Scottish Sanitary Survey Report

Sanitary Survey Report
Loch Melfort
AB178, AB672, AB673, AB674
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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 Loch Melfort classified production area 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).

Loch Melfort is a sea loch situated between Seil Sound and Shuna Sound, approximately 20 km south of Oban on the west coast of Scotland.

The active shellfishery is comprised of a longline mussel farm located west of Creag Aoil, along the outer south shore of the loch. There is also a multi-species shellfish farm based on rafts to the south of the mussel farm, where the harvester is trying to grow Pacific oysters, native oysters, king scallops and queen scallops. However, the harvester reported that culture of these species had not yet been successful on this site.

The main sources of faecal contamination to the shellfishery are a single point source discharge of sewage from the shore base south of the mussel farm, multiple private sewage discharges to the west of Kames, diffuse contamination from livestock and wildlife sources arising from the shoreline south and west of the mussel farm area, and diffuse contamination from yachts using anchorages west of the mussel farm.

Predicted tidal excursion distances are well under 1 km, and probably less than 500 m much of the time, therefore sources very local to the fishery are likely to have the most impact.

It is recommended that the production area boundary be amended to exclude the head of the loch and point sources at Kames, east of the shellfishery. The RMP for mussels should remain as NM 8061 1112. The RMP for the multi-species site should be amended to the raft location, at NM 8053 1095.

II. Sampling Plan

Production Area	Loch Melfort	Loch Melfort
Site Name	Creag Aoil	Loch Melfort
SIN	AB-671-1448-13	AB-178-051-08
Species	Pacific oyster, native oyster, king scallop, queen scallop	Common mussel
Type of Fishery	Suspended aquaculture	Long-line aquaculture
NGR of RMP	NM 8053 1095	NM 8061 1112
East	180530	180610
North	710950	711120
Tolerance (m)	40	40
Depth (m)	1-3	1-3
Method of Sampling	Hand	Hand
Frequency of Sampling	Monthly	Monthly
Local Authority	Argyll and Bute Council	Argyll and Bute Council
Authorised Sampler(s)	William MacQuarrie Ewan McDougall Allison Hardie Heather Harley	William MacQuarrie Ewan McDougall Allison Hardie Heather Harley
Local Authority Liaison Officer	Ewan McDougall	Ewan McDougall
Production Area Boundaries	The area bounded by lines drawn between NM 7964 1097 to NM 7820 1196 and between NM 8100 1292 and NM 8100 1145 and extending to MHWS	The area bounded by lines drawn between NM 7964 1097 to NM 7820 1196 and between NM 8100 1292 and NM 8100 1145 and extending to MHWS

III. Report

1. General Description

Loch Melfort is a sea loch situated between Seil Sound and Shuna Sound, approximately 20 km south of Oban on the west coast of Scotland. Loch Melfort is 5.6 km in length, has a maximum width of 2.5 km and a maximum recorded depth of 75 m. It has a westerly orientation and is sheltered from the open ocean by the islands of Luing and Shuna.

The area surrounding the loch lies within the Argyll and Bute Council area and is sparsely inhabited. Population is located mainly at the head of the loch.

A sanitary survey was undertaken on the classified fishery at Loch Melfort 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 selected for survey at this time based on a risk-based ranking of the area amongst those in Scotland that have yet to receive sanitary surveys.

A sanitary survey was conducted on Loch na Cille, a small inlet on Loch Melfort, in the August of 2013. Elements of that document have been used to inform this report.

Figure 1.1 Location of Loch Melfort

2. Fishery

Loch Melfort currently contains a long-line mussel farm near the outer south shore of the loch, southwest of Creag Aoil and rafts for suspended culture of multiple species inshore of the east side of the mussel farm. The site summary is shown in Table 2.1.

Table 2.1 Loch Melfort shellfishery

Production area	Site	SIN	Species	RMP
Loch Melfort	Loch Melfort	AB-178-051-08	Common mussels	NM 8061 1112
Loch Melfort: Creag Aoil	Creag Aiol Pacific oysters	AB-671-1448-13	Pacific oysters	NM 8061 1113
	Creag Aiol native oysters	AB-672-1449-12	Native oysters	
	Creag Aiol king scallops	AB-673-1450-07	King scallops	
	Creag Aiol queen scallops	AB-674-1451-15	Queen scallops	

The current production area boundaries are defined as the area bounded by lines drawn between NM 7964 1097 to NM 7820 1196 extending to MHWS.

An application was submitted by the harvester in 2013 for classification of Pacific oysters (*Crassostrea gigas*), native oysters (*Ostrea edulis*), king scallops (*Pecten maximus*), and queen scallops (*Aequipecten opercularis*). A provisional RMP assessment was undertaken for the additional species at Creag Aoil in November 2013. The area given in the classification application for Creag Aoil was the same as that occupied by the long-line mussel farm, and therefore it was presumed that all five species were to be cultured on or near the long-lines. A provisional RMP was recommended at NM 8061 1113, where the mussel samples were being taken at the time.

At the time of the shoreline survey in September 2014, the site consisted of thirteen long-lines approximately 300 m long with 10 m droppers. These were reported to be used for mussel production only. There were also rafts in place inshore of the long-lines, though no record was made of the extent of these during the shoreline survey. Aerial images from Bing (image date April 2012) show three rafts located approximately 100 m northeast of the shorebase. These were also present in photographs taken during the shoreline survey, and their estimated location coincides with the locations of oyster and scallop samples submitted for classification from 2013 to 2014. However, no samples were taken of these species during the shoreline survey as the harvester informed the survey team that cultivation of these four species had not yet been successful and therefore no stock was available for sampling. Samples of Pacific oysters and both scallop species have been submitted since the shoreline survey.

The Loch na Cille production area (common cockles) lies at the head of Loch na Cille, and within the current boundaries of the Loch Melfort production area.

The extent of the existing mussel farm was recorded during the shoreline survey and this area is shown in Figure 2.1.

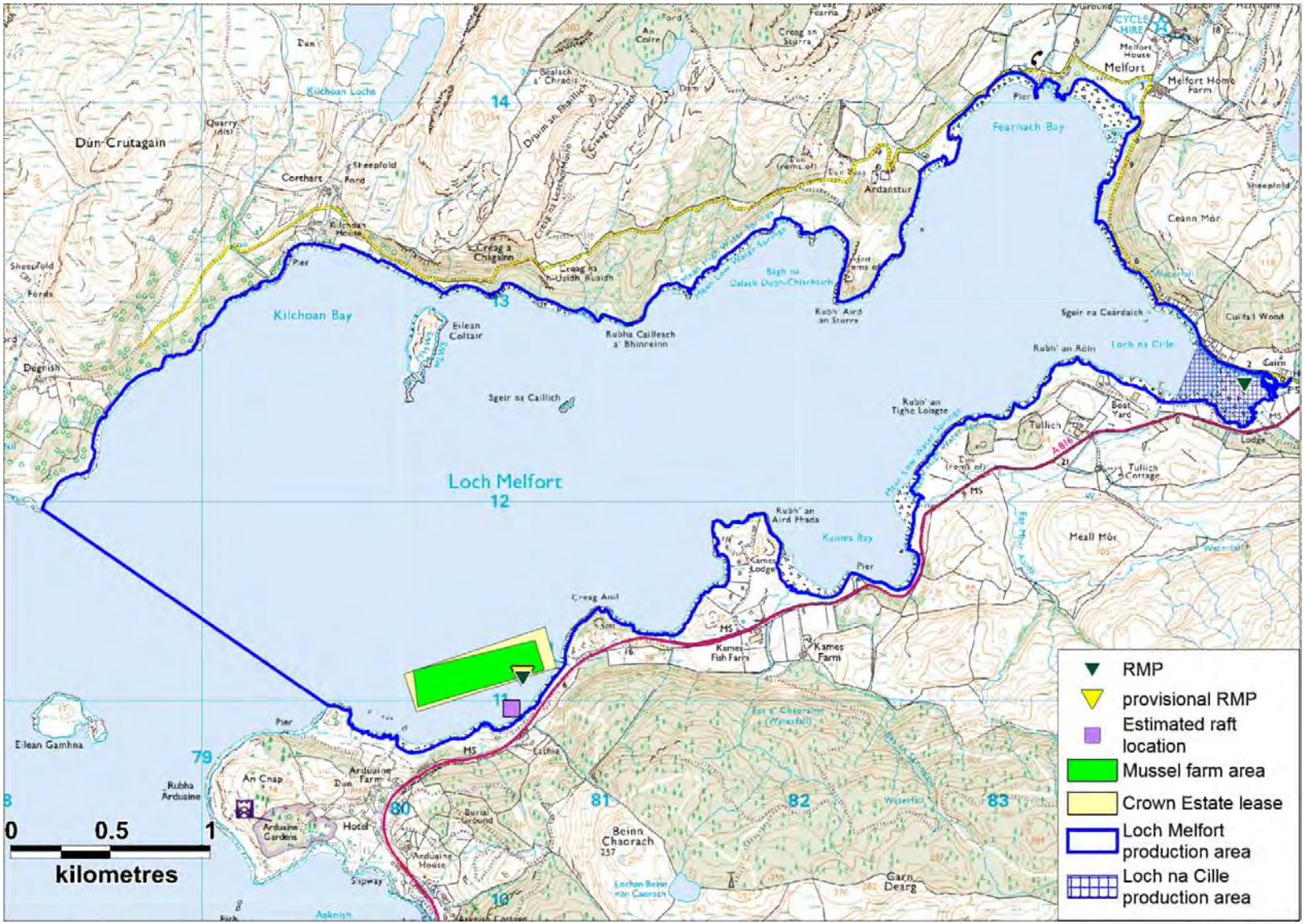


Figure 2.1 Loch Melfort Fishery

3. Human Population

Information was obtained on the population within the vicinity of Loch Melfort production area from the General Register Office for Scotland. The last census was undertaken in 2011. Population densities within the census output areas surrounding Loch Melfort are shown in Figure 3.1. The census output areas vary in size and population within them will not be evenly distributed. Therefore the population, geographic area, and calculated density for each census output area in Table 3.1.

Table 3.1 Census output area and population – Loch Melfort

Census Output Area ID	Population	Area (km^2)	Density (persons/km^2)
S00069096	74	7	11
S00069119	113	15	7.7
S00069120	57	24	2.4
S00069378	96	26	3.7
S00069641	108	0.14	760
S00069249	72	3.2	22
S00069184	70	16	4.5
S00069241	128	4.5	28
S00069457	117	110	1.0

The A816 runs along the southern shore of the loch and a smaller road runs along the remainder of the shoreline. Homes are located mainly along the roads, with small settlements located along the south shore and at the head of the loch. The population density is highest around Kilmelford, at the head of the loch.

There is a significant amount of tourist accommodation in the area. There are hotels at Arduaine and Kilmelford, and there is a timeshare holiday village at Melfort (Melfort Village, 2014). The hotel at Arduaine offers moorings a short distance south of the mouth of the loch, in Asknish Bay. National Trust for Scotland operate Arduaine Gardens year-round as a visitor attraction. B&B and self-catering accommodation is also widely available in the area.

Yachting is a major activity in and around the loch and there are three harbours offering moorings or marina berths for both visiting and resident yachts. Melfort Pier and Harbour complex provides accommodation in addition to 21 moorings and a pier (Mellow Melfort, 2014). Kilmelford Yacht Haven offers 55 moorings plus eight berths(http://www.kilmelfordyachthaven.co.uk/). Craobh Haven marina lies outside Loch Melfort and provides 250 berths as well as on shore accommodation. There are a further 7 anchorages in the wider area (Clyde Cruising Club, 2007).

Although the greatest concentration of resident population is at Kilmelford, homes at Kames and Arduaine lie closest to the mussel farm. Tourism and yachting activity are expected to greatly increase the population around the loch during the summer months. The mussel farm lies between two anchorages, the nearest of which is immediately west of the mussel farm. Yachts discharging sewage waste overboard whilst using this areas would be expected to contribute to faecal contamination levels in the near vicinity, and those using the anchorage west of the mussel farm would be most likely to have an impact on water quality there.

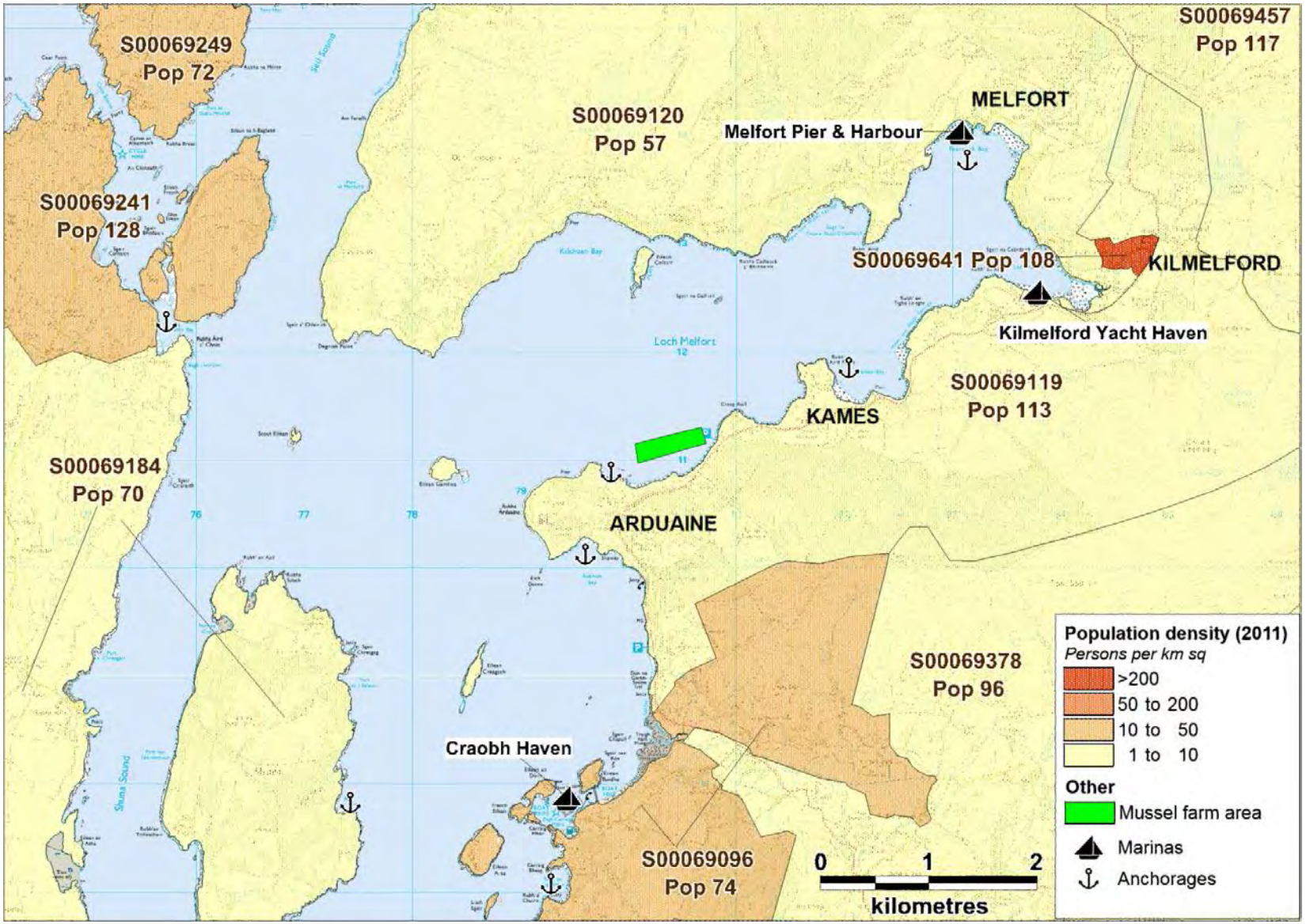


Figure 3.1 Population map for the area around Loch Melfort

4. Sewage Discharges

Information on sewage discharges within an area 5 km around the point NM 8061 1112 (at the RMP) 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 quality, spill frequency, dispersion or modelling studies, or whether improvements were being undertaken or planned.

