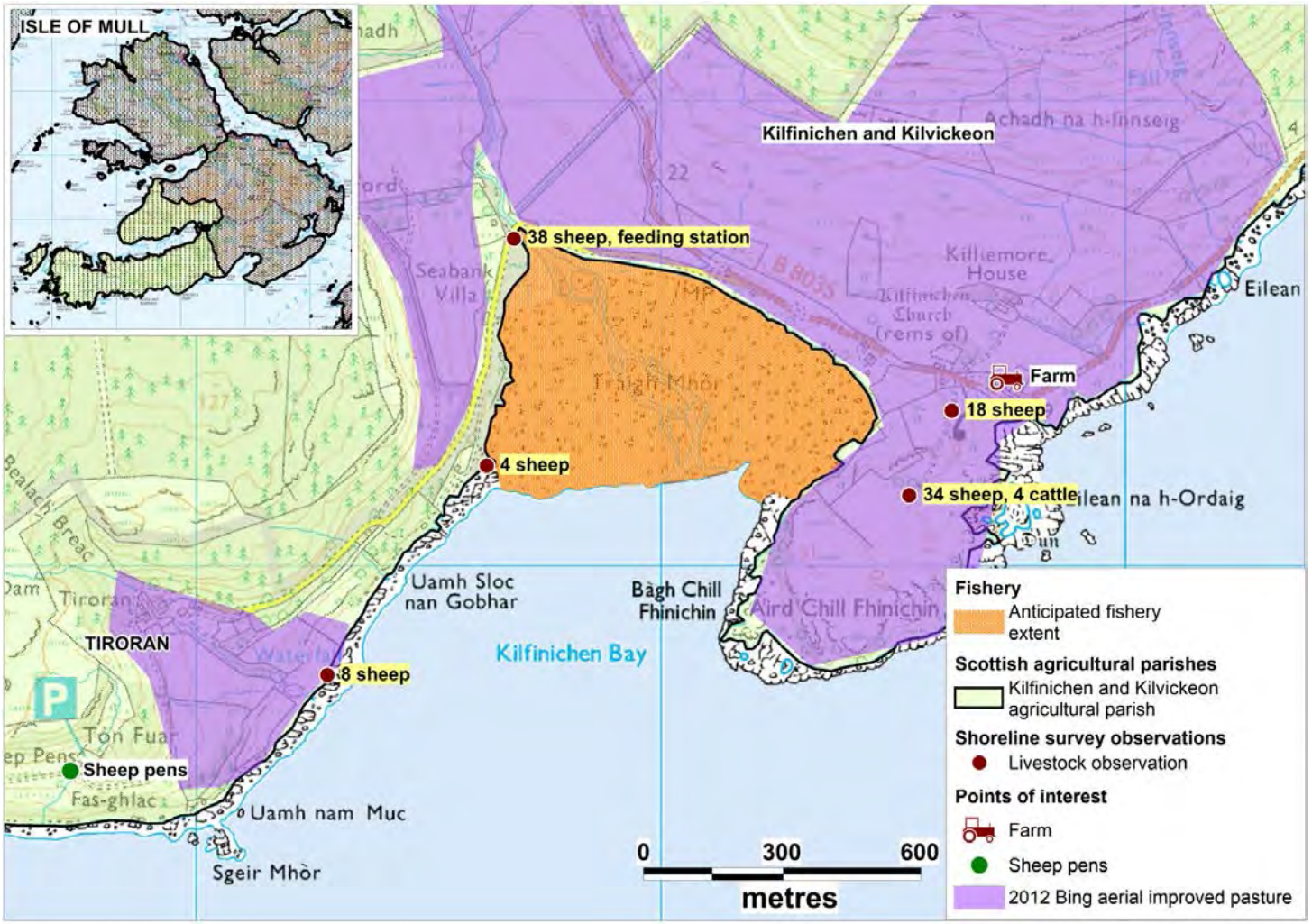

Figure 5.1 Livestock observations at Kilfinichen Bay

6. Wildlife

Wildlife species present in and around the production area will contribute to background levels of faecal contamination at the fishery, and large concentrations of animals may constitute significant sources when they are present. Seals (pinnipeds), whales (cetaceans) and some seabirds may deposit faecal wastes directly into the sea, whilst birds and mammals present on land will contribute a proportion of any faecal indicator loading carried in diffuse run-off or watercourses.

The species for which information was potentially available and which could contribute to faecal indicator levels at Kilfinichen Bay are considered below.

Pinnipeds

The Special Committee on Seals (2013) reported that there has been no significant change in the number of harbour seals observed hauled out along the west coast of Scotland (including the Outer Hebrides). Seals are noted to be present in and around Loch Scridain, however it was not possible to determine the specific distribution within the loch as distribution data was reported to 10 km squares. There are grey seal breeding colonies on the Isle of Mull, though none appeared to lie within Loch Scridain. No seals were observed during the 2014 shoreline surveys of either Kilfinichen Bay or Loch Scridain.

Cetaceans

Cetacean sightings reported to the Hebridean Whale and Dolphin Trust for Loch Scridain for the years between 2008 and 2014 included bottlenose dolphins and harbour porpoises (Hebridean Whale and Dolphin Trust, 2014) for Loch Scridain. No cetaceans were observed during the 2014 shoreline surveys of either Kilfinichen Bay or Loch Scridain.

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. It should be appreciated that the sources of this data are varied, with some recorded as unknown or estimated, whilst some come from reliable detailed surveys such as those carried out for the Seabird 2000 report by Mitchell *et al.*, (2004). Data applicable for the 5 km area around the fishery are listed in Table 6.1. Very few breeding seabirds were reported in the area and none within 1 km of Kilfinichen Bay.

. During the shoreline survey, eight gulls were only wildlife observed. A greater diversity and number of birds were seen during the 2014 Loch Scridain East shoreline survey. These included 89 ducks, 30 gulls, eight oystercatchers and two grey herons, of which

the majority were observed along the south side of Loch Scridain >2 km from Kilfinichen Bay.

Table 6.1 Seabird counts within 5 km of Kilfinichen Bay

Common name	Species name	Count*	Method	Accuracy
Common Gull	*Larus canus*	10	Occupied territory and nests	Accurate
Herring Gull	*Larus argentatus*	4	Occupied territory	Accurate

Otters

No specific survey reports were found of otters within Loch Scridain. There are however numerous anecdotal accounts of otters within the loch (Pure Travel, 2010). No otters were observed during the 2014 shoreline surveys of either Kilfinichen Bay or Loch Scridain.

Deer

Red deer are widespread within the Isle of Mull (Wild Future Outdoors Ltd., 2014) and are predominantly found on hills and forest. In the summer they are found on higher ground, whilst in winter they are on mostly low lying land. No deer were observed during the 2014 shoreline surveys of either Kilfinichen Bay or Loch Scridain.

Conclusions

Overall contamination from wildlife such as birds, otters, deer, cetaceans and seals is expected to be low and will be sporadic from both a spatial and temporal perspective.

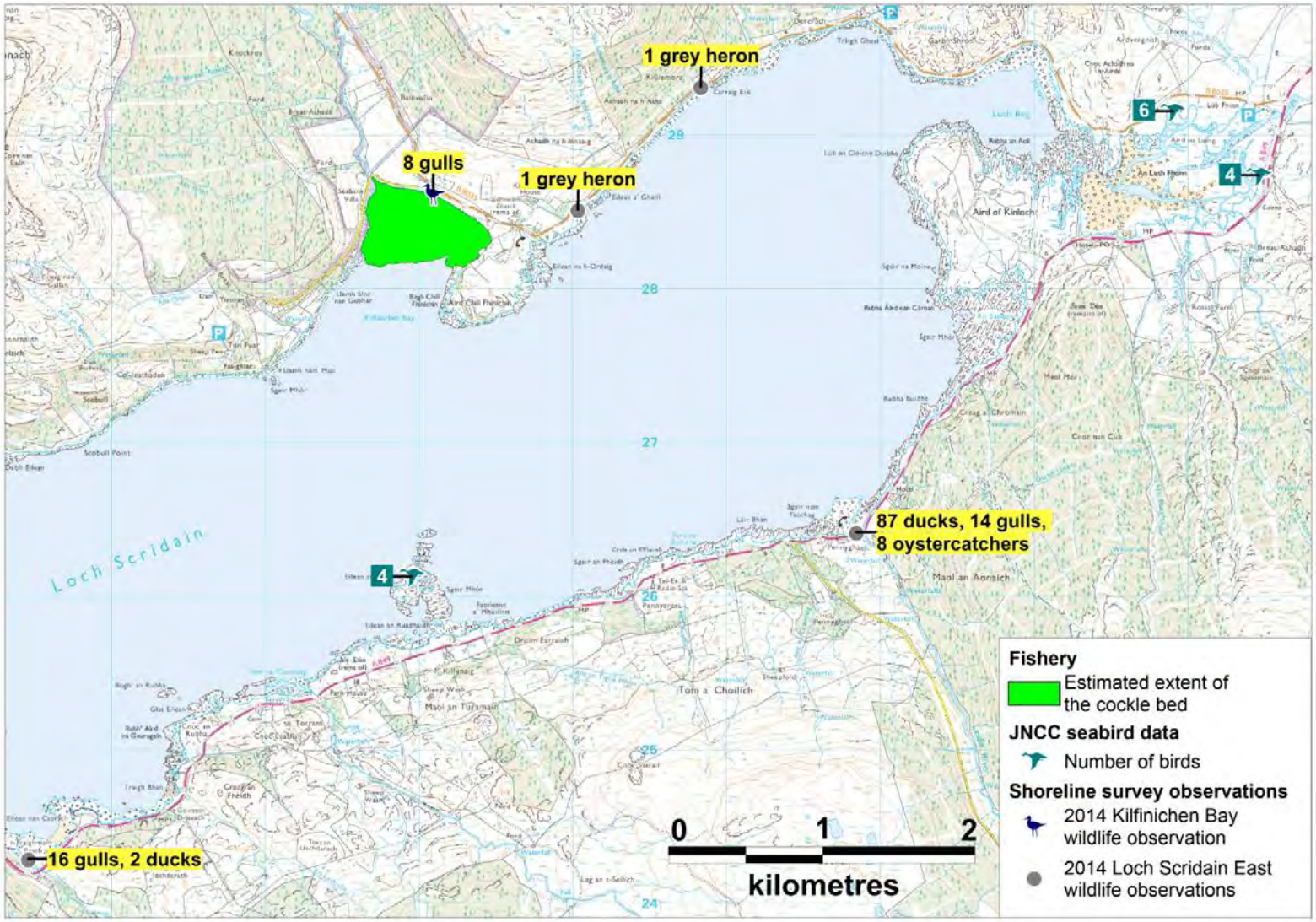

Figure 6.1 Map of wildlife distributions around Kilfinichen Bay

7. Land Cover

The Land Cover Map 2007 data for the area is shown in Figure 7.1.There are no built up or urban areas represented. The predominant land cover type adjacent to Kilfinichen Bay is improved grassland with additional areas of coniferous and broad-leafed woodland. There are also areas of dwarf shrub heath and rough grassland. Most of the intertidal area within the bay is erroneously recorded as rock rather than sediment in the data set.

Faecal indicator organism export coefficients for faecal coliform bacteria have been found to be approximately $8.3x10^8$ cfu/km^2/hr for areas of improved grassland and approximately $2.5x10^8$ cfu/km^2/hr for rough grazing (Kay, et al., 2008). The contributions from all land cover types would be expected to increase significantly after rainfall events, however this effect would be particularly marked from improved grassland areas (roughly 1000-fold) (Kay, et al., 2008).

The highest potential contribution of contaminated run-off to the Kilfinichen Bay cockle bed is from the areas of improved grassland which surround much of the fishery. This contribution would be expected to increase after rainfall events.

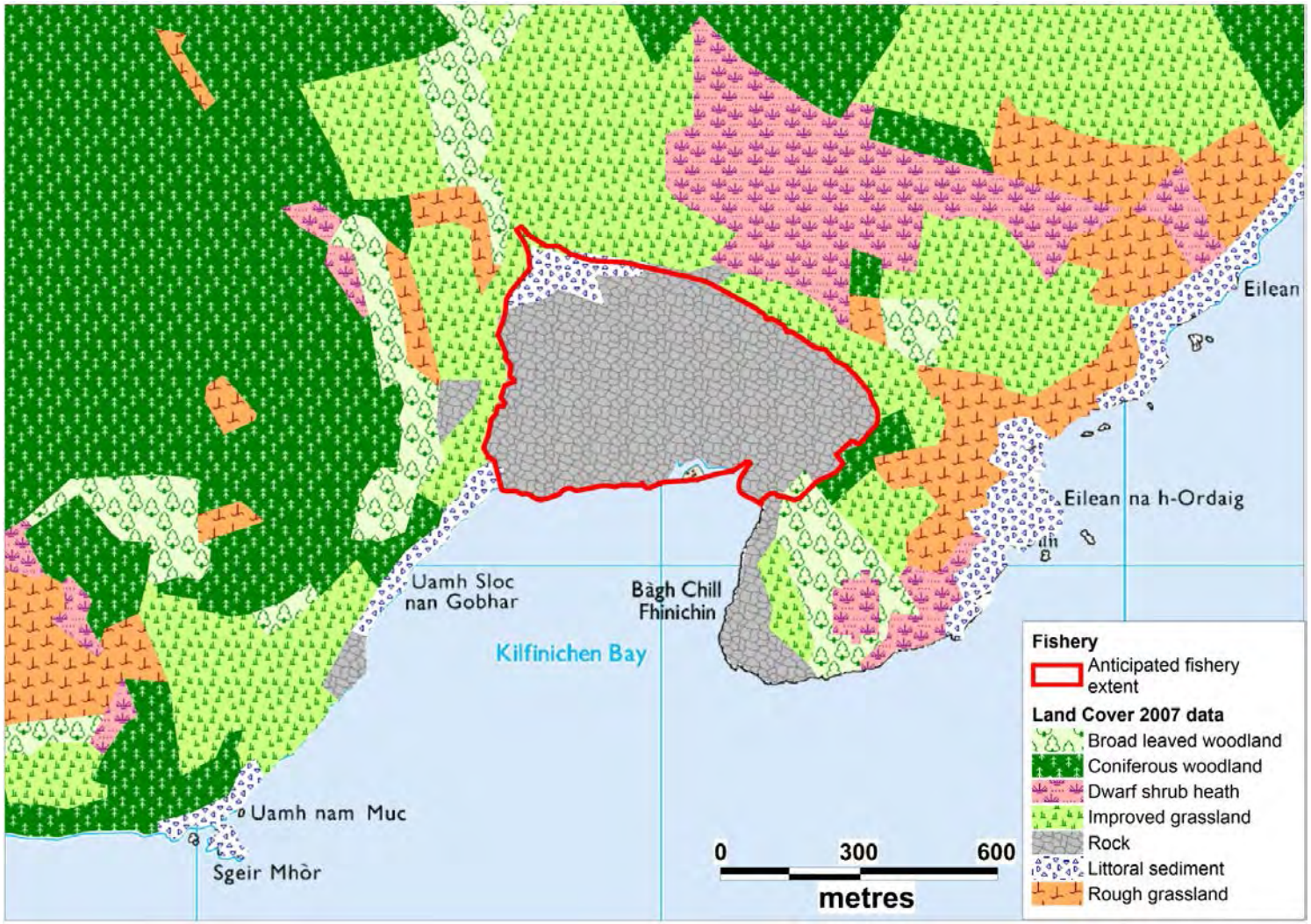

Figure 7.1 LCM2007 land cover data for the area around Kilfinichen Bay

8. Watercourses

There are no gauging stations on watercourses entering Kilfinichen Bay.

Spot measurements of flow and microbial content were obtained during the shoreline survey conducted on the 13th August 2014. Precipitation in the 48 hour period prior to the survey was heavy at times. The watercourses listed in Table 8.1 are those measured and sampled during the shoreline survey. No areas of land drainage were recorded. The locations and loadings of measured watercourses are shown in Figure 8.1.

Table 8.1 Watercourses entering Kilfinichen Bay

No.	Eastings	Northings	Description	Width (m)			Depth (m)			Flow (m^3/d)	Loading (*E. coli* per day)
1	147283	727353	Allt an Sgaphair	0.35			0.12			1330	5.3×10^8
2	147410	727431	Unnamed watercourse	0.55			0.11			2990	2.1×10^9
3	148246	727732	Allt Orain	1.5			0.17			11200	6.5×10^{10}
4	148442	727994	Unnamed watercourse	0.1[1]	0.05[2]	0.2[3]	0.05[1]	0.04[2]	0.03[3]	336	5.4×10^8
5	148703	728732	Abhainn Bail a Mhuilinn	10			0.70*			155000*	9.3×10^{10}
6	149090	728621	Unnamed watercourse	0.35			0.10			254	9.4×10^8

[1] Branch 1 [2] Branch 2 [3] Branch 3 Watercourse numbered 4 had three branches, all of which were measured separately. The flows were combined estimate the total *E. coli* loading
* Average taken from two measurements

The largest watercourse entering the survey area was Abhainn Bail a Mhuilinn. This is located at the northwestern end of the bay but the channels from the watercourse run southwest towards the central part of the cockle bed at low tide. . Abhainn Bail a Mhuilinn had and Allt Orain, which discharges to the southwest of the bay, both had moderate estimated *E. coli* loadings. Unnamed watercourse No. 6 was located on the north side of the bay.

Overall, freshwater inputs are expected to provide moderate to high levels of contamination to the cockle bed in Kilfinichen Bay, with the highest impact expected on the northwestern and central parts of the bed.

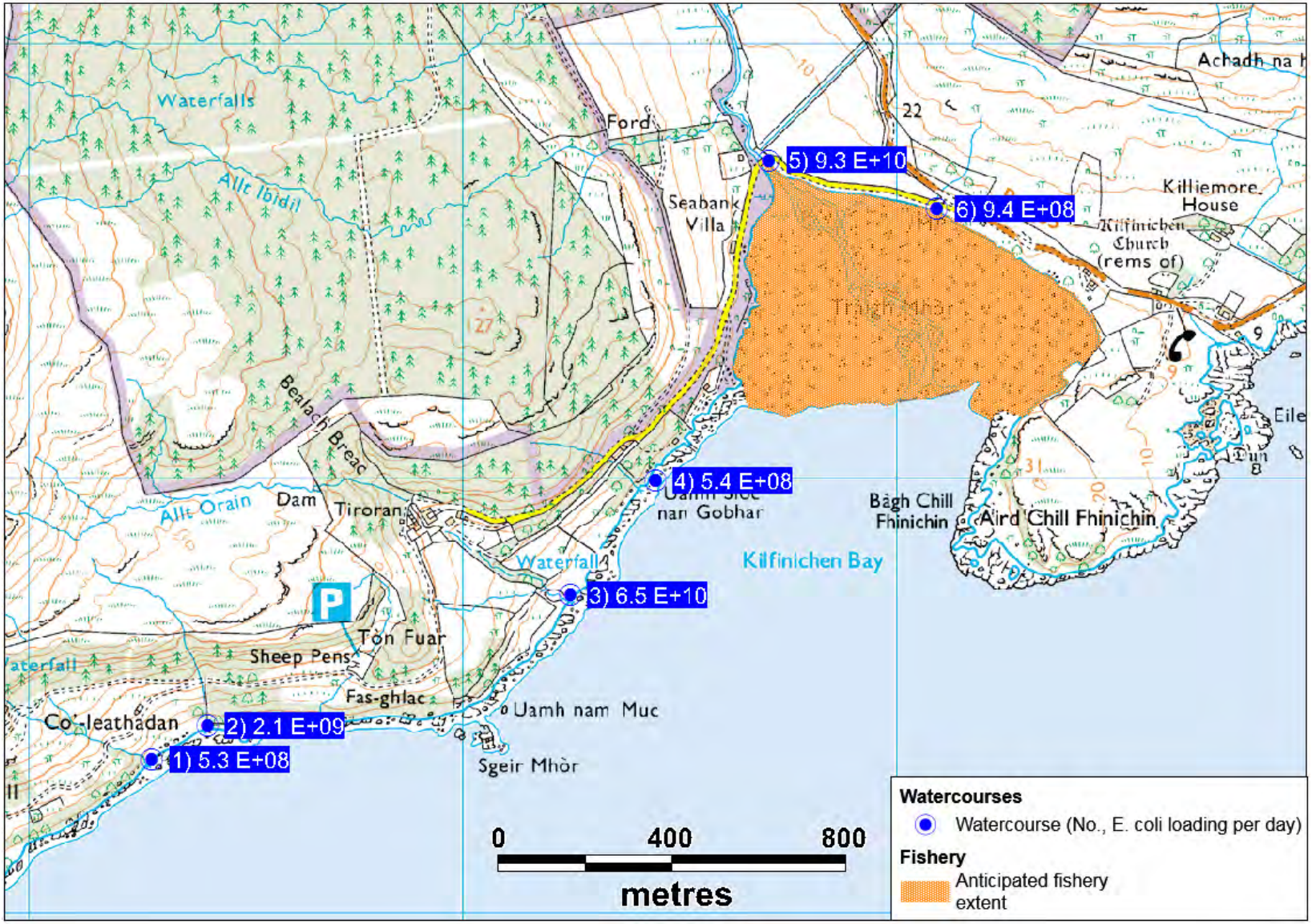

Figure 8.1 Map of watercourse loadings at Kilfinichen Bay

9. Meteorological Data

The nearest weather station for which a near complete rainfall data set was available is located at Mull: Gruline, situated approximately 13 km to the north east of the production area. Rainfall data was available for January 2008 – December 2013. The nearest wind station is Tiree, located 52 km northwest of the production area. Conditions may differ between this station and the fisheries due to the distances between them. However, this data is still shown as it can be useful in identifying seasonal variation in wind patterns.

Data for these stations was purchased from the Meteorological Office. Unless otherwise identified, the content of this section (e.g. graphs) is based on further analysis of this data undertaken by Cefas. This section aims to describe the local rain and wind patterns in the context of the bacterial quality of shellfish at Kilfinichen Bay.

9.1 Rainfall

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

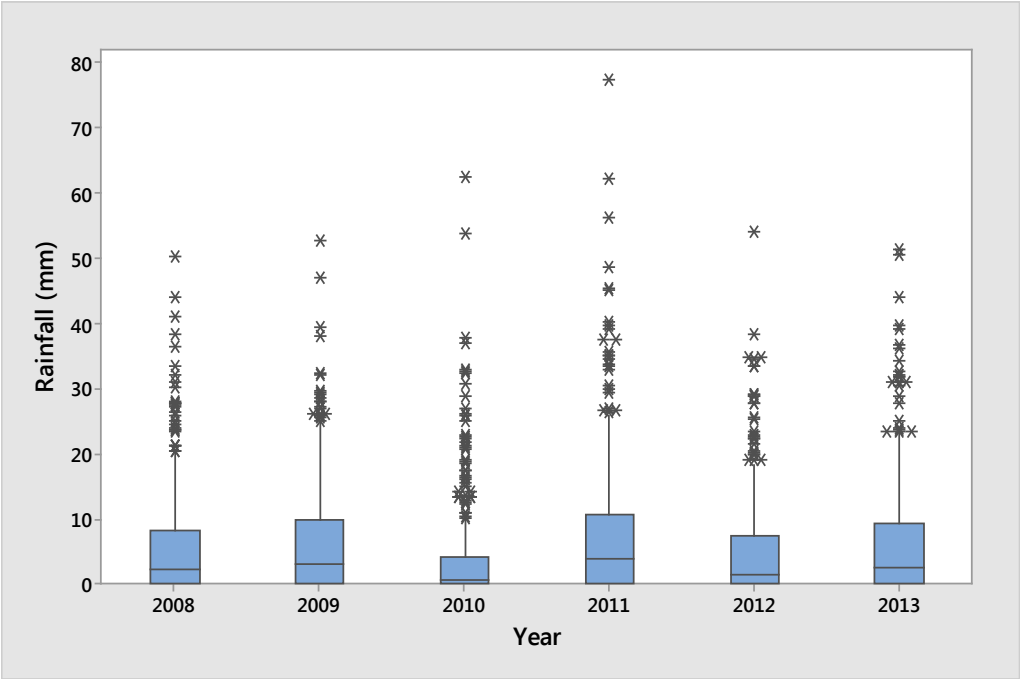

Figure 9.1 Box plot of daily rainfall values by year at Mull: Gruline (2008 – 2013)

Daily rainfall values varied from year to year, with 2010 being the driest year (1427 mm). The wettest year was 2011 (2738 mm). Rainfall values exceeding 50 mm/d occurred in all years, but a high rainfall event exceeding 70 mm/d was recorded in 2011

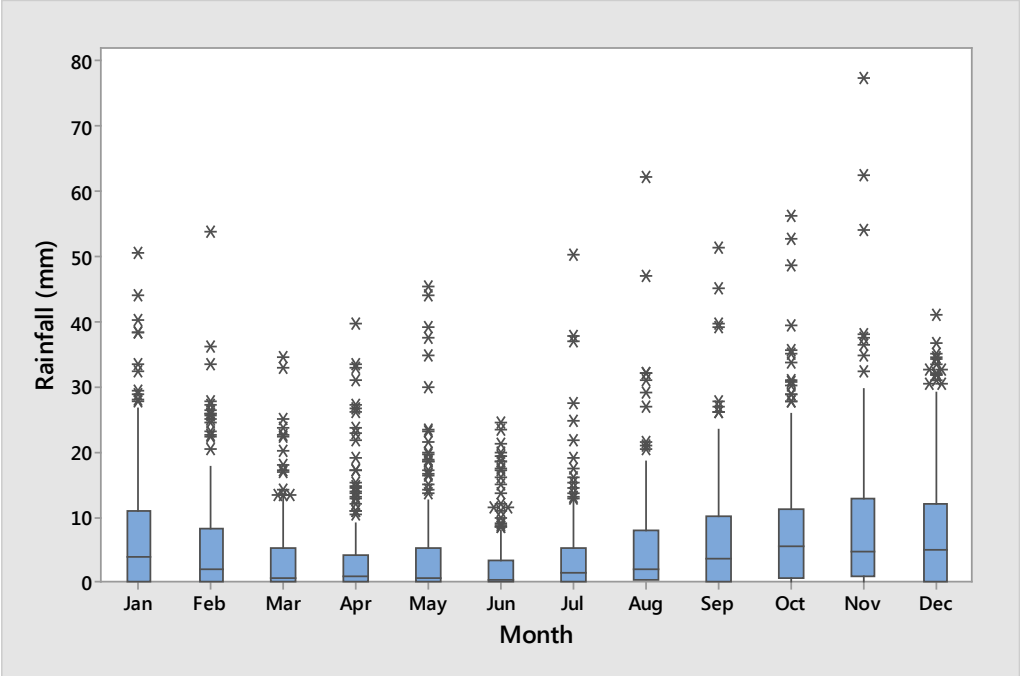

Figure 9.2 Box plot of daily rainfall values by month at Mull: Gruline (2008 – 2013)

Daily rainfall values were higher during the autumn and winter. Rainfall was greatest in November (1689 mm) and driest in June (490 mm). Rainfall values exceeding 50 mm/d occurred in all months between July and February, except for December, and rainfall values exceeding 60 mm/d were seen in August and November.

For the period considered here (2008 – 2013) 42 % of days received daily rainfall of less than 1 mm and 21 % of days received daily rainfall of over 10 mm.

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

9.2 Wind

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

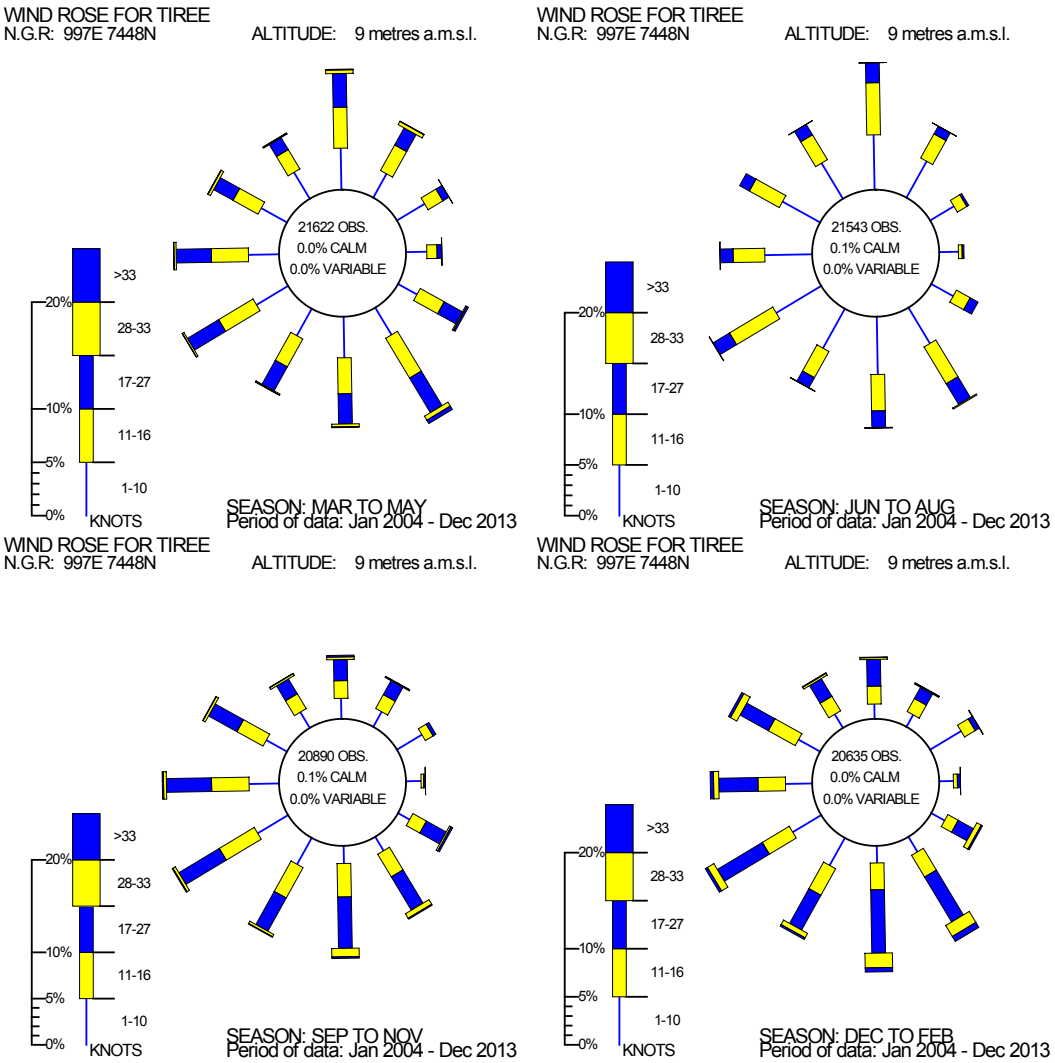

Figure reproduced under license from Meteorological Office. Crown Copyright 2012.