4.1 Community Discharges

Scottish Water reported two community sewage works. There is a WWTW at Kilmelford, which also has associated pumping stations and overflows. Licence information was provided by SEPA for this discharge. There is a community septic tank called Cuilfail Cotts (which I take to be short for cottages), for which SW could not provide a licence number. SEPA did not report a CAR licence for this discharge, so it is presumed to be licensed under one of the older schemes. Unfortunately, SEPA were not able to provide any information on this septic tank without having the old licence number to work from.

Kilmelford STW outlet WWPS pumps septic tank treated effluent to the outfall. Scottish Water have noted that in the case of pump failure, the emergency overflow from this pumping station would be treated sewage effluent as it is coming from the treatment works outlet.

The final outfall location for Kilmelford WWTW has changed since the Loch na Cille sanitary survey was undertaken and now discharges via a long sea outfall to the mouth of Loch na Cille to reduce the impact on the shellfishery there.

Information on locations where sewage sludge is applied to land had been requested from SEPA: it was identified that little data was held on this and that the data that was held could not be made available for assessment within the sanitary survey programme.

Table 4.1 Community sewage discharges – Loch Melfort

Scottish Water					SEPA					
Discharge Name	**Licence number**	**Location**	**Treatment Level**	**PE**	**Discharge Name**	**Licence number**	**Location**	**Treatment Level**	**PE**	**DWF (m3/day)**
Cuilfail Cotts Sep	Not in database	NM 849 130	Septic tank	-						
Kilmelford WWTW	CAR/L/1021959	NM 8359 1299	Septic tank	112	Secondary Outfall	CAR/L/1021959	NM 8359 1299	not specified	Design 164 Connected 112	59
Kilmelford WWTW CSO	CAR/L/1021959	NM 8451 1296	Screened		CSO	CAR/L/1021959	NM 8451 1259			
Kilmelford STW Outlet WWPS	CAR/L/1021959	NM 8449 1259	Septic tank		EO	CAR/L/1021959	NM 8449 1259			
Kilmelford STW Inlet WWPS	CAR/L/1021959	NM 8449 1258	Screened		EO	CAR/L/1021959	NM 8359 1299			

4.2 Consented Private Discharges - SEPA

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

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 are not yet registered with SEPA.

SEPA provided information on 103 sewage discharge consents around Loch Melfort. Three of these were removed from this assessment as they did not plot within watercourse catchments which could have an effect on the fishery. The remaining 100 discharges were distributed around the south shore of Loch Melfort, the Arduaine peninsula, the valley of Staing Mhor and around Croabh Haven.

The consented discharges assessed in this report are listed in Appendix 6 and are shown in Figure 4.1 at the end of this section. Consented discharges within 2 km of the mussel lines are listed in Table 4.2 below.

The majority of the 100 consented discharges go to soakaway. 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 be diverted to sea or watercourses upon failure of the soakaway fields.

The largest consented private discharge, with a PE of 1200, is from Croabh Haven marina, south of Asknish Bay, and less than 5 km from the mussel farm. The content of this discharge is likely to be highly seasonal.

Two separate consents relate to discharges from the Loch Melfort Hotel at Arduaine (CAR/S/1030803 and CAR/R/1025513). Both were identified as being sewage effluent. The location of CAR/S/1030803 plotted to a location approximately 24 m above MHWS and 10 m from a watercourse. The consented PE for this discharge was given as 91. Therefore, the discharge may have an impact on water quality in Asknish Bay. CAR/R/1025513 plotted approximately 200 m north of the other, and has a consented PE of 50. However, it is not clear whether these represent two separate discharges from the hotel, or different consents for the same discharge.

The Celtic Sea shore base at Arduaine has a consented septic tank discharge with a PE of 12 and lies approximate 220 metres south of the east end of the mussel farm.

Thirteen consented discharges were reported around Kames. Nine of these were identified as discharging to sea and one to a watercourse, with the remainder to soakaway. Eight discharge to sea west of Rubh' an Aird Fhada, approximately 1 km east of the mussel farm. All relate to individual septic tanks with PEs of 5-6.

Table 4.2 Private discharge consents within 2 km of the fishery

Licence Number	National Grid Reference	Discharge Type	Discharging to	PE
CAR/R/1013783	NM 80342 09322	Sewage (Private) Primary	Land	11
CAR/R/1015600	NM 80100 09977	Sewage (Private) Secondary	Land	14
CAR/R/1017088	NM 80380 09300	Sewage (Private) Primary	Soakaway	6
CAR/R/1023271	NM 80168 09925	Sewage (Private) Primary	U/T of Asknish Bay	10
CAR/R/1024586	NM 80379 09337	Sewage (Private) Primary	Soakaway	6
CAR/R/1025513	NM 79730 10460	Sewage (Private) Primary	Soakaway	50
CAR/R/1027042	NM 80080 09980	Sewage (Private) Primary	Asknish Bay	6
CAR/R/1033010	NM 79410 10290	Sewage (Private) Primary	Soakaway	15
CAR/R/1033059	NM 79597 10394	Sewage (Private) Primary	Soakaway	15
CAR/R/1035029	NM 80190 10050	Sewage (Private) Primary	Soakaway	6
CAR/R/1037057	NM 79791 10518	Sewage (Private) Primary	Soakaway	7
CAR/R/1037444	NM 81750 11180	Sewage (Private) Primary	Soakaway	5
CAR/R/1037445	NM 81724 11293	Sewage (Private) Primary	Soakaway	5
CAR/R/1037446	NM 82232 11613	Sewage (Private) Primary	Kames Bay	5
CAR/R/1037640	NM 81570 11560	Sewage (Private) Primary	Loch Melfort	6
CAR/R/1037727	NM 81610 11690	Sewage (Private) Primary	Loch Melfort	5
CAR/R/1038097	NM 81663 11708	Sewage (Private) Primary	Loch Melfort	5
CAR/R/1038286	NM 79929 10120	Sewage (Private) Primary	Soakaway	6
CAR/R/1039159	NM 81630 11588	Sewage (Private) Primary	Loch Melfort	5
CAR/R/1039161	NM 81638 11628	Sewage (Private) Primary	Loch Melfort	6
CAR/R/1039196	NM 81685 11873	Sewage (Private) Primary	Loch Melfort	6
CAR/R/1039632	NM 80247 09965	Sewage (Private) Primary	U/T of Asknish Bay	5
CAR/R/1039684	NM 81730 11910	Sewage (Private) Primary	Loch Melfort	6
CAR/R/1039729	NM 81556 11779	Sewage (Private) Primary	Loch Melfort	6
CAR/R/1039972	NM 79910 10080	Sewage (Private) Primary	Asknish Bay	25
CAR/R/1039981	NM 80174 10058	Sewage (Private) Primary	U/N W/C	7
CAR/R/1079474	NM 80590 10880	Sewage (Private) Tertiary	Coast	12
CAR/R/1083436	NM 80410 09250	Sewage (Private) Primary	Soakaway	5
CAR/R/1095793	NM 80660 10820	Sewage (Private) Secondary	Soakaway	8
CAR/R/1108584	NM 81905 11481	Sewage (Private) Primary	East an Sgriodain	6
CAR/R/1111382	NM 80050 10240	Sewage (Private) Primary	Soakaway	8
CAR/S/1030803	NM 79720 10250	Sewage (Private) Primary	Soakaway	91
CAR/S/1098154	NM 81990 11240	Sewage (Private) Secondary	Soakaway	26

U/T=unnamed tributary U/N W/C=unnamed watercourse

South of Rubha Arduaine and Arduaine Farm, there are 14 consented discharges associated with Melfort Hotel, Arduaine Gardens, Arduaine caravan site and private cottages around Asknish Bay. Most are identified as discharging to soakaway, however three of these plot approximately 10m from either MHWS or a watercourse and therefore may contribute faecal contamination to Asknish Bay. The combined PE of all discharges in this area is over 200, and the PE of those identified as discharging to water is 53.

Further private discharges to sea are located around Loch na Cille and Fearnach Bay, all between 3 and 4 km northeast of the mussel farm.

SEPA also provided information regarding eight marine cage fish farms (MCFF) within the area requested. Working facilities on these may have toilets, but no information was provided regarding these.

4.3 Scottish Water Dispersion Studies

A dispersion study of the Kilmelford WWTW discharge was conducted by Anderson Marine Surveys Ltd. in April 2013 on behalf of Scottish Water.

It assessed the likely impact of the WWTW discharge from the Kilmelford long sea outfall (not in use at the time) on the Loch Melfort shellfish growing waters, which include both Loch Melfort and Loch na Cille. The assessment was limited to a desk-based study of tidal predictions, charted bathymetry and probable tidal currents, as well as assumed flows from the Abhainn na Cille, and did not consider spills from the CSO and/or Eos.

Flows were estimated to be nearly quiescent, with neither tidal nor estuarine flow predominating. The predicted tidal excursion was less than 500 m and well under 1 km when estimated river flow was added.

The report concluded that significant bacterial contamination would affect a relatively small proportion of the Loch Melfort Shellfish Growing Water (mainly within a short distance of Loch na Cille). However, the predicted impact at point NM 81527 12435 (approximately mid-loch, north of Kames), was a contribution of 20 faecal coliforms/100ml above background levels. As this point is over 1 m northeast of the mussel farm, any impact at the mussel farm is expected to be less.

4.4 Shoreline Survey Discharge Observations

During the shoreline survey, five observations were noted of sewage discharges and/or sewage-related infrastructure. These are shown in Table 4.3.

Observation 1 refers to three black plastic pipes next to the pier to the south of the mussel farm. No flow was reported at the time of survey. The pipes are near the Celtic Sea shore base, which has a consented septic tank discharge to sea. However, the pipes are likely to be used for discharging water used in cleaning harvested shellfish and it is not clear whether septic effluent is also discharged via the same pipes.

Observations 2 through 5 correspond with discharges from homes at Kames.

Table 4.3 Discharge-associated observations made during the shoreline survey

No.	Date	NGR	Associated Photograph (Appendix 5)	Description
1	09/09/2014	NM 80493 10860	Fig. 9	Three black plastic pipes next to pier. No flow from any of the pipes was observed.
2	09/09/2014	NM 81641 11673	Fig. 4	Discharge pipe (brown plastic) leading from house onto shore and far into the sea.
3	09/09/2014	NM 81588 11798	Fig. 5	Large concrete structure next to shore in front of house. No evidence of pipes or outflows.
4	09/09/2014	NM 81693 11884	Fig. 7	Metal pipe leading from shore into loch with house behind.
5	09/09/2014	NM 81732 11899	Fig. 8	Broken pipe leading from shore into loch. End of pipe was not accessible.

4.5 Summary

The largest sewage discharge in the area comes from Croabh Haven, which has two assoicated discharges with a combined PE of over 1200 that lie approximately 4.5 km to the south of the fishery.

The second largest input comes from Kilmelford WWTW (septic tank), approximately 3.4 km from the fishery. This has a relatively small PE of 112. The modelling study provided by Scottish Water concluded that the discharge was unlikely to have an impact much above background levels of faecal contamination.

Discharges likely to have the greatest impact at the fishery are private discharges to sea associated with the shore base south of the mussel farm, private dwellings at Kames and potentially private dwellings, the hotel and caravans at Asknish Bay, southwest of the mussel farm.

Discharges from further up the loch at Kilmelford and Fearnach Bay, including those from the WWTW, would be expected to contribute to background levels of contamination at the mussel fishery. Those from Croabh Haven could potentially also contribute to background contamination levels in outer Loch Melfort, depending on the predicted movement of contaminants.

Impacts are expected to be seasonal due to the large proportion of holiday accommodation in the area.

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

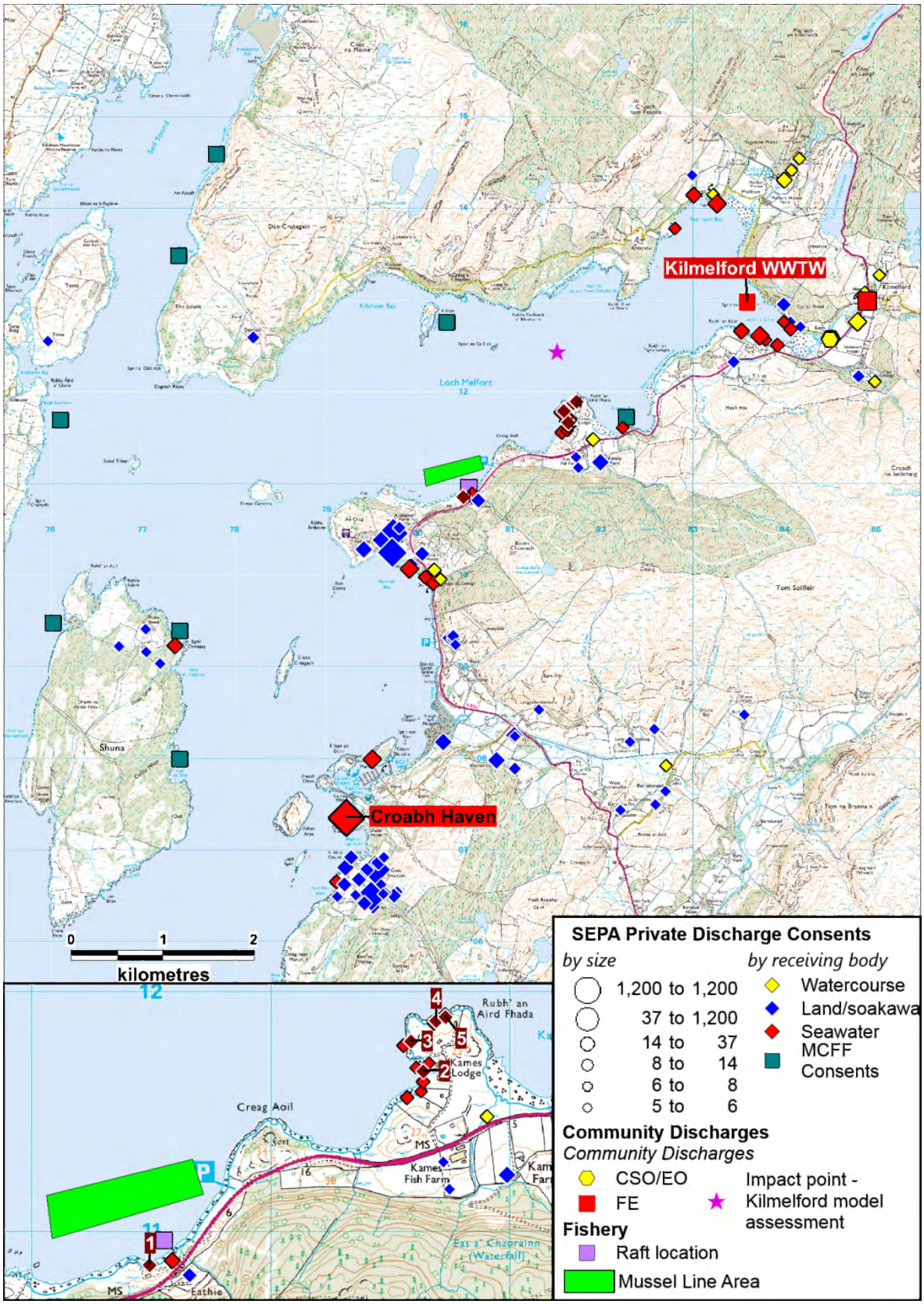


Figure 4.1 Map of discharges for Loch Melfort

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. Parish-level data from the 2013 agricultural census was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the Kilbrandon and Kilchattan, Kilninver and Kilmelford, and Craignish parishes. Reported livestock numbers from these parishes 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 Kilbrandon and Kilchattan, Kilninver and Kimelford and Craignish agricultural parishes

	Kilbrandon and Kilchattan		Kilninver and Kilmelford		Craignish	
	54 km^2		131 km^2		37 km^2	
	Holdings	Numbers	Holdings	Numbers	Holdings	Numbers
Pigs	0	-	*	*	*	*
Poultry	*	*	5	127	7	164
Cattle	6	1107	9	457	7	819
Sheep	20	11814	11	10454	11	10324
Horses used in Agriculture	0	-	0	-	0	-
Other horses and ponies	*	*	*	*	*	*

* data withheld

As the parish data relates to relatively large areas, it is not possible to determine the spatial distribution of the livestock adjacent to the survey area or to identify how many animals are likely to impact the catchment around the shellfish farm. However, the figures do give an idea of the total numbers of livestock over the broader area. Sheep were kept in large numbers in all three areas. Cattle were kept in modest numbers, with relatively fewer kept in Kilninver and Kilmelford than in the other two parishes. Poultry were kept in small numbers.

A source of spatially relevant information on livestock population in the area was the shoreline survey (see Appendix 5) which only relates to the time of the site visit on the 9th – 10th September 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, approximately 17 sheep were observed the hillside west of the shellfish farm and evidence (wool and faeces) of sheep grazing was also observed on the shoreline. Two horses were observed in a field southwest of the fishery.

A review of publicly available aerial images showed a number of farms with pasture and sheep clearly visible around the loch (Bing Maps, accessed 01/12/2014 (imaging date Apr-May 2012, http://mvexel.dev.openstreetmap.org/bing/). Areas identified as farm/pasture pasture are shown in Figure 5.1. SEPA identified a number of consented sheep dips on to land on the southeastern side of the loch. These are locations where animals will be concentrated periodically and therefore are shown in Figure 5.1.

Information on locations where animal slurry is stored and/or applied to land had been requested from SEPA: it was identified that little data was held on this and that the data that was held could not be made available for assessment within the sanitary survey programme.

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 likely to contribute significantly to background contamination levels in the loch. Impacts from livestock grazed along the shoreline adjacent to the fishery are expected to impact the western side of the mussel farm.

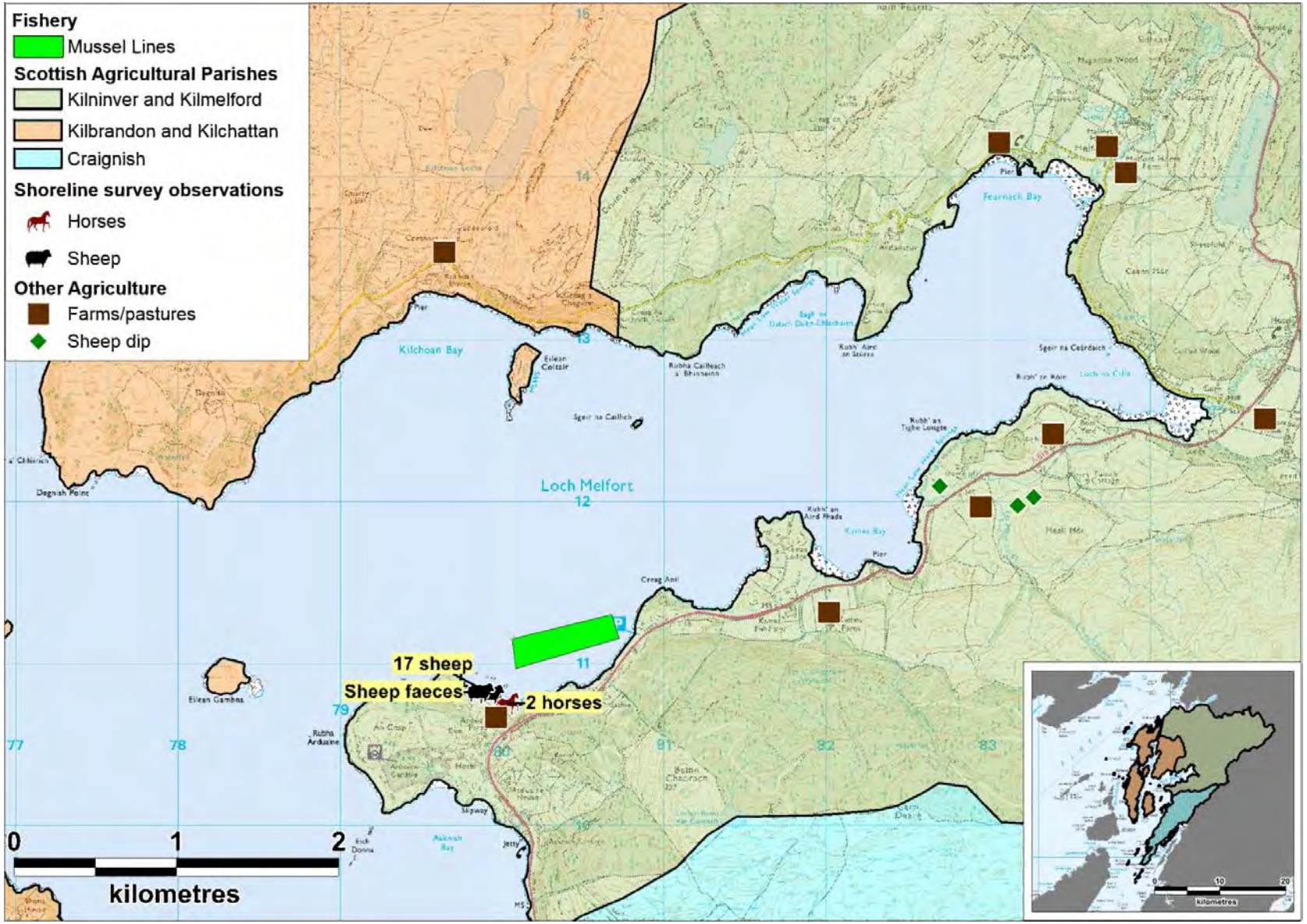


Figure 5.1 Livestock observations at Loch Melfort

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 spatially significant sources where and 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 runoff or watercourses.

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

Pinnipeds

The Special Committee on Seals 2013 report identified that seals were recorded within the areas surrounding Loch Melfort, but no observations were made within Loch Melfort. There are anecdotal accounts of both grey and common seals on the nearby Isle of Shuna, which lies approximately 3.5 km southwest of Loch Melfort. A common seal was observed approximately 1 km northeast of the fishery during the shoreline survey.

Cetaceans

There are no reports of cetaceans within Loch Melfort. However the Firth of Lorn special area of conservation (SAC), which encompasses the group of islands that lie to the west of Loch Melfort, is known to host harbour porpoise, bottlenose dolphins and minke whales (Argyll Marine Special Areas of Conservation, 2014). No cetaceans were observed during the shoreline survey.

Seabirds

Seabird data was downloaded from the collated JNCC dataset from the website (JNCC, 2014) in March 2014. The dataset was then manipulated to show the most recent data where repetitions of counts were present. 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.

The JNCC dataset indicated that the main concentrations of birds were located 1.2 km northeast of the fishery at Sgeir na Caillich and 1.8 km southwest at Eilean Gamhna. Sgeir na Caillich contained a very large breeding colony of common terns, with smaller Arctic tern, common gull, and black headed gull breeding colonies also present. On Eilean Gamhna there was a moderate number of Arctic tern occupied territories, as well as smaller territories for several gull species.

Table 6.1 Seabird counts within 5 km of Loch Melfort

Common name	Species	Count	Method*	Accuracy
Great Black-Backed Gull	*Larus marinus*	8	Occupied nests	1 accurate, 3 unknown
Herring Gull	*Larus argentatus*	46	Occupied territory and nests	1 estimate, 2 unknown, 2 accurate
Common Gull	*Larus canus*	104	Occupied nests	2 unknown, 2 estimates, 1 accurate
Lesser Black-Backed Gull	*Larus fuscus*	10	Occupied nests	Unknown
Black-Headed Gull	*Chroicocephalus ridibundus*	36	Occupied nests	1 unknown, 1 accurate
Black Guillemot	*Cepphus grylle*	11	Individuals on land	Accurate
Common Tern	*Sterna hirundo*	472	Occupied territory and nests	Accurate
Arctic Tern	*Sterna paradisaea*	114	Occupied territory and nests	Accurate

*The counts have been adjusted where the method used was occupied nests/sites/territory to reflect the probable number of individual birds (i.e. counts of nests and occupied territory were doubled)

Birds were the main wildlife observed during the shoreline survey. Individual species were mostly present in low numbers and included oystercatchers, gulls, cormorants and a heron. A large number of eider ducks were seen adjacent to the mussel farm.

Otters

There are anecdotal accounts of otters around Loch Melfort, including at Arduaine, to the southwest of the the mussel farm (The National Trust for Scotland, 2011). No otters were observed during the shoreline survey.

Deer

Although no accurate data on deer numbers were available for the area around Loch Melfort, there are anecdotal accounts of healthy populations of red, roe and fallow deer on the nearby Isle of Shuna (Southern Hebrides, 2012) and accounts of red and roe deer on land adjacent to the fishery (Scottish Lochside Cottages, 2014). No deer were observed during the shoreline survey. Deer are likely to be present around much of the loch due to the type of land cover present.

Conclusions

Seals, seabirds, eider ducks, otters and deer are all expected to contribute to background contamination levels at the mussel farm. The eider ducks and cormorants may result in localised concentrations of faecal contamination when and where they are present. Seasonal variation in input is expected, though no specific information was found on seasonal populations in the area.