Figure 9.3 Seasonal wind roses for Tiree

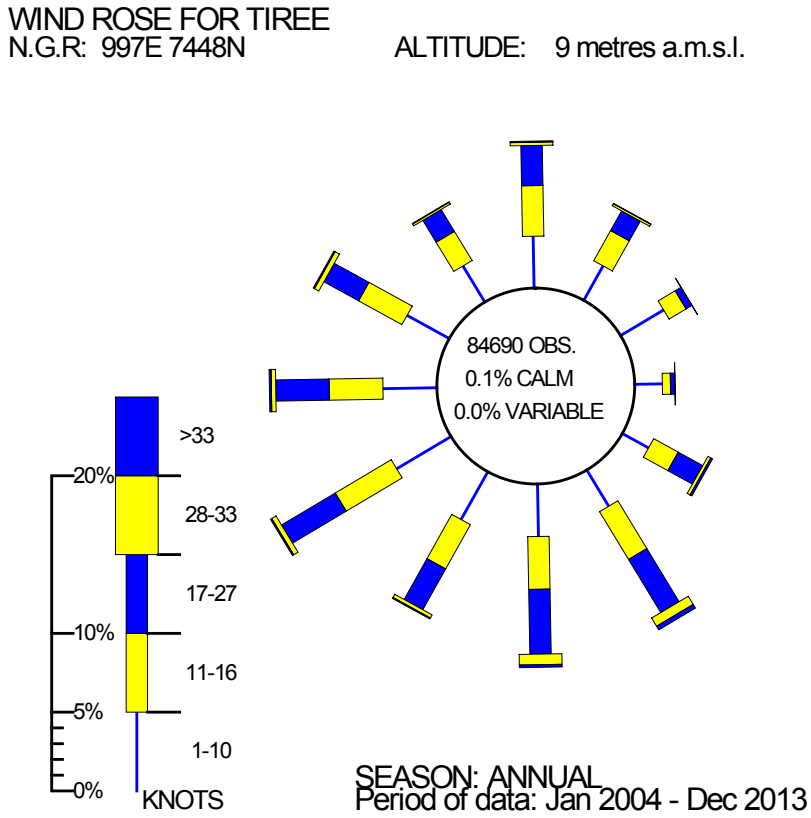

Figure 9.4 Annual wind rose for Tiree

Overall the winds predominantly came from between the south and west and to a lesser extent from the north. The strongest wind tends to come from the south. Seasonally the strongest winds occurred during the autumn and winter with wind strength much lower in the summer. Northerly winds tended to occur principally in spring and summer.

Wind is an important factor in the spread of contamination as it has the ability to drive surface water at about (3%) of the wind speed (Brown, 1991) so a gale force wind (34 knots or 17.2 m/s) would drive a surface water current of about 1 knot or 0.5 m/s. Therefore, strong winds can significantly alter the pattern of surface currents. Strong winds also have the potential to affect tide height depending on wind direction and local hydrodynamics of the site. A strong wind combined with a spring tide may result in higher than usual tides, which will carry any accumulated faecal matter at and above the normal high water mark into the production area.

10. Classification Information

Kilfinichen Bay was awarded a B classification for common cockles (*Cerastoderma edule*) from November to December 2014 and from January to March 2015.

Mussels located within Loch Scridain are currently classified as year-round class A.

11. Historical *E. coli* Data

Results for all samples assigned against Kilfinichen Bay production area for the period 01/01/2009 to the 18/09/2014 were extracted from the FSAS database on 18/09/2014 and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. All *E. coli* results were reported as most probable number (MPN) per 100 g of shellfish flesh and intravalvular fluid.

The 13 samples were identified as valid, were received within 48 hours of collection, had box temperatures of <8^{o}C and lay within the production area boundaries.

11.1 Summary of microbiological results

Sampling and result summaries of results assigned to Kilfinichen Bay between 2013 and 2014 are displayed in Table 11.1.

Table 11.1 Summary of historical sampling and results

Sampling Summary	
Production area	Kilfinichen Bay
Site	Kilfinichen Bay
Species	Common cockles
SIN	AB-695-1507-04
Location	Various
Total no of samples	13
No. 2013	4
No. 2014	9
Results Summary	
Minimum	20
Maximum	9200
Median	490
Geometric mean	402
90 percentile	1620
95 percentile	4700
No. exceeding 230/100g	7 (54%)
No. exceeding 1000/100g	4 (31%)
No. exceeding 4600/100g	1 (8%)
No. exceeding 18000/100g	0

Since sampling began in November 2013, half of the sampling results have exceeded 230 *E. coli* MPN/100 g.

11.2 Overall geographical pattern of results

The geographical locations of all sample results assigned to Kilfinichen Bay are mapped thematically in Figure 11.1. The majority of the samples have been taken on the eastern half of the cockle bed and lie within the RMZ boundaries. The highest sample of 9200 *E.*

coli MPN/100 g was reported as having been taken towards the northwest corner of the RMZ.

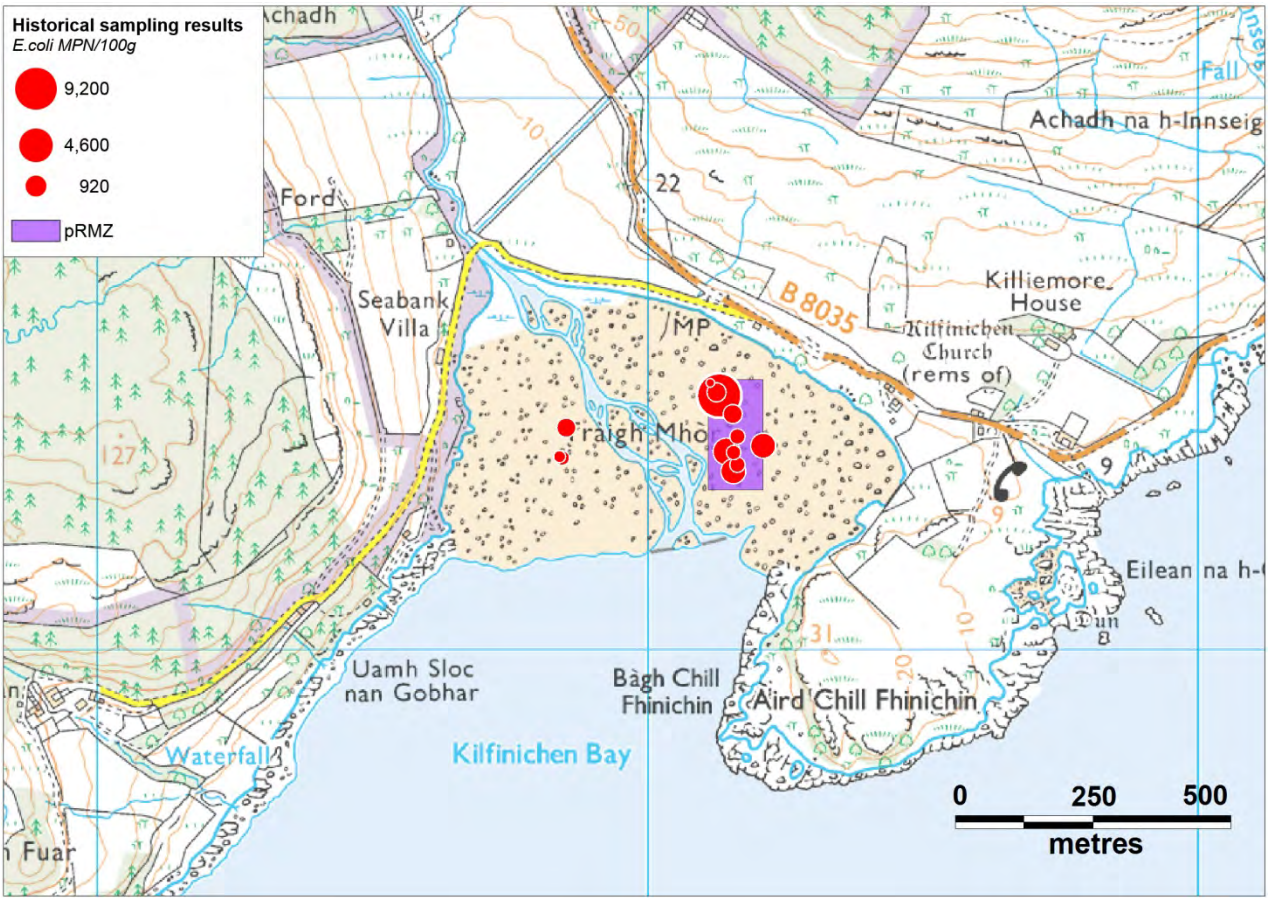

Figure 11.1 Map of reported sampling locations for common cockles at Kilfinichen Bay

11.3 Overall temporal pattern of results

A scatterplot of *E. coli* results against date for sites in Kilfinichen Bay is presented in Figure 11.2.

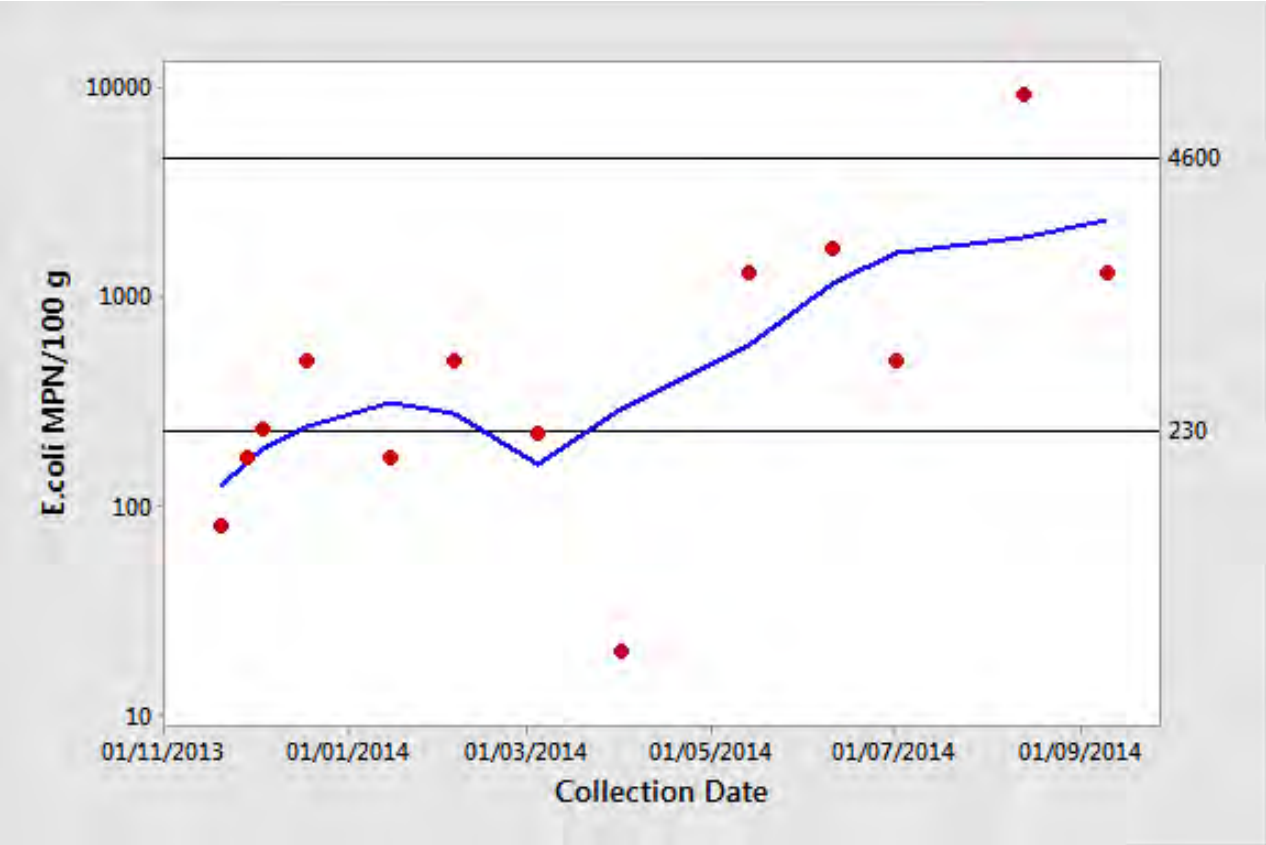

Figure 11.2 Scatterplot of *E. coli* results by collection date at Kilfinichen Bay, fitted with a lowess line

An increase in contamination levels at Kilfinichen Bay is apparent between November 2013 and August 2014, when the highest sample result was reported.

11.4 Summary and conclusions

Sampling at Kilfinichen Bay has only recently begun in November 2013, but already half of the sampling results have been >230 *E. coli* MPN/100 g. The highest result was obtained from a sample recorded as having been taken towards the northwestern extent of the RMZ. There was a noticeable increase in contamination levels in sampling results over the assessment period, with all four results >1000 *E. coli* MPN/100 g taken between May and September 2014. This may reflect a seasonal effect but it will only be possible to subject this to statistical analysis when results are available over at least a two year period.