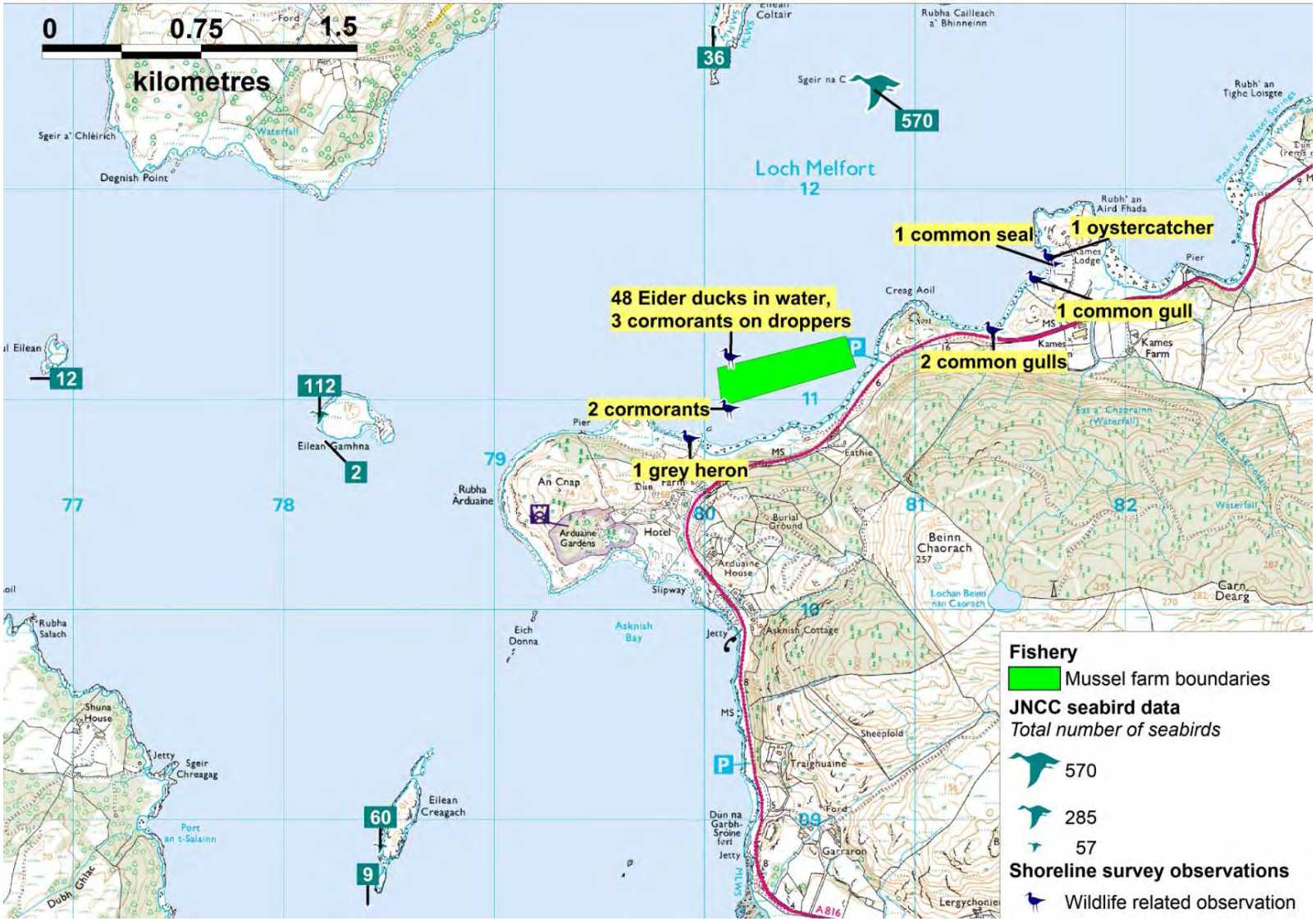


Figure 6.1 Map of wildlife around Loch Melfort

7. Land Cover

The Land Cover Map 2007 data for the area is shown in Figure 7.1. The predominant land cover types around the loch are improved grassland, rough grassland, coniferous and broad leaved woodland and dwarf shrub heath. During the shoreline survey, the majority of the land surveyed was noted to be rough grazing and woodland. The small built up areas at the head of the loch relate to the settlement of Kilmelford and Kilmelford Yacht Haven.

Faecal indicator organism export coefficients for faecal coliform bacteria have been found to be approximately 1.2 – 2.8x10^{9} cfu km^{-2} hr^{-1} for urban catchment areas, approximately 8.3x10^{8} cfu km^{-2} hr^{-1} for areas of improved grassland and approximately 2.5x10^{8} cfu km^{-2} hr^{-1} for rough grazing (Kay, et al., 2008a). 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*., 2008a).

The potential contribution of contaminated run-off to the shellfish bed is likely to be moderate due to areas of improved grassland and rough grazing close to the shoreline. Any impact is likely to be greatest along the western end of the mussel farm. Any contribution would be expected to increase after rainfall events.

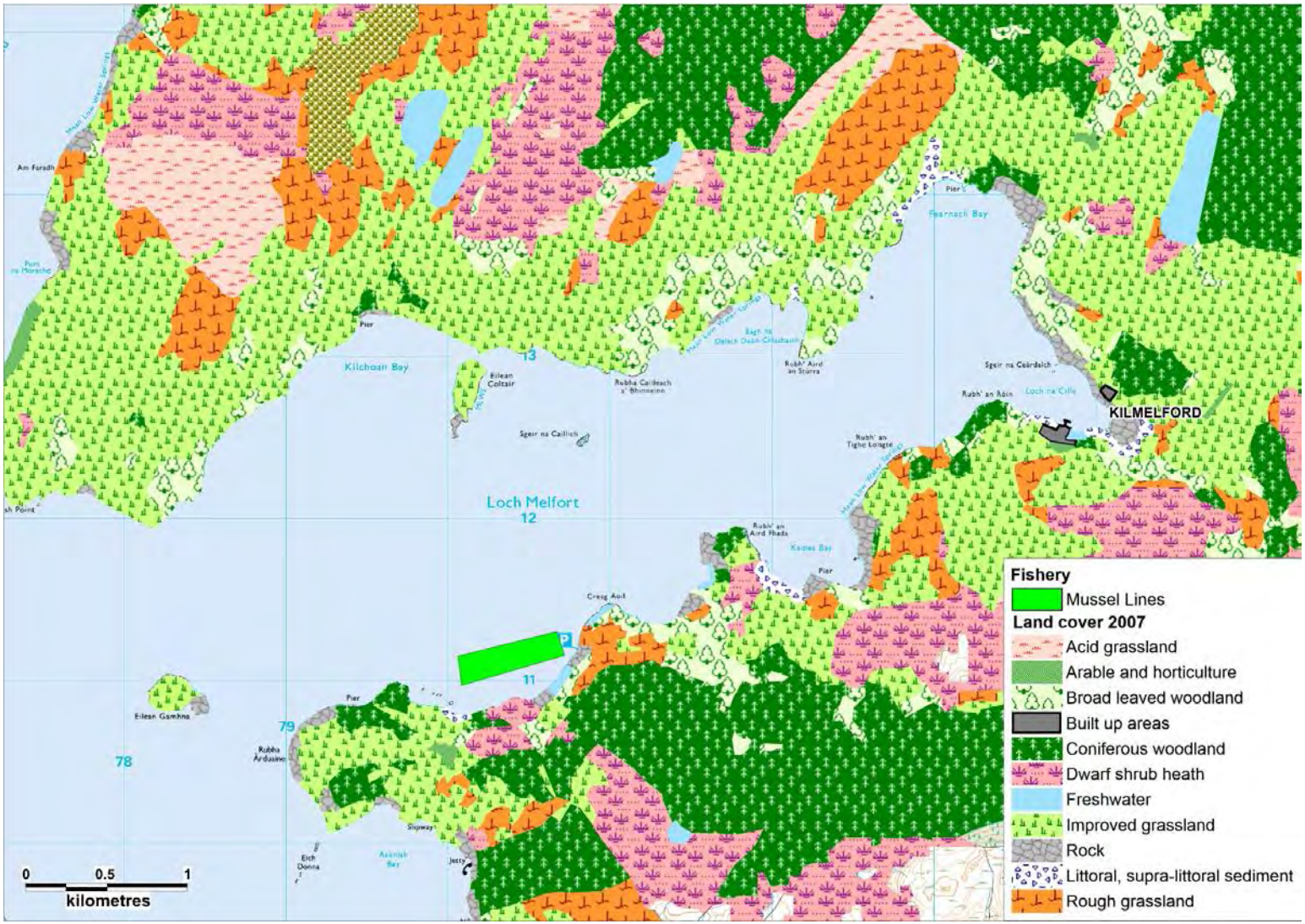


Figure 7.1 LCM2007 land cover data for the area around Loch Melfort

8. Watercourses

There are no gauging stations on watercourses entering Loch Melfort.

Spot measurements of flow and microbial content were obtained during the shoreline survey conducted on the 9th - 10th September 2014. Light scattered showers were recorded in the 48 hrs prior to the survey. The watercourses listed in Table 8.1 are those recorded during the shoreline survey. The locations and loadings of measured watercourses are shown in Figure 8.1.

Table 8.1 Watercourses entering Loch Melfort

No.	Eastings	Northings	Description	Width (m)	Depth (m)	Flow (m^3/d)	Loading (*E. coli* per day)
1	179751	710848	Unnamed watercourse	0.07	0.02	0.005	10×10^4
2	180431	710706	Unnamed watercourse	0.34	0.03	111	$<1.1 \times 10^7$
3	180623	710926	Unnamed watercourse	2.81	0.07	629	8.8×10^8
4	180860	711209	Unnamed watercourse	0.63	0.05	286	$<2.9 \times 10^7$
5	181370	711326	Unnamed watercourse	1.1	0.06	291	$<3.7 \times 10^7$

Nine small watercourses were located along the shoreline adjacent to the fishery on the south coast of the loch, four of which had insufficient flow to measure or sample. The remaining five had low to moderate estimated *E. coli* loadings. The watercourse with the highest estimated *E. coli* loading of 8.8×10^8 was located approximately 190 m south of the mussel farm. Two further small watercourses were observed in the bay east of the fishery were not measured or sampled.

Overall, freshwater inputs would be expected to provide low levels of contamination to the mussel farm in Loch Melfort, with the highest impact expected from the watercourses that discharge directly adjacent to the shellfish farm. These will have the greatest effect at the eastern and southern sides of the farm.

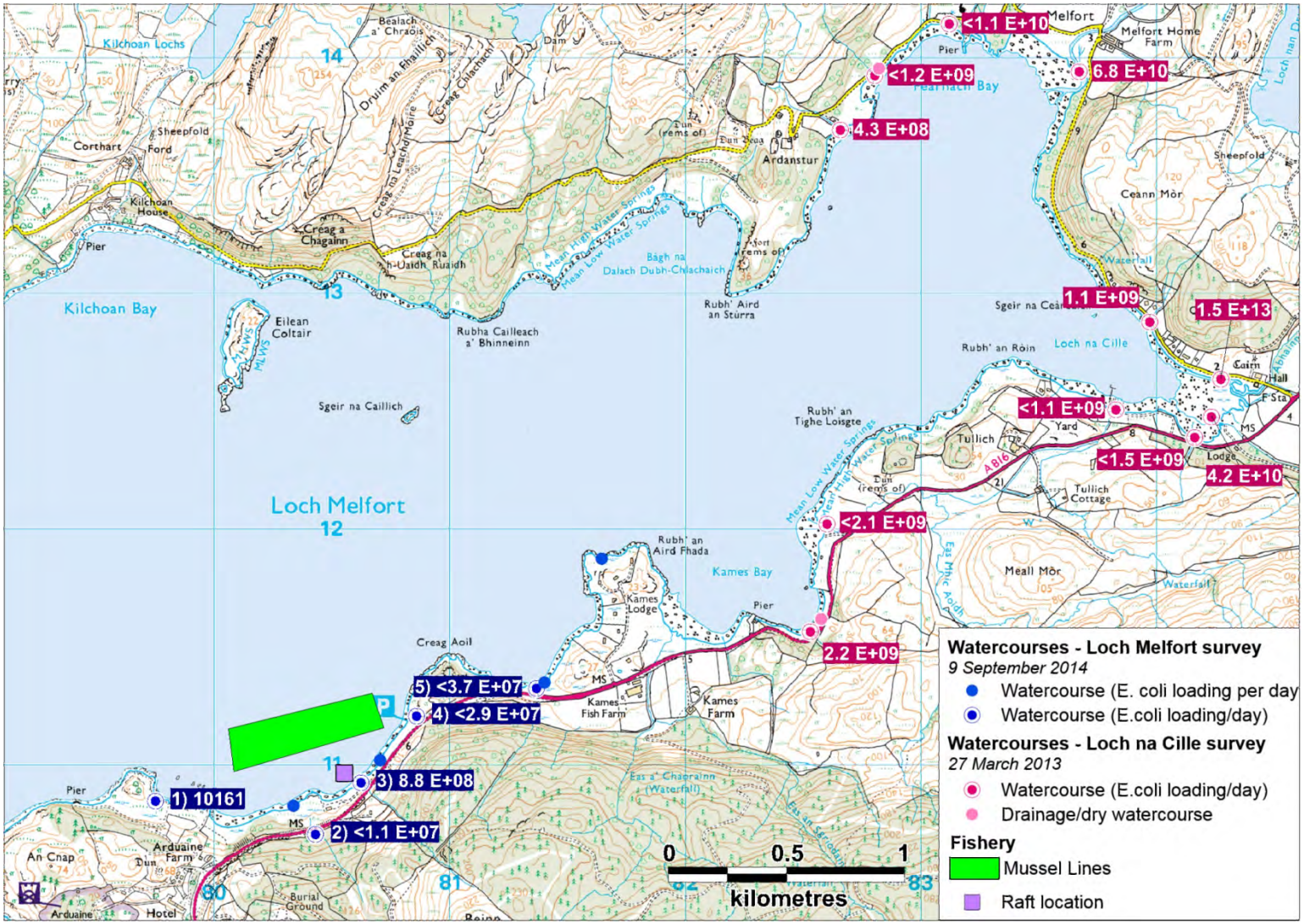


Figure 8.1 Map of watercourse loadings at Loch Melfort

9. Meteorological Data

The nearest weather station for which nearly complete rainfall data was available is located at Lismore; Frackersaig Farm, situated approximately 25 km to the north of the production area. Rainfall data was available for January 2008 – November 2013. Data was not available for December 2013. The following dates were excluded during data validation as they were estimated or aggregated: 11–14/01/2008, 31/03/2008, 01/04/2008, 04–05/06/2008, 16–19/06/2008, 04–05/05/2009, 17–18/05/2009, 10–11/08/2009, 01–02/12/2010, 16–22/08/2011, 29–30/10/2011, 22–23/08/2012, 04–05/12/2012.

The nearest wind station is situated in Glasgow, Bishopton, located 74 km southeast of the production area. Conditions will differ between this station and the fisheries due to the distances between them. However, this data is still shown as it can be useful in identifying seasonal variation in wind patterns.

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

9.1 Rainfall

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

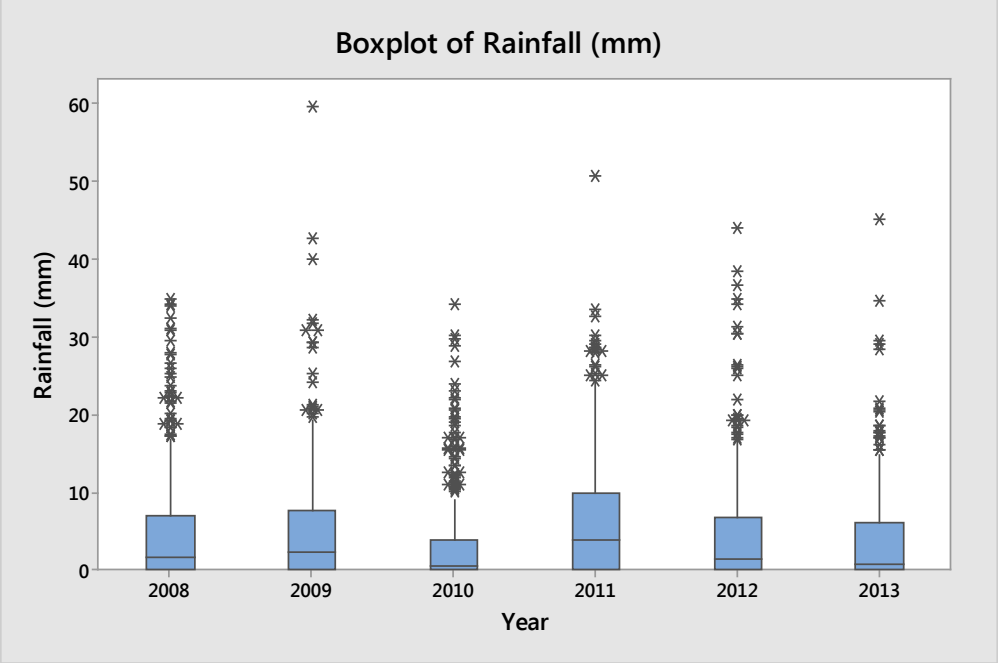


Figure 9.1 Box plot of daily rainfall values by year at Lismore; Frackersaig Farm (2008 – 2013)

Daily rainfall values varied from year to year, with 2010 being the driest year (1199 mm). The wettest year was 2011 (2354 mm). Rainfall values exceeding 40 mm/d occurred in 2009, 2011, 2012 and 2013.

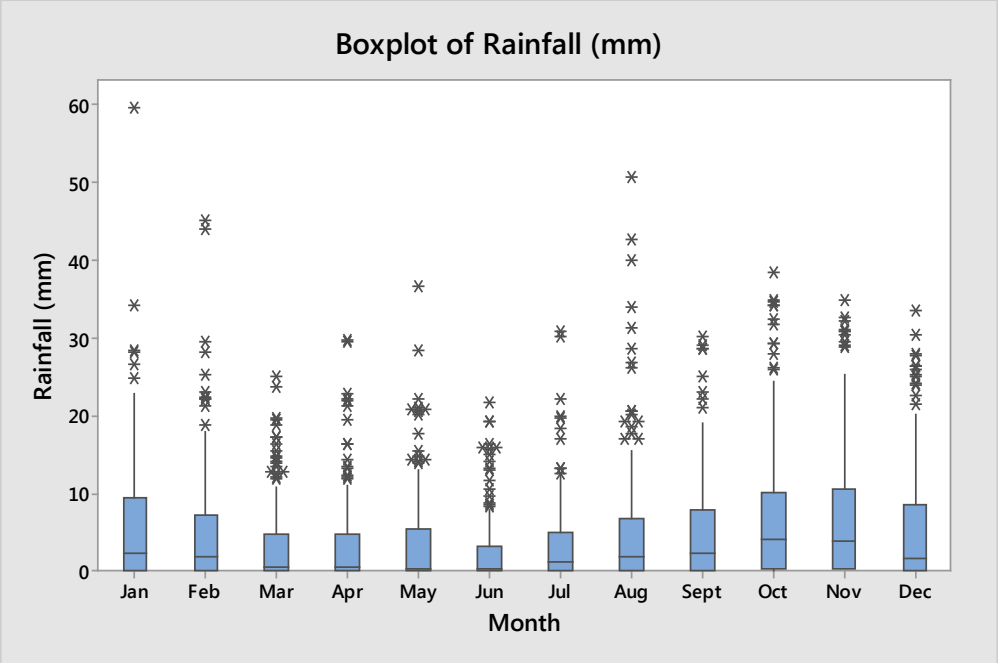


Figure 9.2 Box plot of daily rainfall values by month at Lismore; Frackersaig Farm (2008 – 2013)

Daily rainfall values were higher during the autumn and winter. Weather was driest in June (429 mm) and generally increased from August peaking in October (1348 mm). Caution should be used in interpreting the monthly data as data were missing for the

month of December 2013. Rainfall values exceeding 40 mm/d were seen in January, February and August.

For the period considered here (2008 – 2013) 47 % of days received daily rainfall of less than 1 mm and 17 % of days received daily rainfall of over 10 mm.

It is 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.

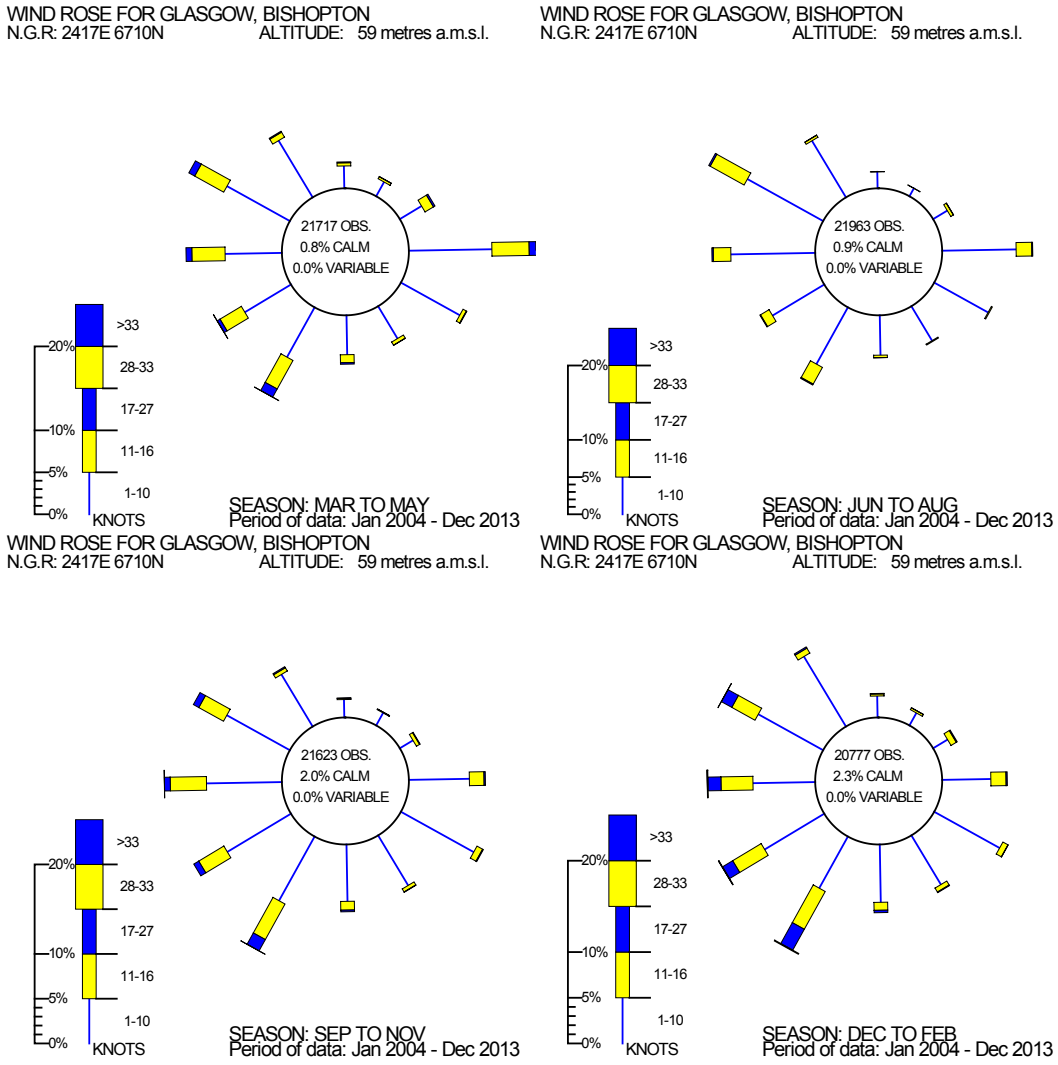


Figure 9.3 Seasonal wind roses for Glasgow, Bishopton

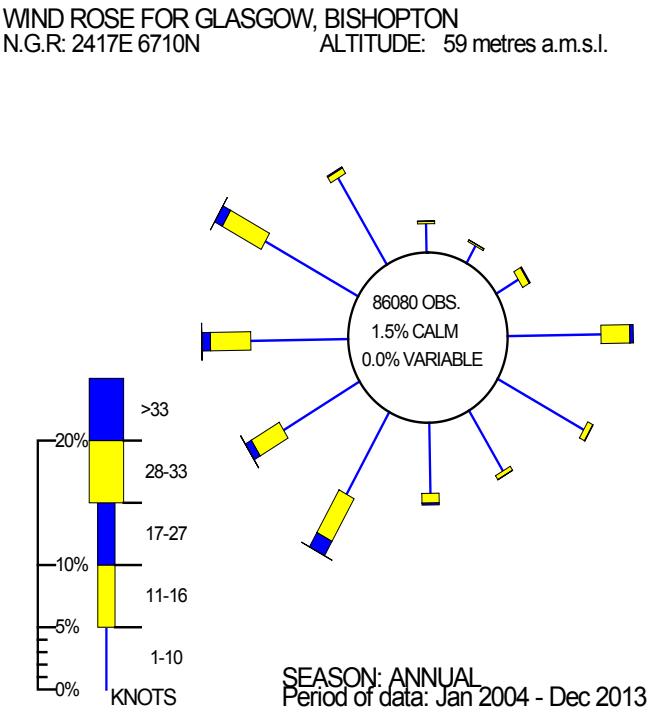


Figure 9.4 Annual wind rose for Glasgow, Bishopton

Overall, the annual wind rose shows winds blow most frequently from the southwest to northwest, but also blow regularly from the east. Winds were stronger when coming from the west than the east. The strongest wind tends to come from south-southwest. Seasonally, the strongest winds occurred in the autumn and winter: with those from the south and the west predominating. In the spring, a notable proportion of strong winds came from the east and in summer from the north-northwest.

Both the Clyde (at Bishopston) and Loch Melfort lie approximately along a west-east axis.

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

Loch Melfort is classified for production of common mussels (Mytilus edulis). The classification history since 2006 is listed in Table 10.1 below.

Table 10.1 Loch Melfort: (common mussel) classification history

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	A	A	A	A	A	A	A	A	A	A	A	A
2007	A	A	A	A	A	A	A	A	A	A	A	A
2008	A	A	A	A	A	A	A	A	A	A	A	A
2009	A	A	A	A	A	A	A	A	A	A	A	A
2010	A	A	A	A	A	A	A	A	A	A	A	A
2011	A	A	A	A	A	A	A	A	A	A	A	A
2012	A	A	A	A	A	A	A	A	A	A	A	A
2013	A	A	A	A	A	A	A	A	A	A	A	A
2014	A	A	A	A	A	A	A	A	A	A	A	A
2015	A	A	A									

Loch Melfort: Creag Aoil was awarded classification in November 2014 for Pacific oysters (*Crassostrea gigas*), native oysters (*Ostrea edulis*), king scallops (*Pecten maximus*), and queen scallops (*Aequipecten opercularis*). The classification is A for all species from November 2014 to March 2015.

11. Historical *E. coli* Data

11.1 Validation of historical data

Results for all samples assigned to Loch Melfort for the period 01/01/2009 to the 27/11/2014 were extracted from the FSAS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. The data was extracted on 27/11/2014. All *E. coli* results were reported as most probable number (MPN) per 100 g of shellfish flesh and intravalvular fluid.

All sample results reported as below the limit of detection (<20 or <18) were reassigned a value of 10 *E. coli* MPN/100 g for the purposes of statistical evaluation and graphical representation.

One sample from Loch Melfort mussels plotted over 6.5 km northwest of the production area and was excluded from further analysis. The remaining samples of all species plotted within the Loch Melfort production area, were identified as valid, were received at the laboratory within 48 hours of collection and had box temperatures of <8^{o}C upon arrival.

11.2 Summary of microbiological results

Sampling and results summaries for Loch Melfort between 2009 and 2014 are listed in Table 11.1.

Table 11.1 Summary of historical sampling and results at Loch Melfort fisheries (2009-2014)

Sampling Summary					
Production area	Loch Melfort	Loch Melfort King Scallops	Loch Melfort native oysters	Loch Melfort Pacific oysters	Loch Melfort Queen Scallops
Site	Loch Melfort	Creag Aoil King Scallops	Creag Aoil Native oysters	Creag Aoil Pacific oysters	Creag Aoil Queen scallops
Species	Common mussels	King Scallops	Native oysters	Pacific oysters	Queen scallops
SIN	AB-178-051-08	AB-673-1450-07	AB-672-1449-12	AB-671-1448-13	AB-674-1451-15
Location	Various	Various			
Total no of samples	69	13	11	13	13
No. 2009	12	-	-	-	-
No. 2010	11	-	-	-	-
No. 2011	12	-	-	-	-
No. 2012	11	-	-	-	-
No. 2013	12	2	2	2	2
No. 2014	11	11	9	11	11
Results Summary					
Minimum	<18	<18	<18	<18	<18
Maximum	2800	170	50	220	110
Median	20	20	<18	20	20
Geometric mean	25	23	15	29	23
90 percentile	230	170	49	200	98
95 percentile	330	170	50	220	110
No. exceeding 230/100g	4 (6%)	0	0	0	0
No. exceeding 1000/100g	2 (3%)	0	0	0	0
No. exceeding 4600/100g	0	0	0	0	0
No. exceeding 18000/100g	0	0	0	0	0

Although the majority of mussel sample results at Loch Melfort have been low, two results exceeded 1000 *E. coli* MPN/100 g. Sampling at the multi-species site south of the mussel farm started in late 2013 and has since been regular for all species except native oysters, for which no samples have been submitted since September 2014. Results for all four species have been below 230 *E. coli* MPN/100 g.

11.3 Overall geographical pattern of results

The geographical locations of all sample results assigned to Loch Melfort and Creag Aoil are displayed in Figure 11.1.

Results for all species from Creag Aoil were mapped together as they were reported against the same locations for each sampling occasion. The points are displayed against a different scale than those from Loch Melfort as there were no high results recorded at Creag Aoil. Therefore,the sizes of points between the two areas cannot be directly compared.