12. Designated Waters Data

Shellfish Water Protected Areas

The Shellfish Waters Directive (2006/113/EC) has been repealed (as at 31 December 2013) and equivalent protection for areas previously designated under that Directive is given by The Water Environment (Shellfish Water Protected Areas: Environmental Objectives etc.) (Scotland) Regulations 2013. Kilfinichen Bay cockle bed is within the boundaries of the Loch Scridain Shellfish Water Protected Area (SWPA). The SWPA designation covers 30 km^2 including the majority of Loch Scridain and Kilfinichen Bay production area and shellfish bed. The designated SWPA for Loch Scridain is shown in Figure 12.1. Since 2007, assessment of the bacteriological status of shellfish waters has been undertaken using the shellfish hygiene *E. coli* data and this data has been reviewed in Section 11.

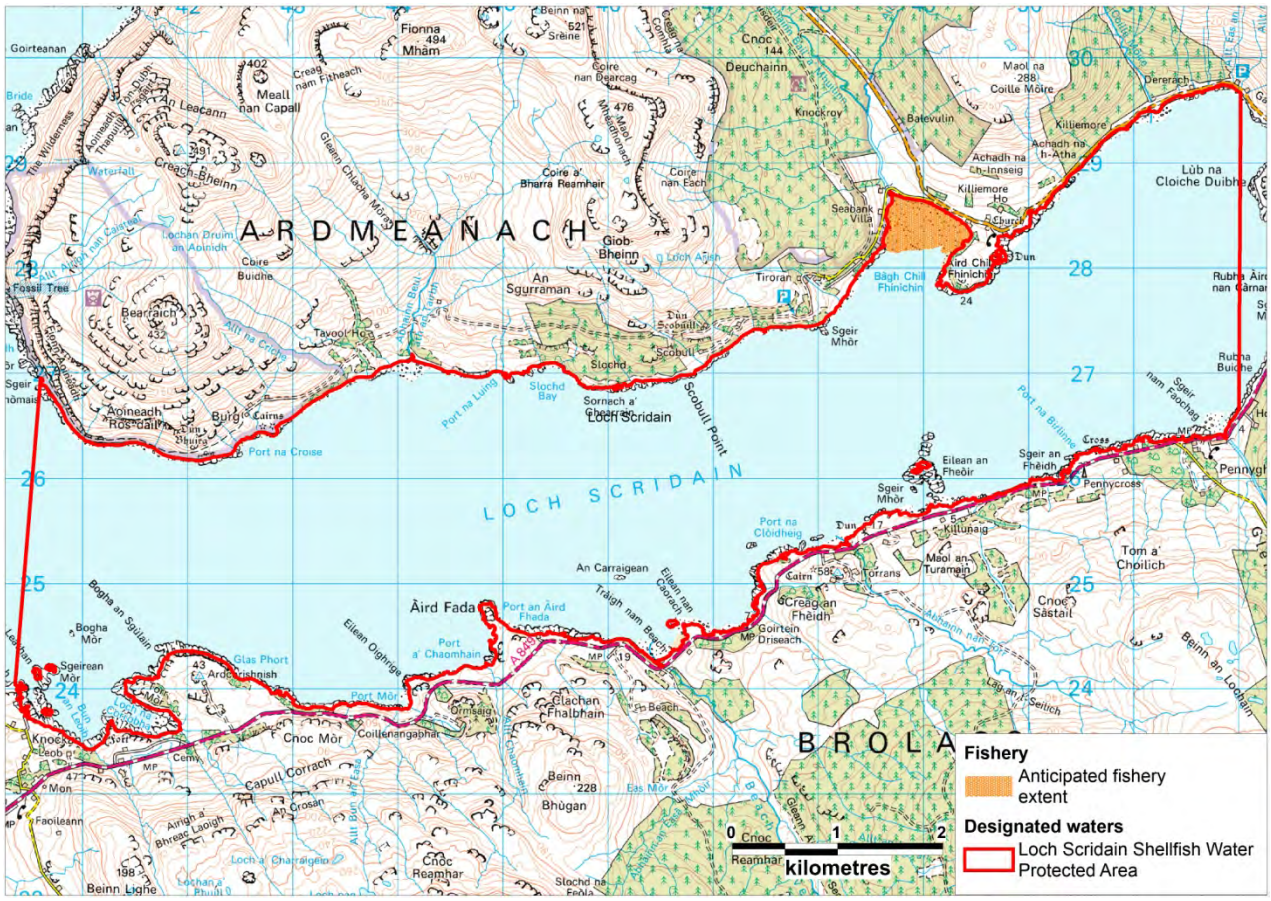

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Figure 12.1 Designated shellfish water protected area – Kilfinichen Bay

Bathing Waters

There are no designated bathing waters within Kilfinichen Bay.

13. Bathymetry and Hydrodynamics

13.1 Introduction

13.1.1 The Study Area

Kilfinichen Bay is an inlet located on the northern shore of the sea loch of Loch Scridain on the west coast of the Isle of Mull, Argyll and Bute. Kilfinichen Bay is bordered on its eastern side by the headland of Aird Kilfinichen, with the area known as Ardmeanach lying to the west. The extent of the hydrographic survey assessment area encompasses the entirety of Loch Scridain, within the red line in Figure 13.1 demarcating the western edge of the area, between the headlands of Carraig Chorrach and Rubha na h-Uamha.

The assessment area lies within a sparsely populated region. Loch Scridian is bounded along its southern shore by the A849 road, with the B8035 extending along the north eastern half of the shoreline.

Loch Scridain is open to the sea at its western end, with Loch Beg and the inlet An Leth Fhonn found at the head. Numerous small streams and burns flow into Loch Scridain, including Abhainn Bail a' Mhuilinn, which enters the loch through Kilfinichen Bay. The landscape surrounding Loch Scridain includes low hills and areas of woodland.

The total length of the assessment area is 19.3 km, with a maximum width of 4 km. Kilfinichen Bay lies roughly 6 km west of the head of Loch Scridain, and is approximately 1 km wide at its maximum point.

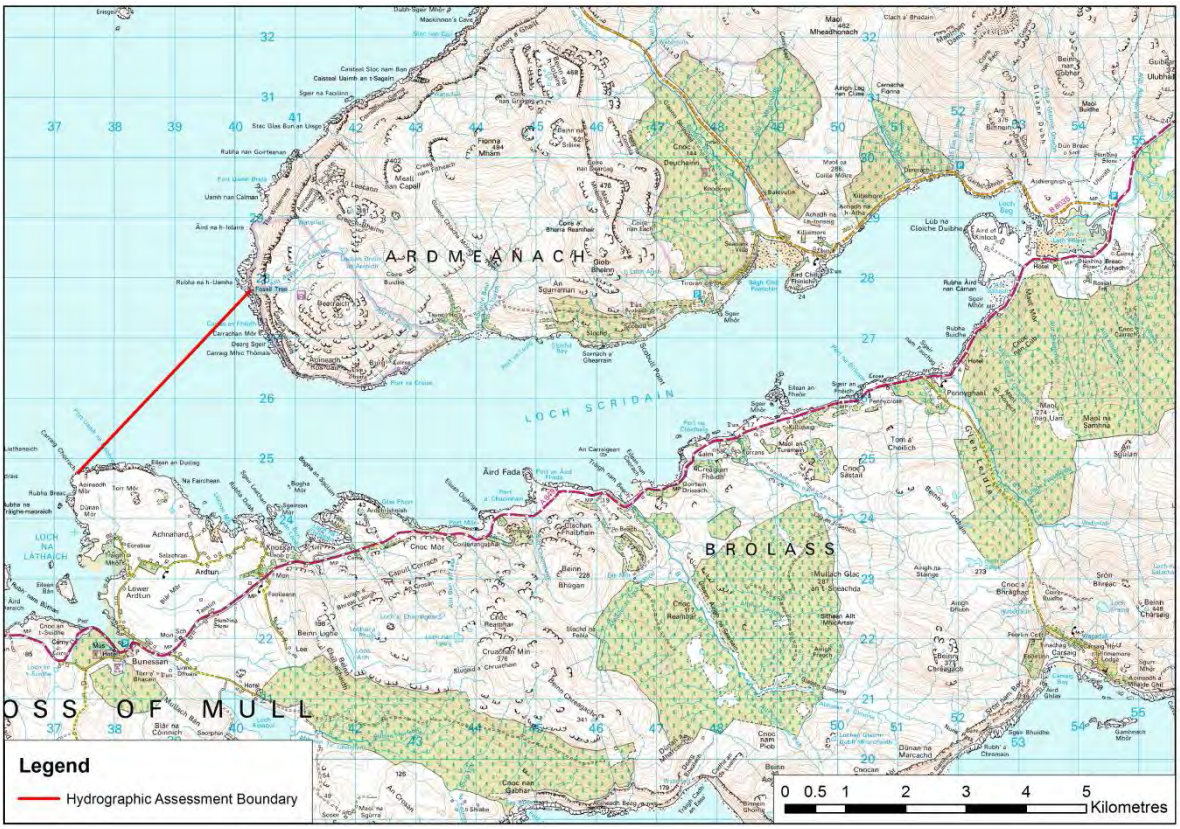


Figure 13.1 Extent of the hydrographic study area

Coordinates for Kilfinichen Bay: 56.376249 °N 006.070095 °W OSGB36

National Grid 148801.708 727877.4

13.2 Bathymetry and Hydrodynamics

13.2.1 Bathymetry

Figure 13.2 shows the bathymetry of the assessment area. There is one relatively deep sill at the western end of Loch Scridain, which stretches between Ardchrishnish on the southern side of the loch and Dun Bhuirg on the northern side. The mean depth of this sill is 34 m (Edwards & Sharples, 1986). The deepest point of Loch Scridain is found immediately to the east of this sill, reaching a depth of 120 m.

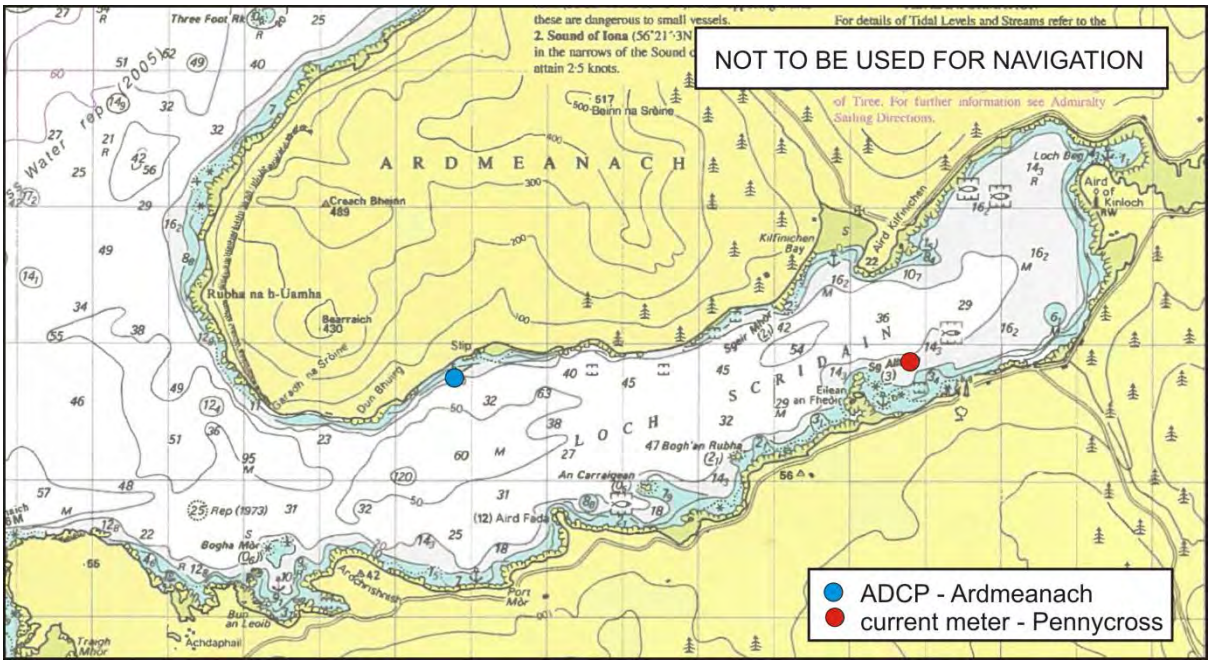


Figure 13.2 Admiralty chart (2771) extract for Kilfinichem Bay in Loch Scridain with ADCP and current meter stations indicated.

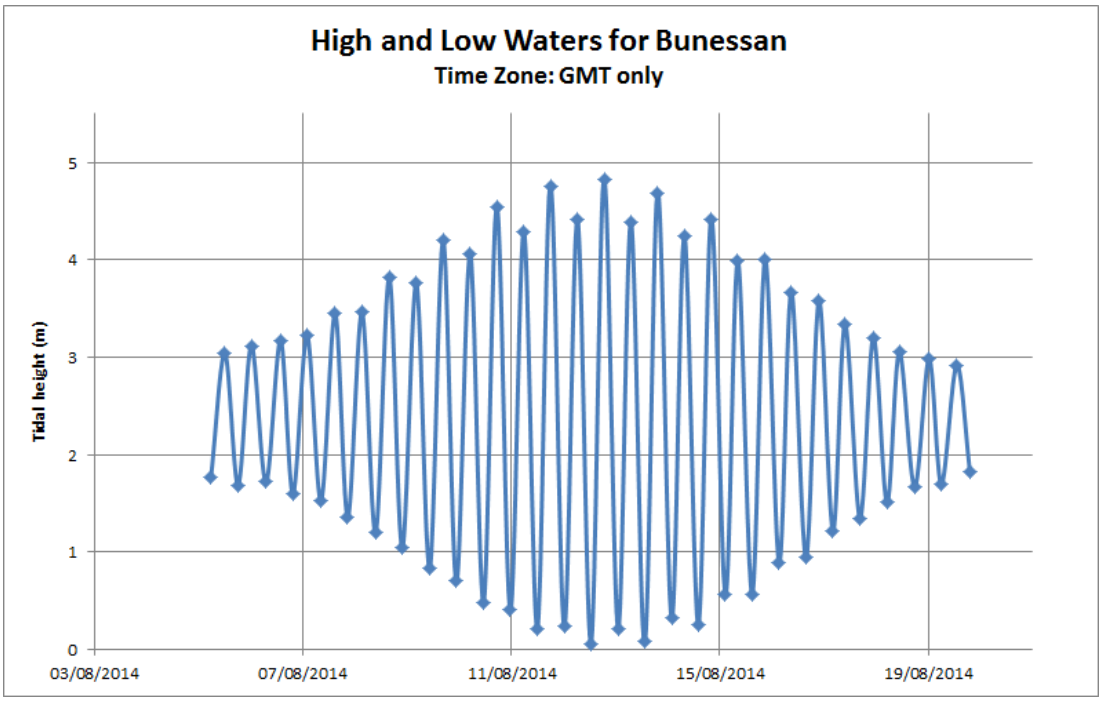
The mean depth of Loch Scridain at low water is 29.8 m, while the estimated low water volume is 7.5 x 10^8 m^3 (Edwards & Sharples, 1986).

Generally, bathymetry within the assessment area slopes steeply from the northern and southern shores of the loch to the basin, which averages approximately 30 m in depth along the length of the loch. Bathymetry shallows at the eastern end of the loch, and a large intertidal area of about 1 km^2 is found at its easternmost point, at the mouth of the Coladoir River.

13.2.2 Tides

Data on tidal information is provided based on tidal characteristics determined from Bunessan. Bunessan is just outside the assessment area, in Loch Na Làthaich 12 km west of Kilfinichen Bay.

Standard tidal data for Bunessan, centred around the survey date of 12th August 2014, are shown in Figure 13.3. Tidal predictions for Bunessan indicate that in this region the tidal characteristics are semi-diurnal, with a well-developed spring-neap cycle.



Reproduced from Poltips3 [www.pol.ac.uk/appl/poltips3]

Figure 13.3 Two week tidal curve for Bunessan.

Tidal heights in Bunessan, data from Poltips3 [www.pol.ac.uk/appl/poltips3]:

Mean High Water Springs = 4.30 m
Mean Low Water Springs = 0.60 m
Mean High Water Neaps = 3.00 m
Mean Low Water Neaps = 1.80 m

This gives an approximate tidal volume of water within the assessment area during each tidal cycle of:

Springs: 1.34×10^8 m^3
Neaps: 4.34×10^7 m^3

13.2.3 Tidal Streams and Currents

There are no published tidal diamonds for this area. Some enhancement of the speed of the tidal streams around headlands within Loch Scridain may be important.

ADCP data were available at one specified site within the assessment area: South Ardmeanach. Data were obtained from SEPA for this site, whose location is shown in Figure 13.4. Raw current meter data were available from SEPA at one further site, near Pennycross. The location of this site is also shown in Figure 13.4

The South Ardmeanach survey spanned a period of fifteen days, focussing on a half-lunar period in order to capture a spring-neap cycle: 15th – 30th December 2010 (Anderson Marine Surveys Ltd, 2011).

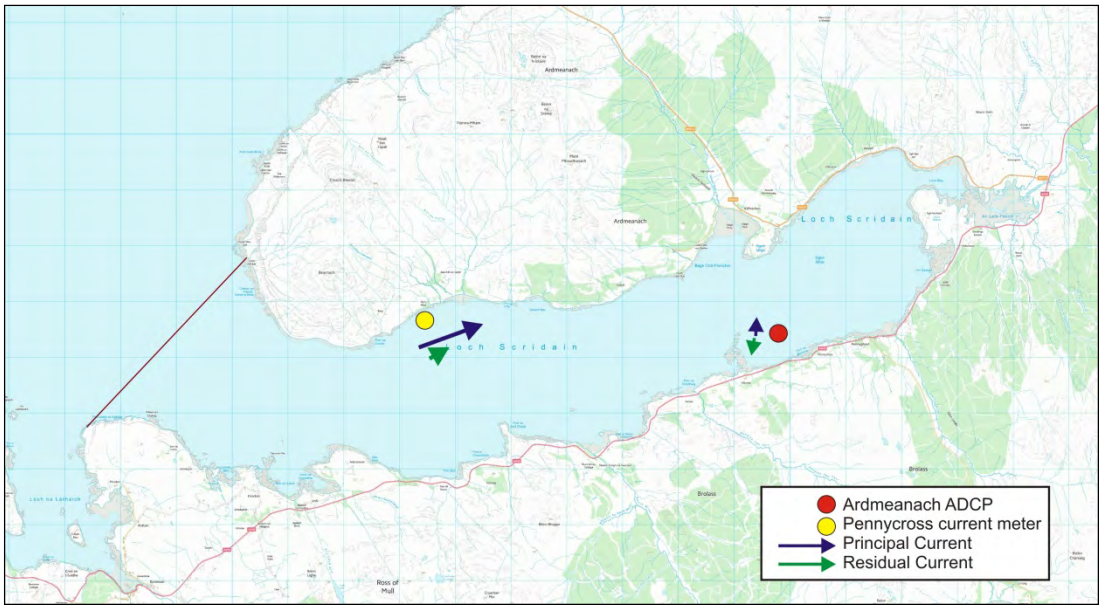


Figure 13.4 Map showing Loch Scridain ADCP and current meter sample sites within the assessment area.

Using the maximum principal current amplitude and residual current velocities and the assumption of a uniform sinusoidal tide, the cumulative transport distance and direction that might be expected during each phase of the tide is shown above.

Data from South Ardmeanach, N 56°21.621', W 006°06.09.337' were collected between 15/12/10 and 30/12/10 and are summarised in Table 13.1. The average water depth recorded for the duration of the survey was 36.2 m.

Whilst we note that mean current speeds are fairly similar across all depths measured, the principal current axis nearest the sea surface (15.5 m above seabed) is reported to flow in the opposite direction (i.e. it is shifted 180°) compared to the near bed and the mid-water levels (Anderson Marine Surveys Ltd, 2011). Given the nature of tidal forcing this 180° shift is rather unlikely, as tidal currents tend to flow in the same direction at the same time throughout the water column. The flood and ebb tides will be directed 180° to each other, so the reported 180° shift may be an artefact of the data analysis which

places more emphasis on the ebb tide (250° heading) at the surface and on the flood tide (70° heading) at mid-water and near-bed levels.

The data collected do not include the upper 20 m of the water column. Whilst previous interpretations of the data have argued that surface conditions will be similar to the 'sub-surface' measurements (Anderson Marine Surveys Ltd, 2011) we think it is likely that the surface measurements would show faster speeds on both flood and ebb tides due to the formation of a distinct surface layer, particularly at times of high run-off.

The strongest currents at the site are most frequently characterised by flows parallel to bathymetric contours, and broadly aligned with the adjacent shoreline in a west-southwest to east-northeast direction. The maximum recorded velocity was 0.138 m s^{-1}. The direction of the residual currents fall within a similar range as principal current directions (i.e. aligned with the axis of the loch), and residual current speeds were fairly similar across all depths measured and an order of magnitude smaller than the principal current. Current velocity and direction demonstrated periodicity over 12.5 hours at all depths, and recorded velocities varied across the spring-neap cycle as expected.

Table 13.1 South Ardmeanach current data measured in 2011. Note that the total water column depth is 36.2 m, so current data within the surface layer are not available

Average Depth	Near-bed (3.5 m above seabed)	Mid-water (9.5 m above seabed)	Sub-surface (15.5 m from seabed)
Mean Speed (ms^{-1})	0.035	0.041	0.037
Maximum Speed (ms^{-1})	0.111	0.138	0.130
Principal Axis Amp & Dir (ms^{-1}) & (^oM)	0.054 (070)	0.066 (070)	0.059 (250)
Residual speed (ms^{-1})	0.005	0.007	0.004
Residual direction (^oM)	091	060	288

A weather station was also deployed during the South Ardmeanach survey, close to the Ulva Ferry at 56°28.563'N 006°07.589'W. Wind speeds averaged 2.2 m s^{-1}, with a maximum recorded wind speed of 9.3 m s^{-1}. The strongest winds came from a north-westerly direction.

Using the largest recorded mean surface principal current and assuming a uniform sinusoidal tide, the cumulative transport that might be expected during each phase of the tide (approximately 6 hours) has been estimated for the South Ardmeanach site as 0.91 km (based on a surface principal current amplitude of 0.066 m/s). No distinction is made here for springs and neaps.

Data from Pennycross, NM 4987 2645 or N 56°21.852' W 006°03.020 were collected between 24/07/2000 and 07/08/2000 and are summarised in Table 13.2. The average water depth recorded for the duration of the survey was 21 m, and no data was recorded at mid-water depths.

Current speeds at Pennycross are slower than those at South Ardmeanach, and tidal flows are predominantly in a north-south direction. Current speeds and directions at this site may be influenced by the nearby rocky intertidal area and exposed rocks at Eilean an Fheòir.

Table 13.2 Pennycross current data measured in 2000. No data were recorded at mid-water depths.

Average Depth	Near-bed (3 m above seabed)	Sub-surface (18 m above seabed)
Mean Speed (ms^{-1})	0.017	0.025
Maximum Speed (ms^{-1})	0.115	0.104
Principal Axis Amp & Dir (ms^{-1}) & (^oM)	0.060 (006)	0.038 (003)
Residual speed (ms^{-1})	0.002	0.006
Residual direction (^oM)	145	190

Mean current speeds are stronger near the surface than near the seabed, though the maximum current speed of 0.115 ms^{-1} was recorded near the seabed. Residual currents generally flow along the same axis (north-south) as the principal current, but with an easterly component near the seabed. Residual current velocities are an order of magnitude slower in terms of velocity. As at the South Ardmeanach site, current velocity and direction demonstrated periodicity over 12.5 hours at all depths, and recorded velocities varied across the spring-neap cycle as expected.

Weather data corresponding with the Pennycross current meter deployment was not available, and a cursory search on the British Atmospheric Data Centre's database (www.badc.nerc.ac.uk) did not reveal any nearby wind speed datasets covering the specified survey period.

Using the mean surface principal current and assuming a uniform sinusoidal tide, the cumulative transport that might be expected during each phase of the tide (approximately 6 hours) has been estimated for the Pennycross site as 0.34 km (based on a surface principal current amplitude of 0.025 ms^{-1}). No distinction is made here for springs and neaps.

In general, the current meter data from South Ardmeanach and Pennycross suggest that Loch Scridain will be weakly flushed.

Dispersion is an important property of a water body with respect to redistribution of contaminants over time. There are no measurements or published data relating to dispersion in Loch Scridain. Without such data it is difficult to judge what the dispersive environment might be like. However, in Loch Scridain there are few islands and no narrowings or shallow sills to enhance dispersion.

Dispersion of surface contaminants may be enhanced by wave energy within Loch Scridain. Sources of wave energy are from both short period waves generated within the

loch itself and longer period swells originating from the waters to the west which are open to the North Atlantic Ocean.

13.2.4 River/Freshwater Inflow

Three rivers and several larger streams flow into Loch Scridain. The Coladoir River flows into a large intertidal area, An Leth-Fhonn, at Loch Beg, which joins Loch Scridain at its easternmost end. The Leidle River flows into the southern side of Loch Scridain, 500 m to the east of the settlement Pennyghael, and the Beach River flows into the southern side of the loch approximately 5 km to the west. The stream, Abhainn Baile a'Mhuilinn, flows into the northern boundary of Loch Scridain, while Abhainn nan Torr, Allt an t-Sluichd Odhair, and Allt Loch Arm all flow into the southern side of the loch. Several other lesser streams also flow into the assessment area along both northern and southern boundaries.

The annual precipitation for Loch Scridain is approximately 1800 mm and the annual freshwater runoff is estimated as 305 M m^3 yr^{-1} (Edwards & Sharples, 1986) with high seasonal variability. The ratio of freshwater flow to tidal flow is moderate compared to other sea lochs at approximately 1:160 (Edwards & Sharples, 1986), and this ratio will be also be seasonally variable.

13.2.5 Meteorology

The nearest weather station for which a continuous rainfall dataset is available is located at Gruline, Mull. This station is situated approximately 13 km to the northeast of the assessment area. Rainfall records are available from January 2008 to December 2013.

While 2010 generally was the driest year (1427 mm), the highest rainfall for this time period was recorded in 2011 (2738 mm). High rainfall values (> 50 mm d^{-1}) occurred in every year, but rainfall events of > 60 mm d^{-1} were recorded in August 2010 and November 2011.

Daily rainfall varied seasonally, from lower values in spring and summer months (March - June) to higher values in the autumn and winter months (August - February). Mean rainfall at Gruline peaks in November, and the 2011 extreme rainfall event of approximately 77 mm d^{-1} occurred in that month. For the duration of the dataset, daily rainfall of below 1 mm occurred on 42% of days, while daily rainfall above 10 mm occurred on 21% of days.

Run-off due to rainfall is expected to be highest in the autumn and winter months. However, it must also be noted that high rainfall events occurred in most months and consequently that high run-off can occur throughout the year.

Wind data were obtained from Tiree Airport, located 52 km to the northwest of the assessment area. Given the distance between these two locations and varying topography, wind statistics may not be directly transferrable to the specific production

area at Kilfinichen Bay. They are, however, valuable in providing the general pattern of the seasonal wind conditions. Data collected between January 2004 and December 2013 indicate that the predominant wind direction is between south southeast and west. There was also a lesser, but significant, proportion of northerly winds. Seasonally the strongest winds occurred during the autumn and winter. Typically the wind came from around the south and west throughout the year but the summer also saw winds from the northeast. The northerly winds occur mainly in the spring and summer. Local wind directions in Loch Scridain are likely to be somewhat influenced by the surrounding topography.

13.2.6 Model Assessment

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

The box model quantifies the primary exchange mechanisms. The key outputs from the model with respect to this hydrographic assessment is a series of annual mean values that describe the relative importance of the estuarine (gravity) exchange, tidal exchange, and the flushing time, which is the inverse of the exchange rate. These values are given in Table 13.3

Table 13.3 Summary of annual mean parameter values from the box modelling exercise.

Parameter	Value
Tidal Volume Flux ($m^3 s^{-1}$)	33
Estuarine Circulation Volume Flux ($m^3 s^{-1}$)	114
Median Flushing Time (days)	60
95%-ile Flushing Time (days)	79

The ratio of tidal volume flux to estuarine circulation volume flux is less than 0.5 so the estuarine exchange is dominant (Gillibrand, et al., 2013).

The exchange time for the surface and intermediate layers is calculated as 60 days which is much longer compared to the tidal prism estimate of 5.5 days (Marine Scotland, 2012). It is known that the tidal prism method overestimates exchange rates and the large difference suggests that the exchange environment is less efficient than can be captured by simple volume tidal exchanges.

13.3 Hydrographic Assessment

13.3.1 Surface Flow

The site and meteorological data indicate that the discharge of freshwater into the surface will occur around the perimeter of Loch Scridain and directly into the assessment area of Kilfinichen Bay. The meteorological data indicate a moderate seasonal variation in freshwater discharge which will mean that the estuarine exchange has a seasonal variation also. Nevertheless, it is apparent from the tidal and freshwater exchange volumes that freshwater discharge is an important aspect of circulation and exchange in this system.