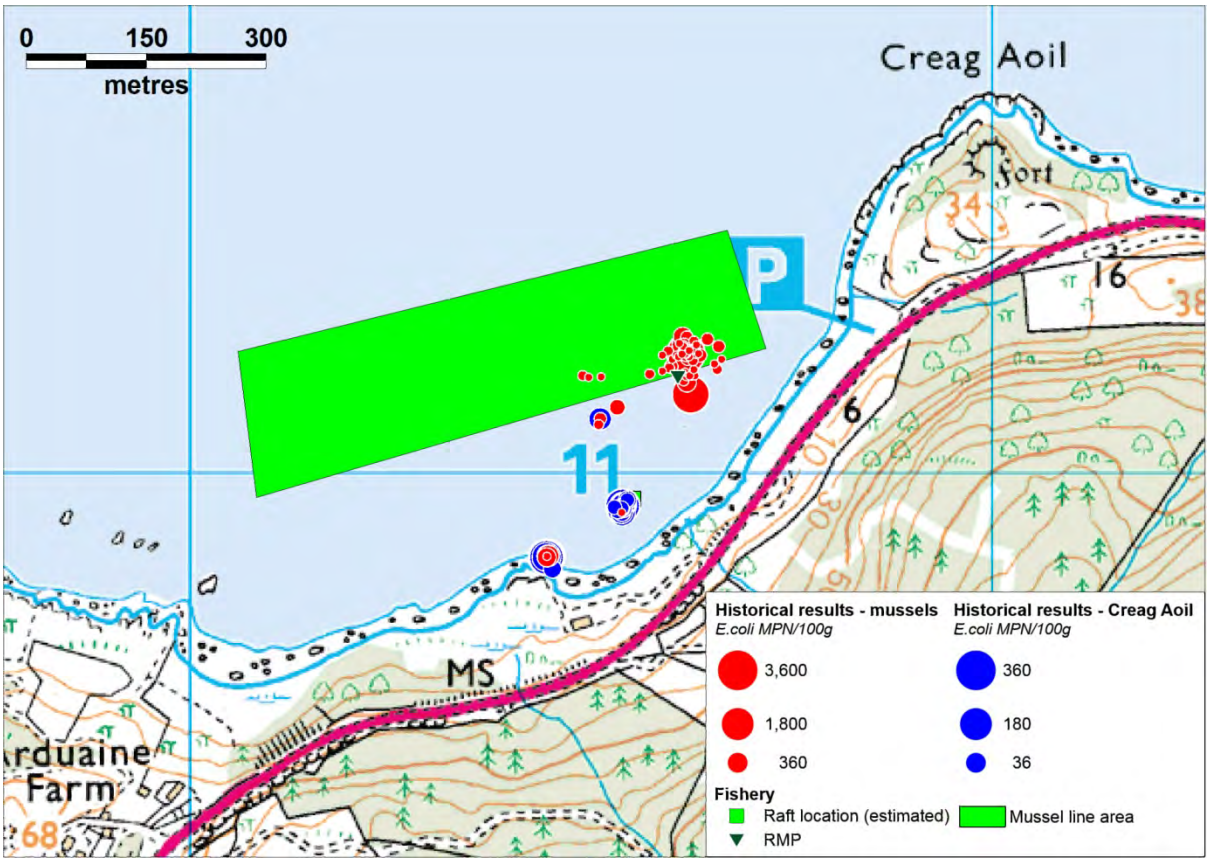


Figure 11.1 Map of reported mussel sampling locations for Loch Melfort

The majority of mussel samples were reported against locations near the southeast end of the mussel farm, in the vicinity of the current RMP. One result was reported from a location at the raft and three were reported from a location near the end of the of the shore base slipway. The two highest results were reported from locations near the RMP. There were no other apparent geographic patterns in the results.

Samples from the Creag Aoil multi-species site were reported from two main locations: the raft and near the end of the shore base slipway. The majority of samples (n=37) were reported from within approximately 10 m of NM 8054 1096, the presumed raft location. One result was reported from a location a short distance south of the recorded mussel farm area.

11.4 Overall temporal pattern of results

Scatterplots of *E. coli* results against date for the Loch Melfort site is presented in Figures 11.2. The dataset is fitted with a lowess trend line. Lowess trendlines allow for locally weighted regression scatter plot smoothing. At each point in the dataset an estimated value is fitted to a subset of the data, using weighted least squares. The approach gives more weight to points near to the x-value where the estimate is being made and less weight to points further away. In terms of the monitoring data, this means that any point on the lowess line is influenced more by the data close to it (in time) and less by the data further away. A trend line helps to highlight any apparent underlying trends or cycles.

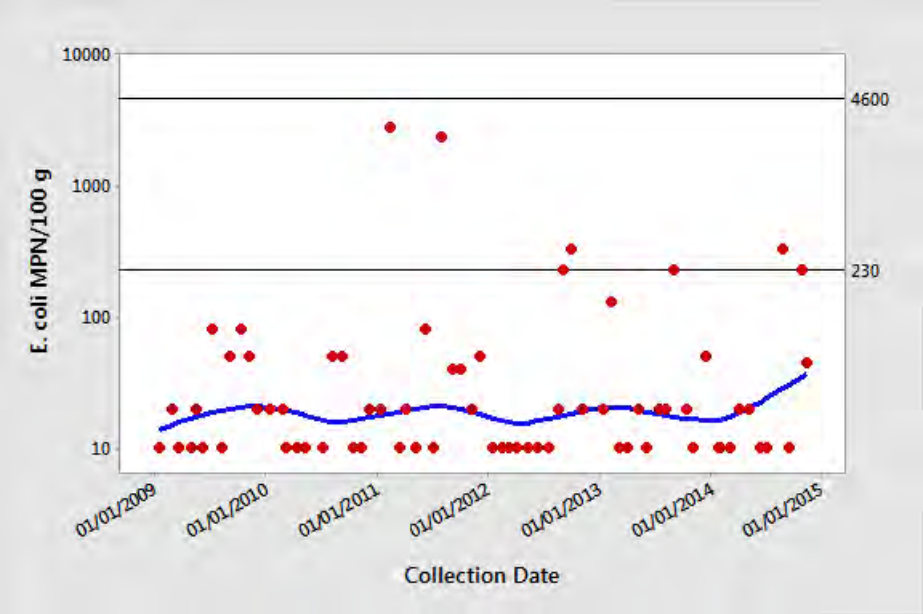


Figure 11.2 Scatterplot of mussel *E. coli* results by collection date at Loch Melfort, fitted with a lowess line

Mussel results remained generally constant and low over the period. More results at or above 230 *E. coli* MPN/100 g were seen from 2012 onward. The two highest results occurred in 2011.

Figures 11.3 to 11.6 show scatterplots of results for Creag Aoil by species. No lowess trend lines have been fitted to these due to the limited number of data points represented.

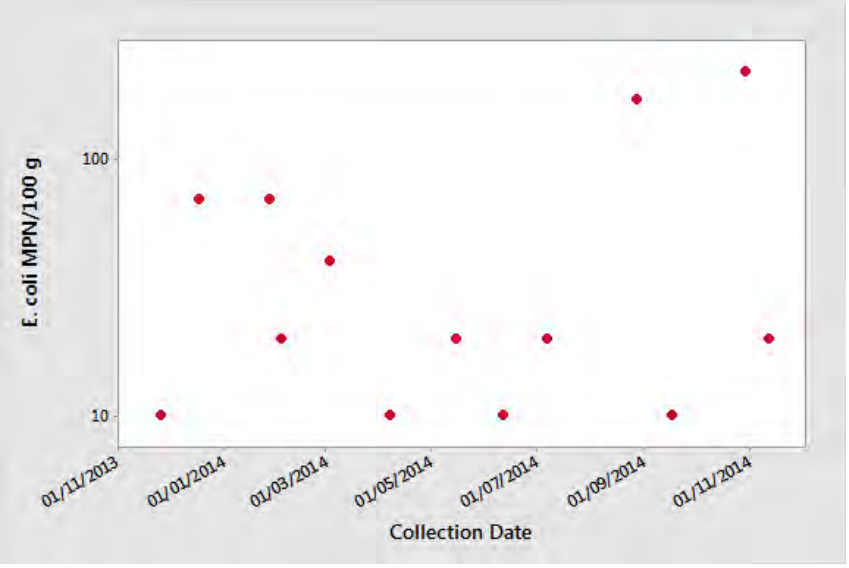


Figure 11.3 Scatterplot of *E. coli* results by collection date at Loch Melfort Pacific oyster

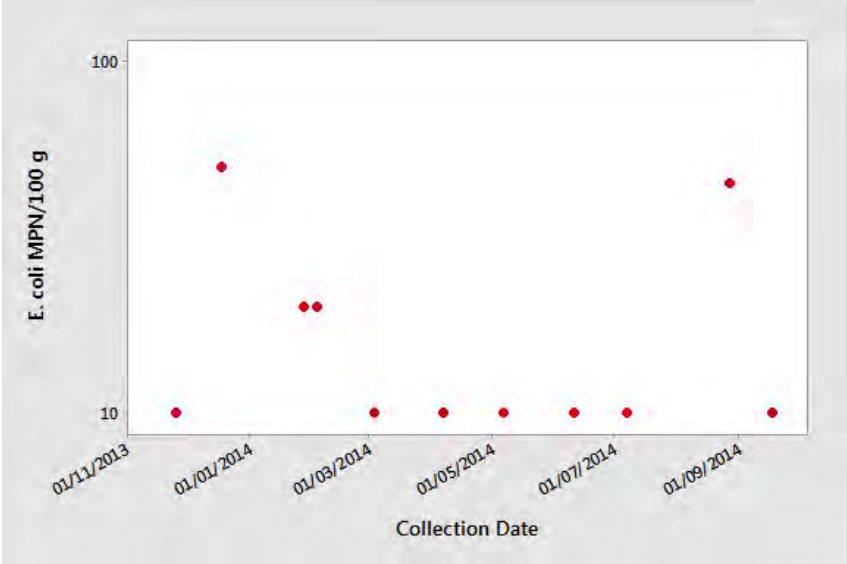


Figure 11.4 Scatterplot of *E. coli* results by collection date at Loch Melfort Native oysters

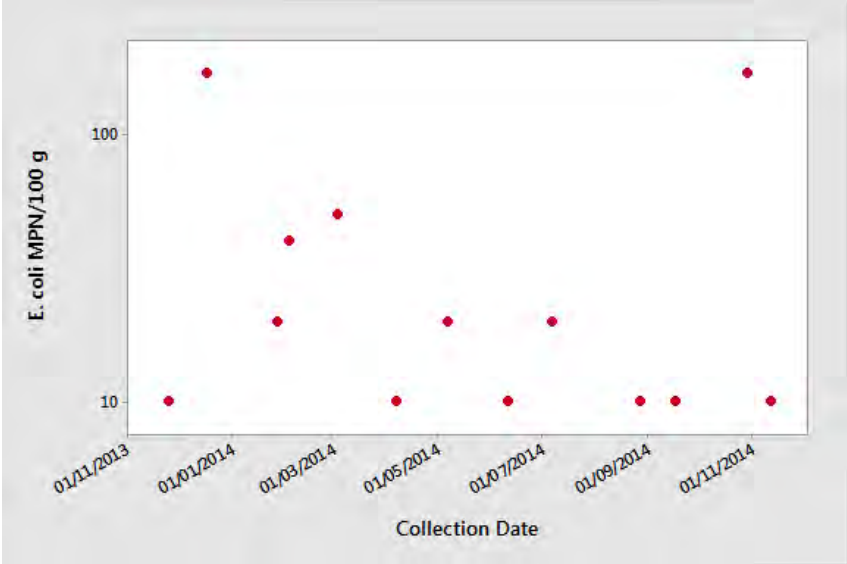


Figure 11.5 Scatterplot of *E. coli* results by collection date at Loch Melfort King scallop

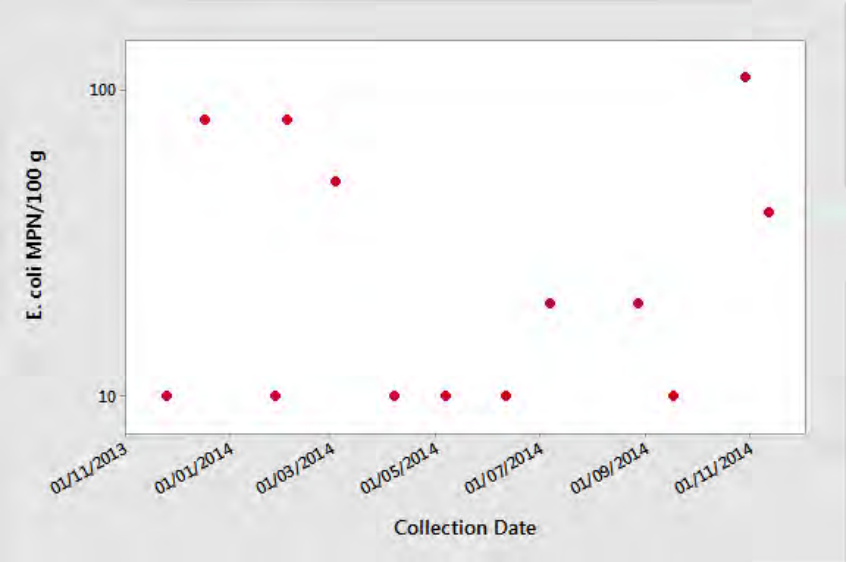


Figure 11.6 Scatterplot of *E. coli* results by collection date at Loch Melfort Queen scallop

Results for all four species were at or below the limit of detection between April and August, with higher results occurring outside this period.

11.5 Seasonal pattern of results

Season dictates not only weather patterns and water temperature, but livestock numbers and movements, presence of wild animals and patterns in human distribution. All of these can affect levels of microbial contamination, causing seasonal patterns in results. A scatterplot of Loch Melfort mussel *E. coli* results by month is displayed in Figure 11.7. Jittering was applied to points at 0.02 (x-axis) and 0.001 (y-axis) respectively. As only 12 months monitoring history was available for shellfish from Creag Aoil, results from this site were not assessed for seasonality.

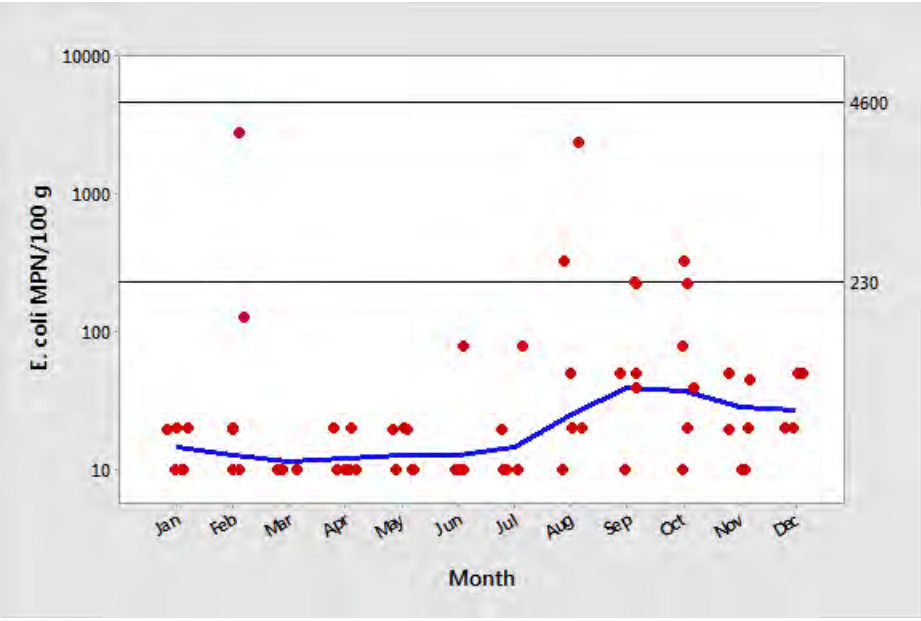


Figure 11.7 Scatterplot of *E. coli* results by month at Loch Melfort, fitted with a lowess line

A slight increase in the trend line is apparent from August to October. The highest results occurred in February, August, and October.

For statistical evaluation, seasons were split into spring (March-May), summer (June-August), autumn (September-November) and winter (December-February). A boxplot of *E. coli* results by season for Loch Melfort is presented in Figure 11.8.

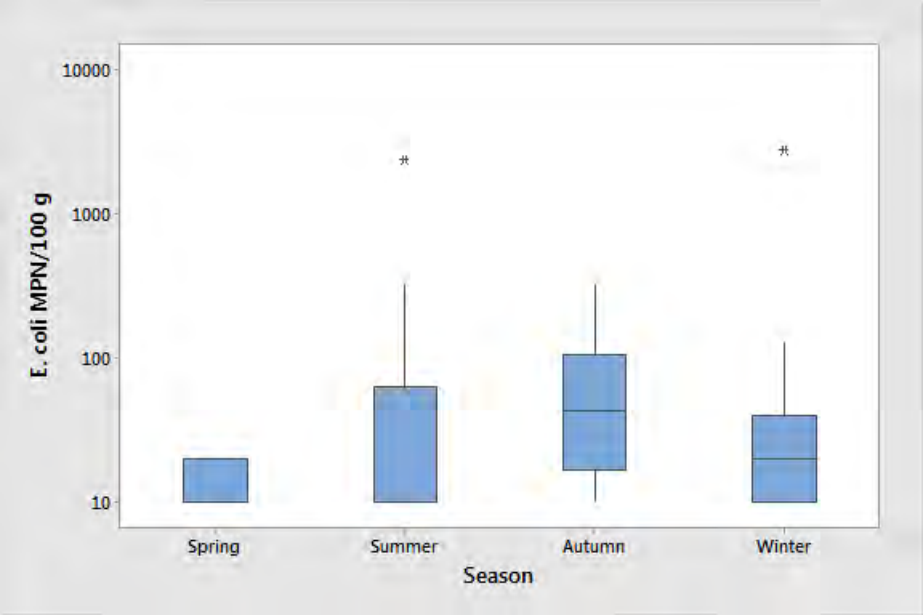


Figure 11.8 Boxplot of *E. coli* results by season at Loch Melfort

A statistically significant difference was found between *E. coli* results for Loch Melfort common mussels by season (one-way ANOVA, p = 0.022) (Appendix 4). Results were significantly higher in autumn than in spring. However, the two highest results occurred in summer and in winter.

11.5.1 Analysis of results against environmental factors

Environmental factors such as rainfall, tides, wind, sunshine and temperature can all influence the flux of faecal contamination into growing waters (Mallin, et al., 2001; Lee & Morgan, 2003). The effects of these influences can be complex and difficult to interpret. This section aims to investigate and describe the influence of these factors individually (where appropriate environmental data is available) on the sample results using basic statistical techniques.

11.5.2 Analysis of results by recent rainfall

The nearest weather station with available rainfall data was at Lismore Frackersaig Farm approximately 25 km north of Loch Melfort. Rainfall data was purchased from the Meteorological Office for the period of 01/01/08 - 30/11/2013 (total daily rainfall in mm). Data was extracted from this for all sample results at Loch Melfort between 01/01/2009 - 30/11/2013.

Two-day rainfall

A scatterplot of *E. coli* results against total rainfall recorded on the two days prior to sampling for Loch Melfort is displayed in Figure 11.9. Rainfall data was available for 57 of the 69 sampling results. Jittering was applied to points at 0.02 (x-axis) and 0.001 (y-axis) respectively.

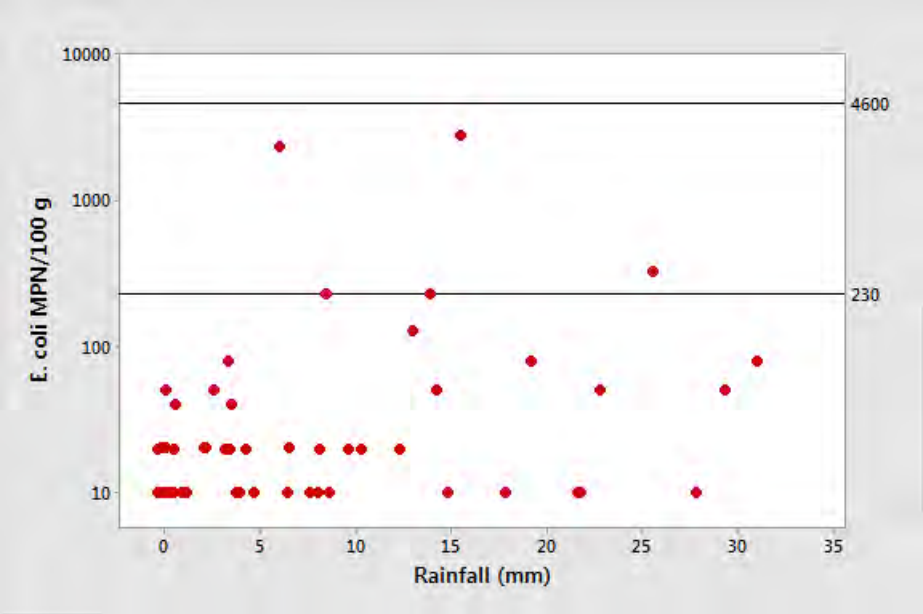


Figure 11.9 Scatterplot of *E. coli* results against rainfall in the previous two days at Loch Melfort

A highly significant correlation was found between *E. coli* results and the previous two day rainfall (Spearman's rank correlation r = 0.349, p = 0.008).

Seven-day rainfall

The effects of heavy rainfall may take differing amounts of time to be reflected in shellfish sample results in different system, the relationship between rainfall in the previous seven days and sample results was investigated in an identical manner to the above. A scatterplot of *E. coli* results against total rainfall recorded for the seven days prior to sampling at Loch Melfort is shown in Figure 11.10. Rainfall data was available for 56 of the 69 sampling results. Jittering was applied at 0.02 (x-axis) and 0.001 (y-axis) respectively.

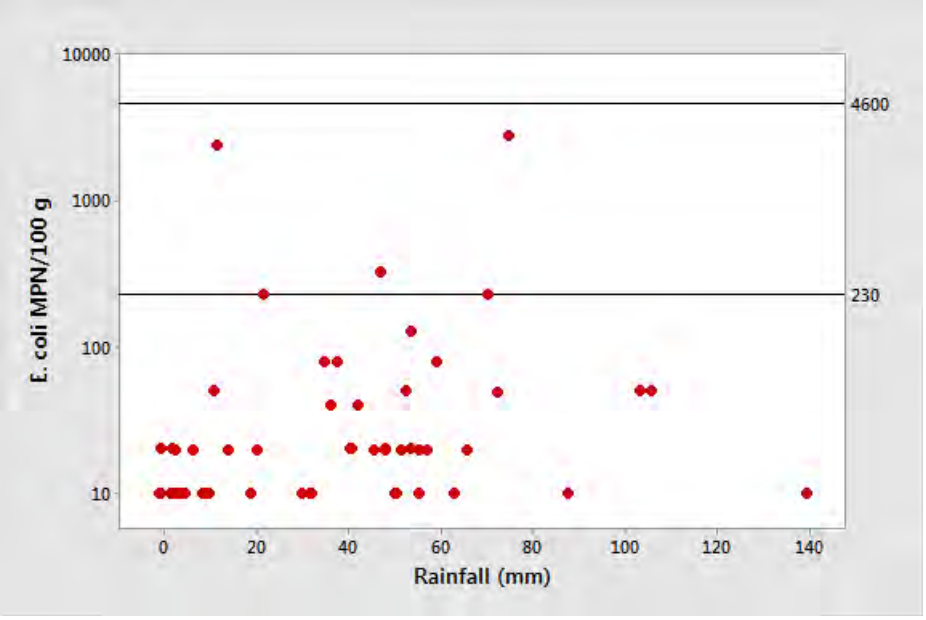


Figure 11.10 Scatterplot of *E. coli* results against rainfall in the previous seven days at Loch Melfort

A very highly significant correlation was found between *E. coli* results and the previous seven day rainfall (Spearman's rank correlation r = 0.417, p = 0.001). However, one of the results greater than 1000 *E. coli* MPN/100 g coincided with 7-day rainfall of less than 20 mm, suggesting that peak contamination events may not be rainfall dependent.

11.5.3 Analysis of results by tidal height

Spring/neap tidal cycle

Spring tides are large tides that occur fortnightly and are influenced by the state of the lunar cycle. They reach above the mean high water mark and therefore increase circulation and particle transport distances from potential contamination sources on the shoreline. The largest (spring) tides occur approximately two days after the full/new moon, at about 45º on a polar plot. The tides then decrease to the smallest (neap) tides, at about 225º, before increasing back to spring tides. A polar plot of *E. coli* results against the lunar cycle is shown for Loch Melfort in Figure 11.11. It should be noted local meteorological conditions (e.g. wind strength and direction) can also influence tide height, but are not taken into account in this section.

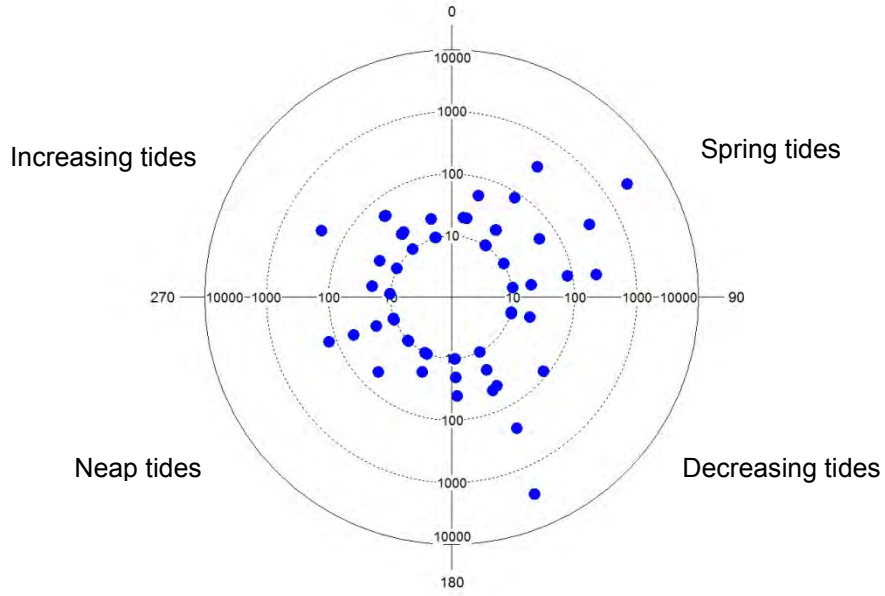


Figure 11.11 Polar plots of *E. coli* results on the spring/neap tidal cycle at Loch Melfort

No significant correlation was found between $\log_{10}$ *E. coli* results and the spring/neap tidal cycle (circular-linear correlation r = 0.208, p = 0.057).

High/low tidal cycle

Tidal state (high/low tide) changes the direction and strength of water flow around production areas. Depending on the location of contamination sources, tidal state may cause marked changes in water quality near the vicinity of the farms. Shellfish species response time to *E. coli* levels can vary from within an hour to a few hours. A polar plot of *E. coli* results against the high/low tidal cycle for Loch Melfort is shown in Figure 11.12. High water is located at 0^{o} on the polar plot and low water at 180^{o}.

High and low water data from Loch Melfort was extracted from POLTIPS-3 in November 2014.

No significant correlation was found between $\log_{10}$ *E. coli* results and the spring/neap tidal cycle (circular-linear correlation r = 0.12, p = 0. 873).

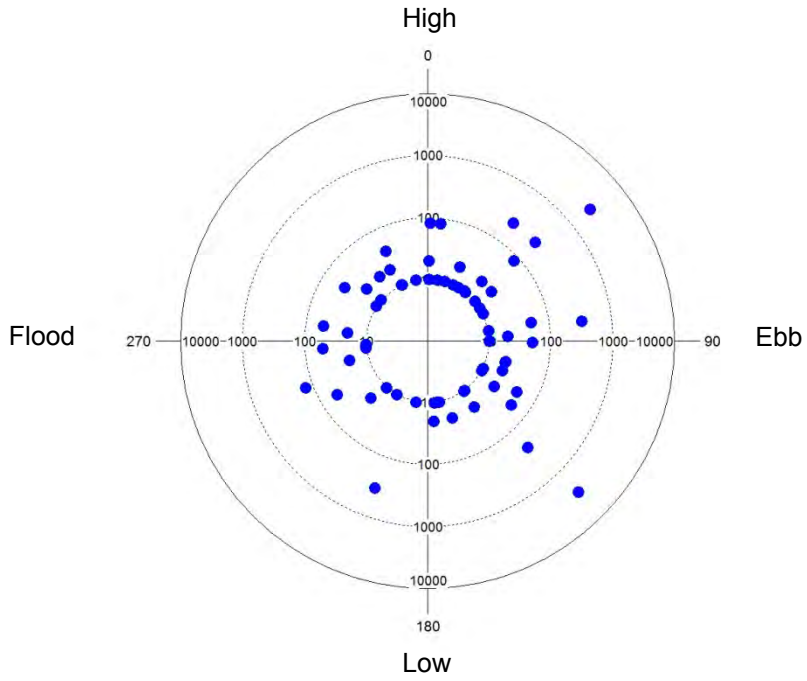


Figure 11.12 Polar plots of *E. coli* results on the high/low tidal cycle at Loch Melfort

11.5.4 Analysis of results by water temperature

Water temperature can affect survival time of bacteria in seawater (Burkhardt, *et al*., 2000). It can also affect the feeding and elimination rates in shellfish and therefore may be an important predictor of *E. coli* levels in shellfish flesh. Water temperature is obviously closely related to season. Any correlation between temperatures and *E. coli* levels in shellfish flesh may therefore not be directly attributable to temperature, but to the other factors e.g. seasonal differences in livestock grazing patterns. A scatterplot of *E. coli* results against water temperature for Loch Melfort is shown in Figure 11.13. Water temperature was recorded for 68 of the 69 sampling results. Jittering of points was applied at 0.02 (x-axis) and 0.001 (y-axis) respectively.