The relatively weak tidal flow and the abundance of freshwater sources in Loch Scridain indicate that it is likely that a well-developed surface layer will form in many areas of the loch, particularly towards the head. A distinct fresh surface layer can be more easily influenced by winds giving rise to complex current systems that can vary with depth.

From the current meter record located along the northern shore of Loch Scridain it is presumed that the flow of water is rather simple with axial flow on the flood and ebb tides that follows the alignment of the loch. The cumulative transport distance on each phase (flood/ebb) of the tide has been estimated at around 0.9 km, which is rather small compared to the length of the loch.

The current meter record located on the southern shore suggests significantly weaker localised flow in the inner part of the loch that is probably influenced by local bathymetry and islands.

The residual flows during the period of measurement are rather weak and somewhat variable in direction. Surface residual flows would be enhanced by winds along the axis of the loch and an inflowing residual might be related to winds blowing with a dominant westerly component.

Net transport of contaminants is related to the residual flow documented in Table 13.2. The residual flows in the surface waters of the assessment area are shown to be rather small and most likely related to variation in the localised wind and freshwater conditions. Using a value of residual flow speed measured at the surface (0.005 m/s), the net transport over a tidal cycle of approximately 12 hours would be around 0.2 km. This is much less than the transport from tidal flow.

From the current meter measurements in Scridain it is likely that any surface contaminant in the loch would be transported along rather short distances on each tidal cycle which could increase its residence time in the loch.

13.3.2 Exchange Properties

The box modelling has shown that the flushing time for the surface and intermediate depth waters within the assessment area is around 60 days. This is much greater than a simple tidal prism approach and may reflect a complexity in exchange that exists in the assessment area. Winds from the west may further reduce the effective flushing of the loch. Despite there being an apparently strong estuarine flow, the current meter data and the variability in freshwater discharge suggests that the assessment area can be described as being 'weakly flushed'.

Although the assessment is bathymetrically rather simple, having only two current meter deployments inherently limits the extent to which the circulation and exchange within Loch Scridain can be described. In the local region of Kilfinichen Bay there are no direct measurements of currents. It is possible that a rotary circulation around the Bay could be set up on each tide, with potentially a counter-clockwise rotation on the flood tide through deflection of the flow by Aird Kilfinichen. Further, the river discharging directly in to Kilfinichen Bay could enhance surface flow out of the bay. Hence, exchange and dispersion within the bay could be greater than for the majority of the assessment area. In general, there is also a paucity of measured hydrographic data or descriptive literature on exchange properties for the area. However, it is possible to make a very broad and qualitative assessment of the likely exchange environment. Consequently, the confidence level of this assessment is LOW.

14. Shoreline Survey Overview

The Kilfinichen Bay shoreline survey was carried out on the 13th August 2014. There was a mixture of light and heavy rain in the preceding 48 hours to the survey and on the day of the survey. The temperature was 14°C, with a wind of F5 reducing to F3 in a NW/W.

The fishery consists of a wild harvest common cockle fishery. The harvester (Mr Marshall) plans to harvest the bay by hand on a part time basis in the near future, specifically in the winter months. The harvester stated that there was a patchy distribution of cockles, with some densely colonised areas.

There is a small population on land adjacent to Kilfinichen Bay and a hotel was noted at Tiroran. Two STs with pipes were observed, but access difficulties prevented the surveyors from determining whether they were flowing. A seawater sample taken close to the end of one of the STs returned a moderately contaminated seawater result of 38 *E. coli* cfu/100 ml. A third pipe with no visible ST was noted within the bay itself, though the end was similarly not visible. A discharging sewage pipe was noted to the southwest of the bay and a freshwater sample taken from the flow returned exceedingly very high result of 10,000,000 *E. coli* cfu/100 ml, indicating marked sewage contamination.

A seawater sample taken on the eastern shoreline of the bay returned a high result of 400 *E. coli* cfu/100 ml.

A pier, slipway and beach slipway were observed west of the bay at Uam nan Gobhar. Two moorings with small pleasure craft were noted on the west side of the mouth of the bay, and there were two empty moorings below the hotel at Tiroran.

A total of 102 sheep were noted, with large flocks seen southeast around Killiemore House and north of the bay around a feeding station. Four cattle were also noted to the southeast at Killiemore House.

Land was rural and split between crofting/small scale farming and forestry. Plantation forest dominated land north and west of the bay, whilst fields and open ground and some small areas of native woodland were found to the east. Around the shores of the bay lay grazing land with a mix of native and plantation forest.

The largest watercourses observed were the Abhainn Bail a Mhuilinn and Ally Orain, with numerous smaller watercourses also noted. Freshwater sample results from watercourses varied between 40 and 580 *E. coli* cfu/100 ml.

The only wildlife observed was eight gulls.

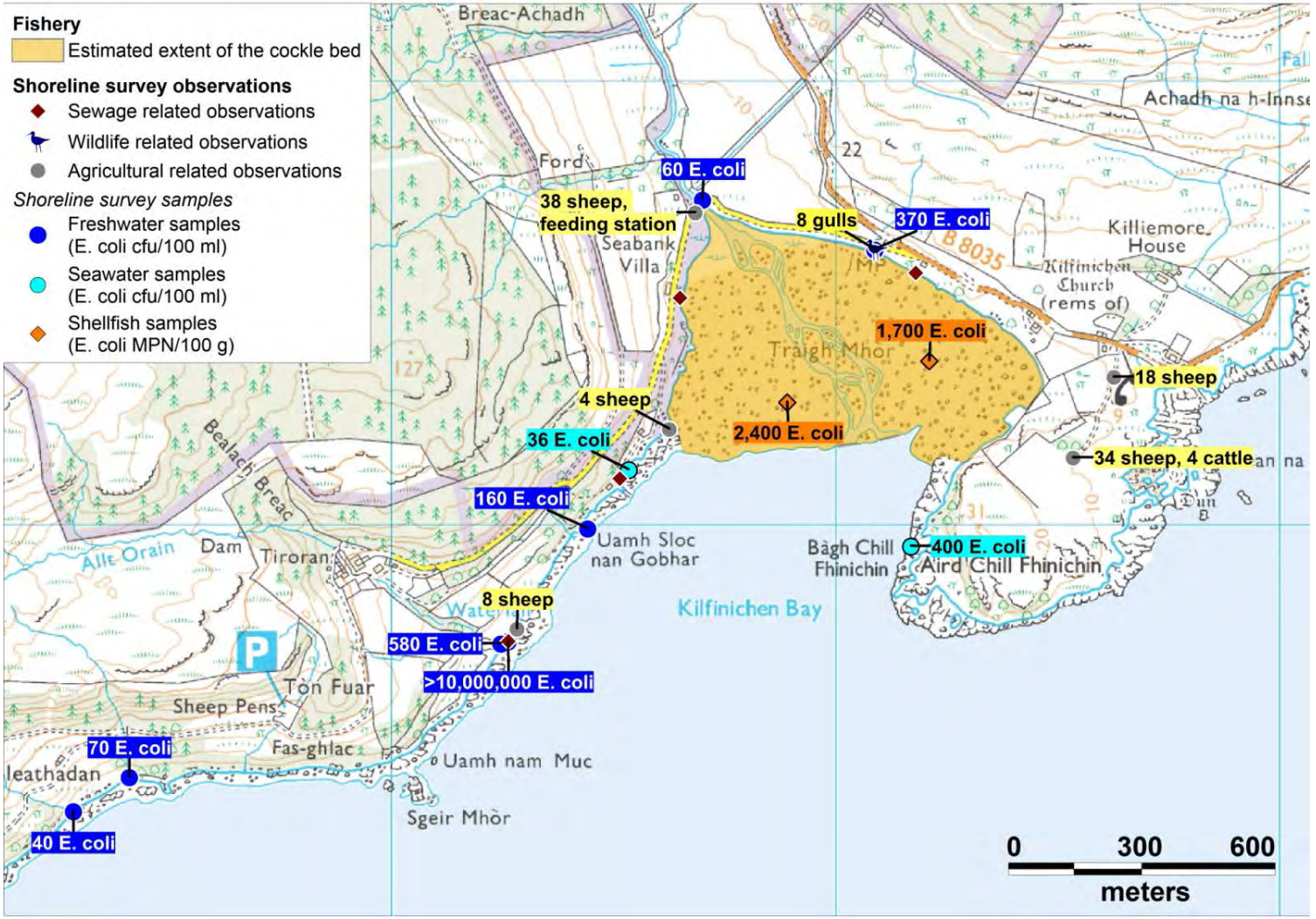


Figure 14.1 Summary of shoreline survey findings for Kilfinichen Bay

15. Bacteriological Survey

A bacteriological survey was undertaken at Kilfinichen Bay to help inform the assessment of spatial impacts from potential sources of contamination in the area. Sampling was undertaken by hand-raking on two occasions at two locations that had been sampled during the shoreline survey. The locations are shown in the map in Figure 15.1. The results, together with the geometric mean and maximum values for these at each site, are given in Table 15.1.

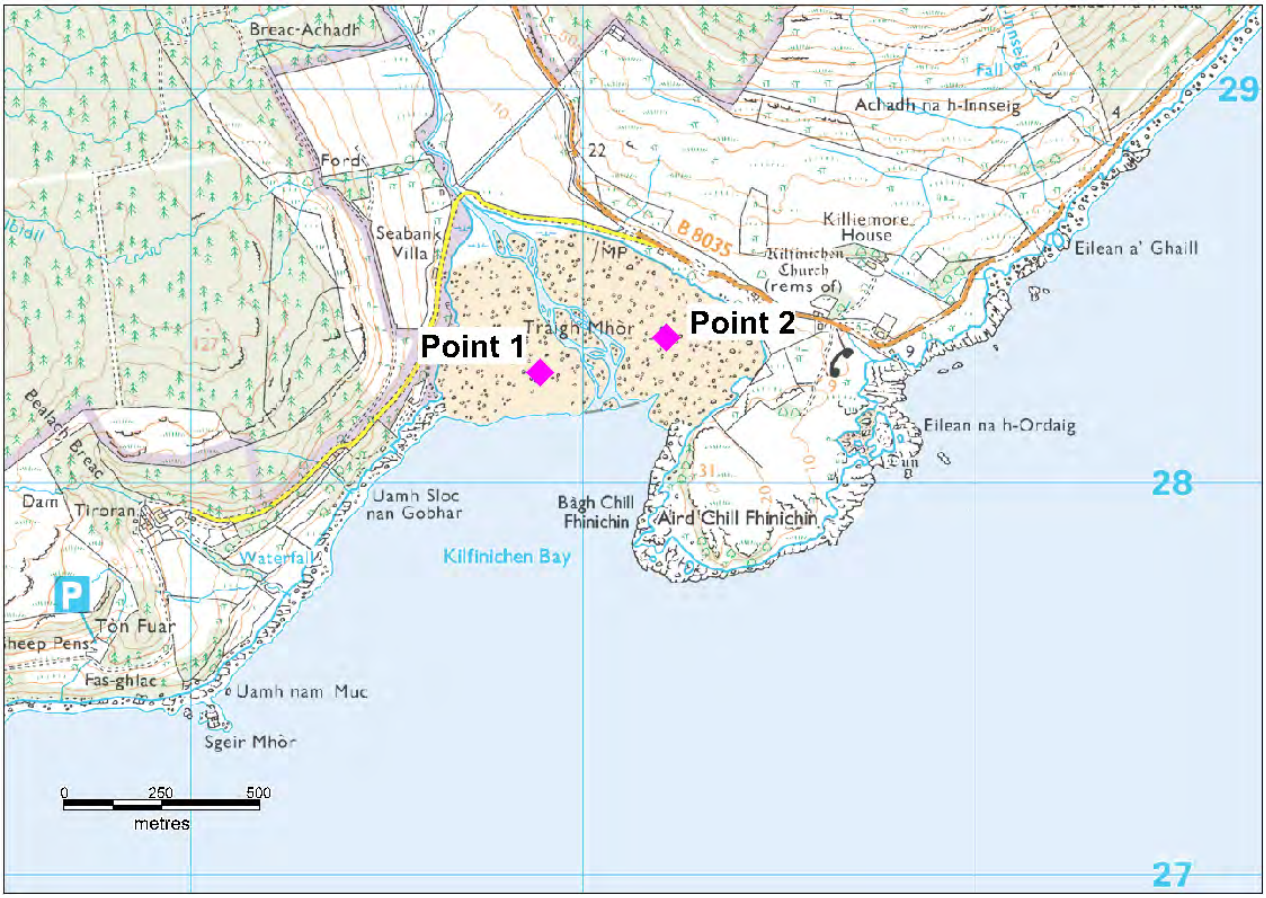


Figure 15.1 Bacteriological survey sampling locations

Table 15.1. Bacteriological survey results

Sample point	NGR	*E. coli* MPN/100 g				
		13/08/2014	09/09/2014	23/09/2014	Geometric mean	Maximum
1	NM 4889 2829	2400	330	230	567	330
2	NM 4921 2837	1700	170	270	427	270

The highest geometric mean and maximum *E. coli* values from the three sets of samples were seen at sample point 1. The results of samples taken at both points during the shoreline survey were markedly higher than those taken on the two subsequent occasions.

16. Overall Assessment

Human sewage impacts

The human population in the vicinity of Kilfinichen Bay is very small. However, there are some small sewage discharges within, and immediately outside the bay and these will impact on the microbiological quality of the cockles.

Agricultural impacts

Sheep were observed at a number of locations around the bay during the shoreline survey and thus may contribute to faecal contamination around the shellfish bed. Those grazing around Abhainn Bail a Mhuilinn will contribute to contamination levels in that watercourse affecting the northwestern and central parts of the bed.

Wildlife impacts

Faecal impacts from wildlife are expected to be relatively low and sporadic, both spatially and temporally.

Seasonal variation

There is some tourist accommodation in the area and so, given that the population is generally low, this will potentially have a marked effect on pollution arising from human sources during the summer months. Contamination from farm animals is expected to be higher during the spring and summer.

The harvester identified that he is expecting to concentrate harvesting during the winter months.

Rivers and streams

Overall, freshwater inputs are expected to provide moderate to high levels of contamination to the cockle bed in Kilfinichen Bay, with the highest impact expected on the northwestern and central parts of the bed. That associated with Abhainn Bail a Mhuilinn will occur over all states of tide while that associated with Allt Orain will only impact at the shellfish bed on a flood tide.

No salinity profiles were taken during the shoreline survey due to the intertidal nature of the area. Salinity results on spot samples taken during that survey did not show any significant freshwater influence.

Movement of contaminants

The hydrographic assessment identified that the strongest currents within Loch Scridain were broadly aligned with the shoreline. The transport distance over a single tidal phase (flood or ebb) was estimated to be approximately 0.9 km. This means that sources

closest to the shellfish bed are most likely to have an impact there. The drying nature of Kilfinichen Bay means that contaminants will flush from the bay on each tidal cycle. However, the low residual flow within the loch will mean that a proportion could re-enter the bay over the following tide.

Temporal and geographical patterns of sampling results

Only a small number of cockle samples had been submitted at the time of assessment for this report. Most of these had been taken within the pRMZ area and the highest result was seen to the northwestern extent of that area. However, a bacteriological survey showed generally higher results at a location to the west of the pRMZ.

Conclusions

Although the human and farm animal populations around Kilfinichen Bay are low, the confined nature of the area means that local sources will impact on the microbiological quality of cockles within the bay. In addition to direct inputs, contamination will be associated with watercourses, primarily Abhainn Bail a Mhuilinn. Available information indicates that contamination will be greatest on the western side of the bay.

17. Recommendations

A summary of the recommendations is shown in Figure 17.1.

Production area

It is recommended that the present production area be maintained. This encompasses the whole fishery. It is not possible to exclude those small sewage inputs that impact on the production area without markedly reducing the area available for harvest. The production area is therefore defined as: the area bounded by lines drawn between NM 4843 2800 and NM 4920 2800 extending to MHWS.

RMP

It is recommended that the RMZ is moved to the west of the current position in order to reflect the higher levels of contamination seen on the western side of the bay. The RMZ is therefore the area bounded by lines drawn from NM 4880 2845 to NM 4890 2845 to NM 4890 2825 to NM 4880 2825 and back to NM 4880 2845.

Tolerance

No tolerance is applicable for an RMZ.

Depth of sampling

Not applicable as the cockles will be hand-raked.

Frequency

Sampling should be undertaken monthly.

Figure 17.1 Map of recommendations at Kilfinichen Bay

18. References

Anderson Marine Surveys Ltd, 2011. *South Ardmeanach - site and hydrographic survey report. AMSL Report No 11/02.9 - rev0,* s.l.: s.n.

Brown, J., 1991. The final Voyage of Rapaiti:A measure of surface drift velocity in relation to the surface wind. *Marine Pollution Bulletin,* 22(1), pp. 37-40.

Clyde Cruising Club, 2007. *Sailing Directions and Anchorages - Part 2 Kintyre to Ardnamurchan.* Glasgow: Clyde Cruising Club Publications, Ltd..

Edwards, A. & Sharples, F., 1986. *Scottish Sea Lochs: a Catalogue,* Oban: Scottish Marine Biological Association/Nature Conservancy Council.

Gillibrand, P. A., Inall, M. E., Portilla, E. & Tett, P., 2013. A Box Model of Seasonal Exchange Mixing in Regions of Restricted Exchange: Application to Two Contrasting Scottish Inlets. *Environmental Moddeling and Software,* Volume 43, pp. 144-159.

Hebridean Whale and Dolphin Trust, 2014. *Recent Sightings.* [Online] Available at: http://www.whaledolphintrust.co.uk/sightings.asp [Accessed 28 10 2014].

JNCC, 2014. *Seabird colony data.* [Online] Available at: http://jncc.defra.gov.uk/page-4460 [Accessed 23 05 2014].

Kay, D. et al., 2008. Faecal indicator organism concentrations and catchment export coefficients in the UK. *Water Research,* 42(10/11), pp. 2649-2661.

Kilfinichen Estate, 2014. *Kilfinichen Estate.* [Online] Available at: http://www.kilfinichen.com/ [Accessed 28 10 2014].

Lee, R. J. & Morgan, O. C., 2003. Envrionmental factors influencing the microbial contamination of commercially harvested shellfish.. *Water Science and Technology,* Issue 47, pp. 65-70.

Mallin, M. A. et al., 2001. Demographis, landscape and meterological factors controlling the microbial pollution of coastal waters. *Hydrobiologica,* Issue 460, pp. 185-193.

Marine Scotland, 2012. *Locational Guidelines for the authorisation of marine fish farmes in Scottish waters.,* Edinburgh: Produced for Marine Scotland Science by the Marine Scotland Performance Graphics Group.

Mitchell, I. P., Newton, S. F., Ratcliffe, N. & Dunn, T. E., 2004. *Seabird populations of Britain and Ireland: results of the Seabird 2000 census (1998-2002),* London: T & A D Poyser.

Special Committee on Seals, 2013. *Scientific Advice on Matters Related to the Management of Seal Populations 2013,* St Andrews: St Andrews University; Sea Mammal Research Unit.

Wild Future Outdoors Ltd., 2014. *Wildlife & Wild Places, Isle of Mull.* [Online] Available at: http://www.wildfuture.co.uk/index.php/isle-of-mull-wildlife-a-wild-places [Accessed 28 10 2014].

19. List of Figures and Tables

Appendices

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

1. General Information on Wildlife Impacts

Pinnipeds

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

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

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

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

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

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

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

Cetaceans

As mammals, whales and dolphins would be expected to have resident populations of *E. coli* and other faecal indicator bacteria in the gut. Little is known about the concentration of indicator bacteria in whale or dolphin faeces, in large part because the animals are widely dispersed and sample collection difficult.

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

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

Birds

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

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

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

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

Deer

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

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

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

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

Otters

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

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

References

Alderisio, K. A. & DeLuca, N., 1999. Seasonal enumeration of fecal coliform bacretia from the feces of ring-billed gulls (Larus delawerensis) and Canada geese (Branta canadensis). *Applied and Environmental Microbiology,* 65(12), pp. 5628-5630.

Gauthier, G. & Bedard, J., 1986. Assessment of faecal output in geese. *Journal of Applied Ecology,* 23(1), pp. 77-90.

Lisle, J. T., Smith, J. J., Edwards, D. D. & McFeters, G. A., 2004. Occurence of microbial indicators and Clostridium perfringens in wastewater, water coloum samples, sediments, drinking water and weddel seal faeces collected at McMurdo Station, Antarctica. *Applied and Environmental Microbiology,* 70(12), pp. 7269-7276.

Poppe, C. et al., 1998. Salmonella typhimurium DT104: a virulent and drug-resistant pathogen. *The Canadian Veterinary Journal,* 39(9), pp. 559-565.

Scottish National Heritage, n.d. *Otters and Development.* [Online] Available at: http://www.snh.org.uk/publications/on-line/wildlife/otters/biology.asp [Accessed 10 10 2012].

Stoddard, R. A. et al., 2005. Salmonella and Campylobacter spp. in Northern Elephant Seals, California. *Emerging Infections Diseases,* 11(12), pp. 1967-1969.

2. Tables of Typical Faecal Bacteria Concentrations

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

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

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

Table 3 – Geometric mean (GM) and 95% confidence intervals (CIs) of the GM faecal indicator organism (FIO) concentrations (cfu/100ml) under base- and high-flow conditions at the 205 sampling points and for various subsets, and results of paired t-tests to establish whether there are significant elevations at high flow compared with base flow

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

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

Table 4 - Comparison of faecal indicator concentrations (average numbers/g wet weight) excreted in the faeces of warm-blooded animals

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

Source: (Gauthier & Bedard, 1986)

References

Gauthier, G. & Bedard, J., 1986. Assessment of faecal output in geese. *Journal of Applied Ecology,* 23(1), pp. 77-90.

Kay, D. et al., 2008a. Faecal indicator organism concentrations and catchment export coefficients in the UK. *Water Research,* 42(10/11), pp. 2649-2661.

Kay, D. et al., 2008b. Faecal indicator organism in concentration sewage and treated effluents. *Water Research,* 42(1/2), pp. 442-454.

3. Hydrographic Assessment Glossary

The following technical terms may appear in the hydrographic assessment.

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

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

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

MHWN. Mean High Water Neap, The highest level that tides reach on average during neap tides.

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

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

MLWN. Mean Low Water Neap, The lowest level that tides reach on average during neap tides.

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

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

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

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

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

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

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

Neap tides occur during the first or last quarter of the moon when the tide-generating forces of the sun and moon oppose each other. The tidal range is smallest and tidal currents are weakest during neap tides.

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

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

Return flow. A surface flow at the surface may be accompanied by a compensating flow in the opposite direction at the bed.

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

4. Shoreline Survey Report

Shoreline Survey Report

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

Document Number	B0067_Shoreline 0037

Revision History

Revision	Changes	Date
A	Draft issue for internal review	18/08/2014
B	Second draft issue for internal review	03/09/2014
01	First formal issue to Cefas	04/09/2014
02	Second formal issue	16/09/2014

	Name & Position	Date
Author	Lars Brunner, Chris Allen	18/08/2014
Checked	Andrea Veszelovszki	15/09/2014
Approved	John Hausrath	16/09/2014

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

Production area:	Kilfinichen Bay
Site name:	Kilfinichen Bay
SIN:	AB-695-1507-04
Species:	Common cockles (*Cerastoderma edule*)
Harvester:	James Marshall, MFV Gradely Ltd.
Local Authority:	Argyll & Bute Council
Status:	Not actively used
Date Surveyed:	13th August 2014
Surveyed by:	Lars Brunner, Chris Allen
Existing RMP:	N/A
Area Surveyed:	Shoreline route from Killiemore House westward to shoreline below Co-leathadan.

19.1.1 Weather

In the 48 hours preceding the survey there was a mixture of light and heavy rain in the survey area.

Wednesday 13th August: Wind NW/W, f5, reducing f3 later. Sea state moderate, reducing to slight later in the day. Cloud cover 80-90%, intermittent showers, some heavy. Temperature 14°C.

19.1.2 Stakeholder engagement during the survey

Contact was made prior to the survey with Mr James Marshall, the harvester, and the survey team met with him during the afternoon on 13th August 2014. Mr Marshall kindly provided further information as to the state of the fishery in the bay, and his future plans for it.

The survey team also met the sampling officer, Mr Ewan MacDougall, on the previous day (12th August 2014). Mr MacDougall was also in communication with the survey team prior to the survey. Although he was not currently sampling from the bay on a regular basis, he provided very helpful information on previous sampling work on the bay.

19.1.3 Fishery

The fishery in Kilfinichen Bay is for common cockles (*Cerastoderma edule*). Mr Marshall indicated that there had been a historical fishery for cockles on site, but no-one other than him had been harvesting the site in recent memory.

Mr Marshall had applied for a fast-track licence for the site, but this had lapsed recently. He had not been working the site actively due to other work

commitments, but was hoping to start harvesting the bay on a part time basis again in the near future, specifically in the winter months when his work commitments gave him more spare time.

He confirmed that the site had a patchy distribution of cockles, but there were several localised areas containing a high density of the species.

19.1.4 Sewage Sources

Kilfinichen Bay is very lightly populated, with a handful of houses being situated around the bay itself. Potential discharge pipes were noted at waypoints (WP) 7, 16 & 22, but no flow was observed discharging onto the shore from any of these pipes. A pipe present below Tiroran (WP 26) was discharging.

19.1.5 Seasonal Population

No campsites or caravan parks were noted in the survey area. A hotel was located at Tiroran.

19.1.6 Boats/Shipping

The only fixed pier and slipway was to the west of the bay at Uam nan Gobhar (WP 21), although there was a small, informal beach slipway present at WP 18 as well. Two moorings with small pleasure craft were noted at WP 18, and there were two empty moorings below the hotel at Tiroran (WP 25). No other vessels were noted in Loch Scridain near the Kilfinichen Bay area on the day of survey.

19.1.7 Farming and Livestock

There appeared to be livestock farming in the fields above and around the bay. A total of fifty two sheep and four cows were noted in the fields to the south of Killiemore House (WP 2 & 3), thirty eight sheep were noted in the fields above Seabank Villa (WP 15). Four more sheep were observed above the upper shore line at WP18, and eight more sheep were noted in the shore below Tiroran House (WP 25).

19.1.8 Land Use

The land use was entirely rural in nature and was split between crofting/ small scale farming and forestry. Plantation forest covered much of the ground to the west and north of Kilfinichen Bay, while to the east of the bay there were fields and open ground, with some small areas of native woodland.

19.1.9 Land Cover

To the south-west and west of the survey route the land cover was predominantly plantation forest, with heavily overgrown wild ground also present. Around the shores of Traigh Mhor (the main section of the bay) was grazed land with a mix of native and plantation forest. The area to the east of the bay was comprised of fields and open ground, with small areas of native woodland.

19.1.10 Watercourses

The largest watercourse on the survey route was the Abhainn Bail a Mhuilinn (WP 14), which discharged into the north of the bay. The other large watercourse on the route is the Allt Orain (WP 28). Numerous smaller watercourses were present on the survey route, and they were recorded in the survey observations in Table 1.

19.1.11 Wildlife/Birds

Few birds were observed on this survey, with only 8 gulls being observed at WP 10. No land based animals were observed other than the sheep and cattle recorded in the farming and livestock section.

The specific observations made at each WP can be found in Table 1, with each of the WP locations displayed in Figure 1.

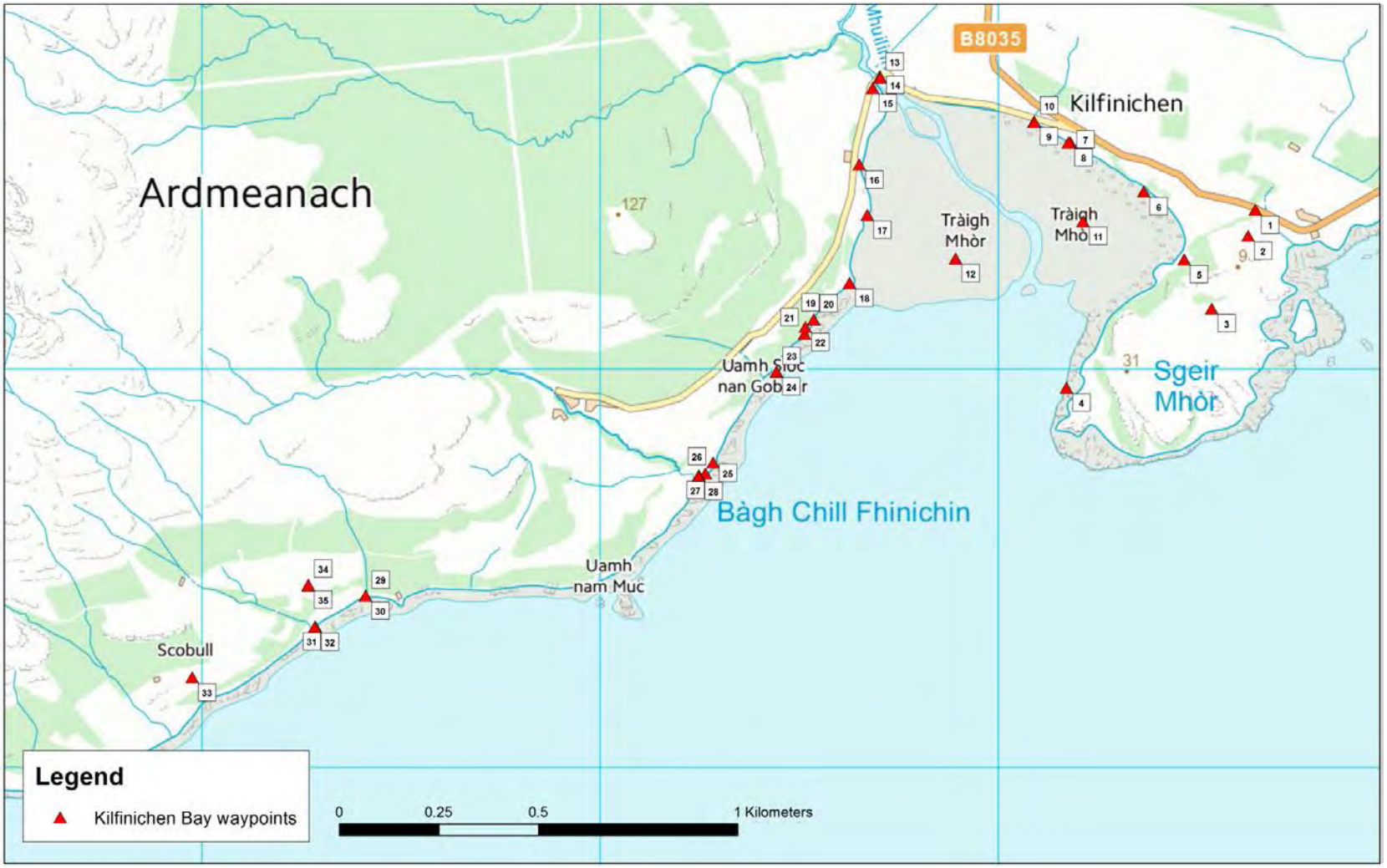


Figure 1. Kilfinichen Bay waypoints

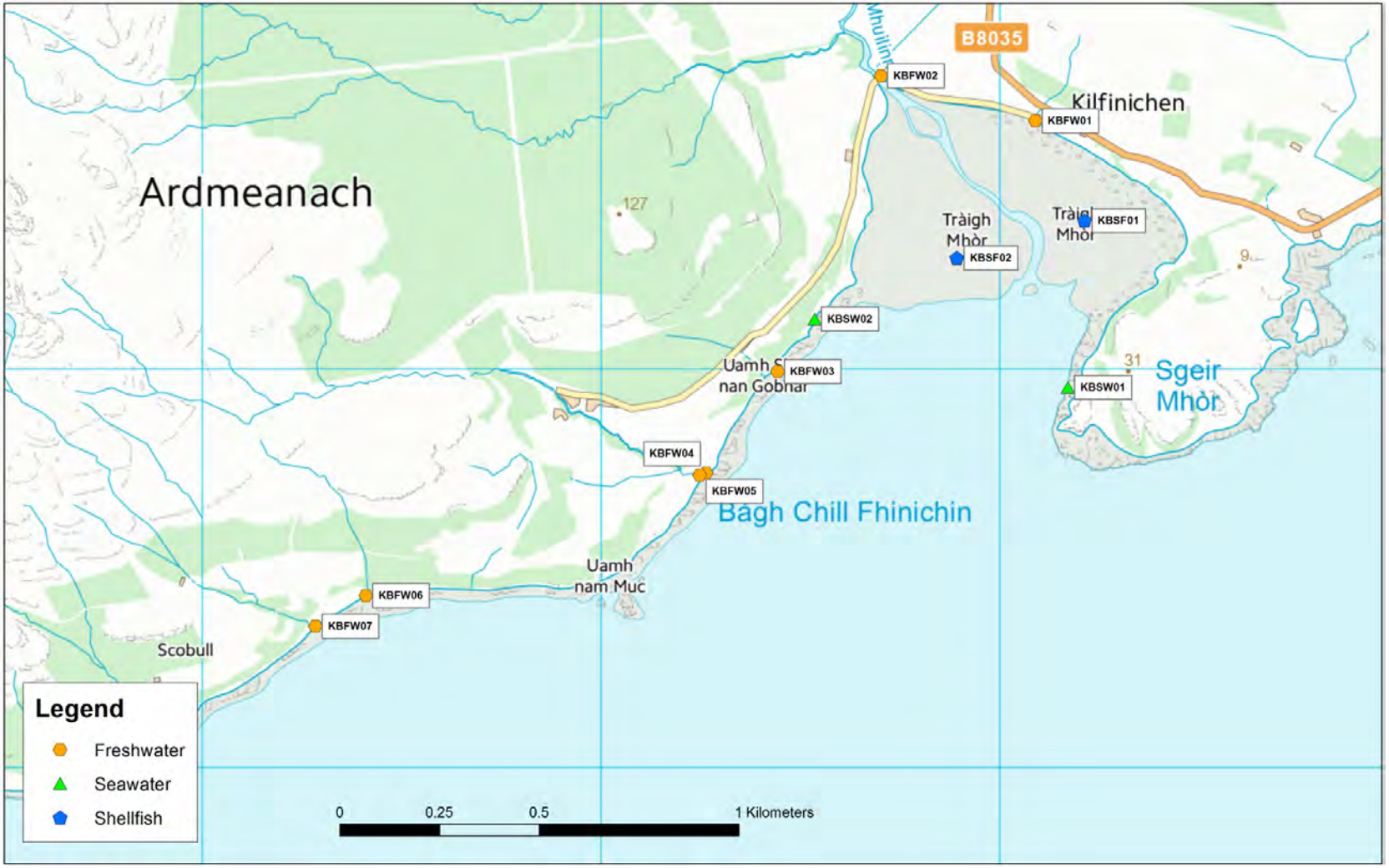


Figure 2. Kilfinichen Bay sample locations

Table 1. Shoreline Observations by Waypoint (WP) number.

WP No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	13/08/2014	13:07	NM 49644 28400	149644	728400			Start of Kilfinichen Bay survey.
2	13/08/2014	13:09	NM 49626 28335	149627	728335			Eighteen sheep observed in field above shoreline.
3	13/08/2014	13:12	NM 49535 28152	149535	728153			Thirty four sheep & four cows observed in field above shoreline.
4	13/08/2014	13:23	NM 49170 27953	149171	727953		KBSW01	Planned seawater sample; eastern side Kilfinichen Bay.
5	13/08/2014	13:34	NM 49465 28276	149466	728276	Figs. 3 & 4		Small stream running through bracken; not sampled (no habitation above).
6	13/08/2014	13:38	NM 49364 28446	149365	728446			Small stream running directly into bay through forestry and grass. No houses above; not sampled.
7	13/08/2014	13:43	NM 49180 28569	149181	728570	Fig. 5		10cm PVC pipe running to high tide mark from property. Pipe outlet blocked by reeds. No discharge. No sign of septic tank in garden above.

WP No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
8	13/08/2014	13:46	NM 49175 28569	149176	728569			Small stream running underneath garden, no sign of contamination. Not sampled.
9	13/08/2014	13:49	NM 49089 28622	149089	728622		KBFW01	Planned freshwater sample.
10	13/08/2014	13:49	NM 49089 28621	149090	728621			Observations associated with WP9 - Width: 35cm; Depth: 10cm; Flow 0.084 m/s; 0.008 SD. Eight gulls observed on lower shore.
11	13/08/2014	14:05	NM 49212 28371	149212	728372		KBSF01	Planned shellfish sample. Cockles from eastern side of bay.
12	13/08/2014	14:24	NM 48892 28278	148892	728278		KBSF02	Planned shellfish sample. Cockles from western side of bay.
13	13/08/2014	14:48	NM 48701 28735	148702	728735	Fig. 6	KBFW02	Planned freshwater sample.
14	13/08/2014	14:48	NM 48703 28732	148703	728732	Fig. 6		Observations associated with WP13 - Total Width 10m; **Depth1**: 80cm; Flow1: 0.294 m/s; 0.025 SD; **Depth2**: 59cm; Flow2: 0.222 m/s; 0.016 SD.

WP No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
15	13/08/2014	15:02	NM 48684 28706	148684	728706			Thirty eight sheep on hill above stream. Feeding station at base of hill.
16	13/08/2014	15:08	NM 48650 28514	148650	728514			Concrete septic tank. No outflow. Large (12-13cm) metal pipe coming out shore side of tank, but running directly into ground. Searched for end of pipe, could not be seen.
17	13/08/2014	15:13	NM 48670 28387	148670	728388			Small stream running off hillside through bracken and forest. No signs of habitation, not sampled.
18	13/08/2014	15:16	NM 48625 28216	148626	728217			Two moorings in bay, both with small pleasure craft. Informal slipway. RIB on trailer above shoreline. Four sheep observed above upper shore line.
19	13/08/2014	15:22	NM 48535 28124	148536	728125			House and bushes just above shoreline. No obvious discharge.
20	13/08/2014	15:22	NM 48535 28125	148536	728125		KBSW02	Planned seawater sample; western side Kilfinichen Bay.

WP No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
21	13/08/2014	15:29	NM 48512 28088	148513	728089	Fig. 7		Shed and slipway.
22	13/08/2014	15:31	NM 48515 28106	148515	728106	Fig. 8		Large fibreglass septic tank next to shed. 10cm diameter PVC pipe running out into ground, re-appears alongside side of pier. No discharge present within the pipe.
23	13/08/2014	15:38	NM 48442 27993	148443	727993	Fig. 9	KBFW03	Planned freshwater sample.
24	13/08/2014	15:38	NM 48442 27993	148442	727994	Fig. 9		Observations associated with WP23. Stream runs over wide rock, splitting into several small flows - very hard to measure. **Flow A)** - Width: 10 cm; Depth: 5cm; Flow: 0.240 m/s; 0.004 SD; **Flow B)** - Width: 5cm; Depth: 4cm; Flow: 0.297 m/s; 0.002 SD; **Flow C)** - Width: 20cm; Depth: 3cm; Flow: 0.350 m/s; 0.085 SD.
25	13/08/2014	15:55	NM 48282 27765	148283	727766			Eight sheep. Two moorings, no vessels present. Dingy on shore.

WP No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
26	13/08/2014	16:06	NM 48263 27738	148264	727739	Fig. 10	KBFW04	Unplanned freshwater sample - Contaminated. 11cm diameter PVC pipe. Flow 1cm deep at centre of pipe.
27	13/08/2014	16:14	NM 48247 27733	148247	727734		KBFW05	Planned freshwater sample.
28	13/08/2014	16:15	NM 48246 27731	148246	727732			Observations associated with WP27. Width: 1m 50cm; Depth: 17cm; Flow: 0.510 m/s; 0.020 SD.
29	13/08/2014	17:28	NM 47410 27431	147410	727431		KBFW06	Planned freshwater sample.
30	13/08/2014	17:28	NM 47410 27431	147410	727431			Observations associated with WP29. Width: 55cm; Depth: 11cm; Flow: 0.572 m/s; 0.020 SD.
31	13/08/2014	17:34	NM 47284 27354	147284	727354		KBFW07	Planned freshwater sample.
32	13/08/2014	17:34	NM 47283 27352	147283	727353			Observations associated with WP31. Width: 35cm; Depth: 12cm; Flow: 0.367 m/s; 0.013 SD.

WP No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
33	13/08/2014	17:51	NM 46974 27226	146975	727226	Fig. 11		At house (Scobull) - no visible septic tank or pipes.
34	13/08/2014	18:02	NM 47266 27456	147266	727457	Fig. 12		House - no visible septic tank or pipes.
35	13/08/2014	18:03	NM 47266 27458	147266	727459			End of Kilfinichen Bay survey.

Photographs referenced in the table can be found attached as Figures 3 – 12.

Sampling

Seawater and freshwater samples were collected from the locations marked in Figure 2. A total of seven freshwater and two seawater samples were collected. Both the seawater samples were from the planned locations on the east and west side of Kilfinichen Bay. All the planned freshwater samples were also collected, with one additional sample (KBFW04) taken from an outflow pipe at WP 26.

Two shellfish samples of common cockles (*Cerastoderma edule*) were taken from Kilfinichen Bay, one sample from the eastern side and one from the western side (see Figure 2).

All samples were transferred to a Biotherm 30 box with ice packs and posted to Glasgow Scientific Services (GSS) for *E. coli* analyses. All samples collected during the survey were received by GSS within 48 hours of collection. This extended sample submission deadline was agreed to prior to the survey commencing. The temperature of all samples was 1.8°C on arrival at GSS.

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 following formula:

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

The bacteriological sample results for the freshwater and seawater samples are detailed below in Table 2, whilst Table 3 shows the shellfish sample results.

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	*E. coli* (cfu/100ml)	Salinity (ppt)
1	13/08/14	KBFW01	NM 49089 28622	Freshwater	370	-
2	13/08/14	KBFW02	NM 48701 28735	Freshwater	60	-
3	13/08/14	KBFW03	NM 48442 27993	Freshwater	160	-
4	13/08/14	KBFW04	NM 48263 27738	Freshwater	>10000000	-
5	13/08/14	KBFW05	NM 48247 27733	Freshwater	580	-
6	13/08/14	KBFW06	NM 47410 27431	Freshwater	70	-
7	13/08/14	KBFW07	NM 47284 27354	Freshwater	40	-
8	13/08/14	KBSW01	NM 49170 27953	Seawater	400	26.02
9	13/08/14	KBSW02	NM 48535 28125	Seawater	36	26.74

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref.	Type	*E. coli* (MPN/100g)
1	13/08/14	KBSF01	NM 49212 28371	common cockles	1700
2	13/08/14	KBSF02	NM 48892 28278	common cockles	2400

Salinity Profiles

No CTD salinity profiles were taken as no boat work was required.

Photographs

Figure 3: Kilfinichen Bay, looking to the South and West. Photo taken from WP 5

Figure 4: Kilfinichen Bay, looking to the North and East, also taken from WP 5

Figure 5: PVC pipe running to shoreline below house on shoreline. End obscured by reeds, but no discharge. WP 7

Figure 6: Abhainn Bail a Mhuilinn River, running into Kilfinichen Bay. Photo taken from road running over bridge, site of WP 13 & 14

Figure 7: Pier and slipway (out of shot to left) at Uam nan Gobhar. Moorings with boats offshore (WP 21)

Figure 8: PVC discharge pipe on side of pier, with fibre glass tank present on upper shoreline (centre right within red box). WP 22

Figure 9: Stream encountered with dispersed flow over rocks and onto shore (WP 23 & 24)

Figure 10: Pipe present below hotel at Tiroran, with active discharge (WP 26)

Figure 11: House at Scobull. No visible signs of septic tank or discharge (WP 33)

Figure 12: House at Co-Leathadan, where there were no visible signs of septic tank or discharge (WP 34)