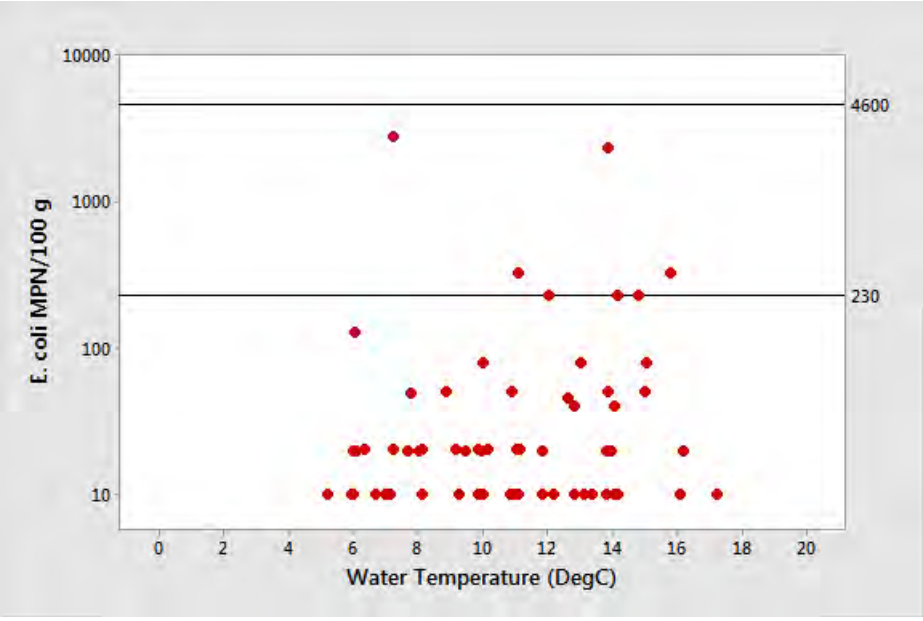


Figure 11.13 Scatterplot of *E. coli* results against water temperature at Loch Melfort

No significant correlation was found between *E. coli* results and water temperature (Spearman's rank correlation r = 0.12, p = 0.387). Sampling occurred at water temperatures between 5 and 17°C, with the majority of results >230 *E. coli* MPN/100 g associated with water temperatures of between 11 and 16°C.

11.5.5 Analysis of results by salinity

Salinity will give a direct measure of freshwater influence and hence freshwater borne contamination at a site. A scatterplot of *E.* coli results against salinity for Loch Melfort is shown in Figure 11.14. Salinity was recorded for 38 out of the 69 sampling results. Jittering of results was applied to points at 0.02 (x-axis) and 0.001 (y-axis) respectively.

No significant correlation was found between common mussel *E. coli* results and salinity (Spearman's rank correlation r = -0.209, p = 0.209).

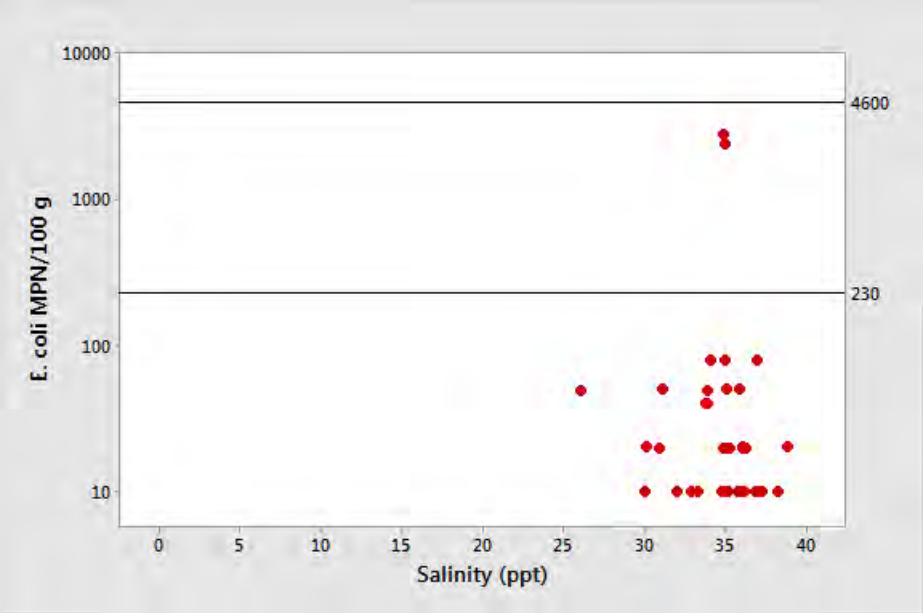


Figure 11.14 Scatterplot of *E. coli* results against salinity at Loch Melfort

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

In the results from Loch Melfort two common mussel samples had results >1000 *E. coli* MPN/100 g and are listed below in Table 11.2.

Table 11.2 Loch Melfort historic *E. coli* sampling results over 1000 *E. coli* MPN/100g

Collection Date	*E. coli* (MPN/100 g)	Location	2 day rainfall (mm)	7 day rainfall (mm)	Water Temp (°C)	Salinity (ppt)	Tidal state (spring/neap)	Tidal State (high/low)
09/02/2011	2800	NM 8062 1115	16.0	77.1	7.0	35	Decreasing	Ebb
01/08/2011	2400	NM 8063 1110	5.9	9.7	14.0	35	Spring	High

The two highest sample results were both taken in 2011, one from February and the other from August. Sampling locations plotted 30 m northeast and 27 m southeast of the RMP at NM 8061 1112, respectively.

Relatively high previous two and seven day rainfall was reported for the sample taken in February (16.0 and 77.1 mm), whilst antecedent rainfall was lower for the August sample (5.9 and 9.7 mm). Water temperature varied between 7 and 14^{o}C, whilst both samples were taken at 35 ppt salinity.

11.7 Summary and conclusions

Result from Loch Melfort mussels have predominantly been low, with only two results exceeding 1000 *E. coli* MPN/100 g. The majority of samples were reported from near the RMP, however a small number were reported from near the shore base and one from the raft location. Samples were reported from near the shore base from August to October 2014. This was the same location from which Creag Aoil samples were reported, and therefore it is not clear whether mussel sampling had moved during this time or whether one location had been mistakenly reported for all samples from the area.

Results from samples of the four species being grown on the multi-species site were all below 230 *E. coli* MPN/100 g. Reported sampling locations have mainly been from either the raft area or the intertidal shoreline near the shore base.

Statisically significant seasonality was shown in common mussel sampling results, which were higher in autumn than spring. However, the two highest results occurred in summer and winter. Sample results by month showed a small rise between late July and October. The two highest results were from samples taken in February and August.

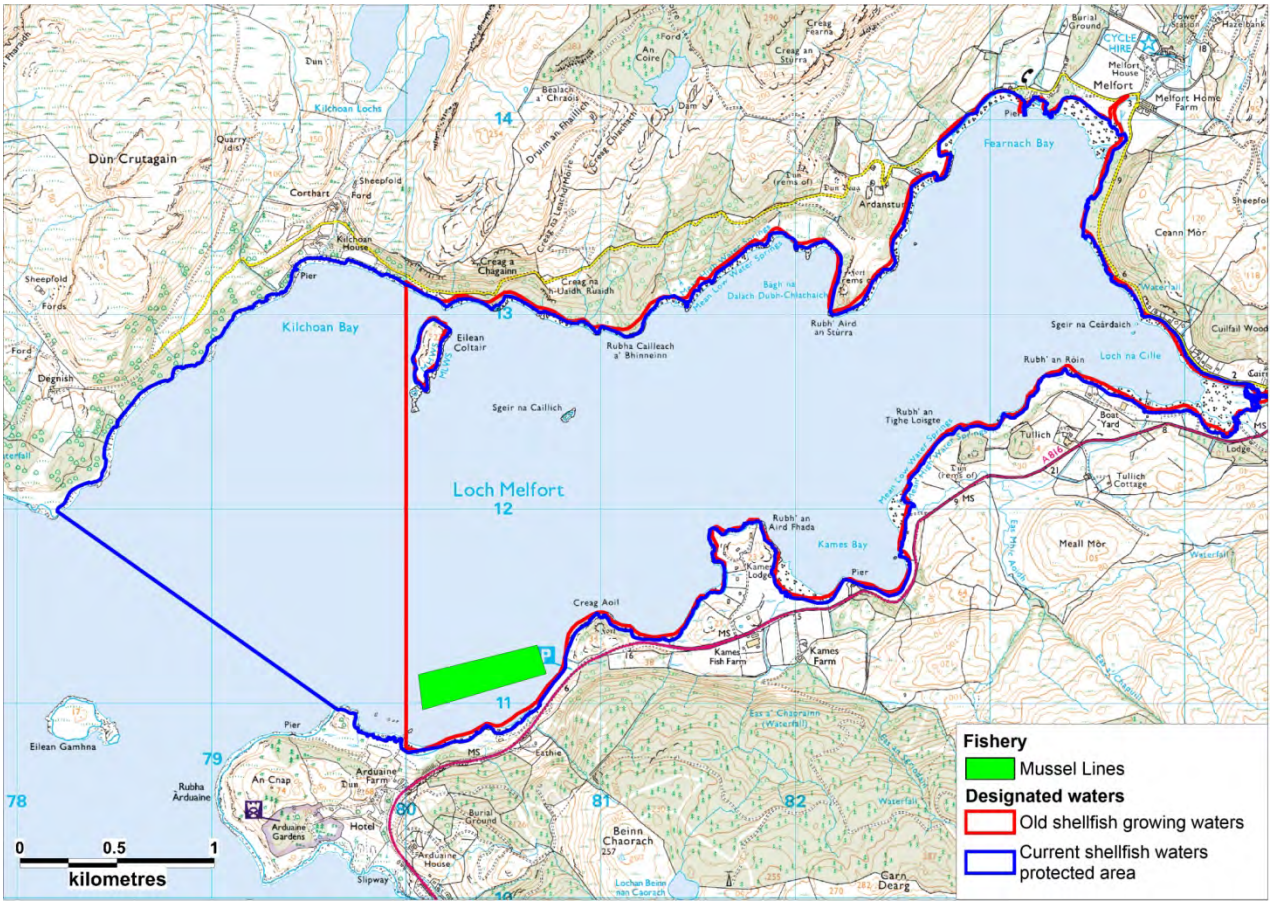
Strong statistical correlations were reported between sample results and both two- and seven-day rainfall.

No statistically significant correlations were found between sample results and water temperature, salinity, or tidal state.

12. Designated Waters Data

Shellfish Water Protected Areas

The Shellfish Waters Directive (2006/113/EC) was repealed on 31 December 2013. 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. The boundaries of the Loch Melfort Shellfish Water Protected Area (SWPA) extend to include Kilchoan Bay compared to the previous Loch Melfort Shellfish Growing Water (SGW), as shown in Figure 12.1. The SWPA designation covers Loch Melfort and includes the production area and mussel farm. 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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Ordnance Survey licence number [GD100035675]

Figure 12.1 Designated shellfish water protected area – Loch Melfort

Bathing Waters

There are no designated bathing waters within Loch Melfort.

13. Bathymetry and Hydrodynamics

13.1 Introduction

13.1.1 The Study Area

The Loch Melfort assessment area is situated in Argyll on the west coast of Scotland. The assessment area comprises the whole of Loch Melfort, with the western assessment area boundary stretching between Degnish Point in the north and Rubha Arduaine in the south. The landscape around the assessment area is characterised by low hills, areas of commercial forestry, and several small freshwater lochs. Many small streams flow into the assessment area from these lochs and the surrounding hills. Two more substantial streams flow into the loch at the villages of Melfort and Kilmelford. A map of the assessment area can be found in Figure 13.1.

The assessment area is 5.6 km in length and 2.3 km in width at the widest point and 0.8 km in width at the narrowest point. Two islands are found within the assessment area – the larger Eilean Coltair (0.5 km in length) and the small Sgeir na Caillich. A further larger island, Eilean Garrhna, is found immediately outside the assessment area boundary.

Coordinates for Loch Melfort:

056.251830°N 005.541674°W
OS GB36 180696 712234

Figure 13.1 Extent of the Loch Melfort hydrographic assessment area

13.2 Bathymetry and Hydrodynamics

13.2.1 Bathymetry

Figure 13.2 shows the bathymetry of the assessment area. Water depths generally vary between 20 m and 50 m across the majority of the assessment area, shallowing rapidly in the vicinity of the coastline. Water depths remain similar outside of the assessment area, apart from shallow areas around the island Eilean Gamhna.

An isolated deep area can be found immediately to the north of Arduaine Point, along the assessment area boundary, reaching a maximum depth of 75 m. Several shallow areas are found in the middle portion of the loch, including the tidally exposed Campbell Rock.

Loch Melfort has a single sill which lies immediately outside the assessment area, stretching between Degnish Point, Eilean Gamhna, and Arduaine Point. The sill is 2.1 km in length and had a mean depth of 19 m (Edwards & Sharples, 1986).

There are no large areas of intertidal sand, mud, or boulders within the assessment area, with the most extensive area found at Loch na Cille covering 0.08 km^2.

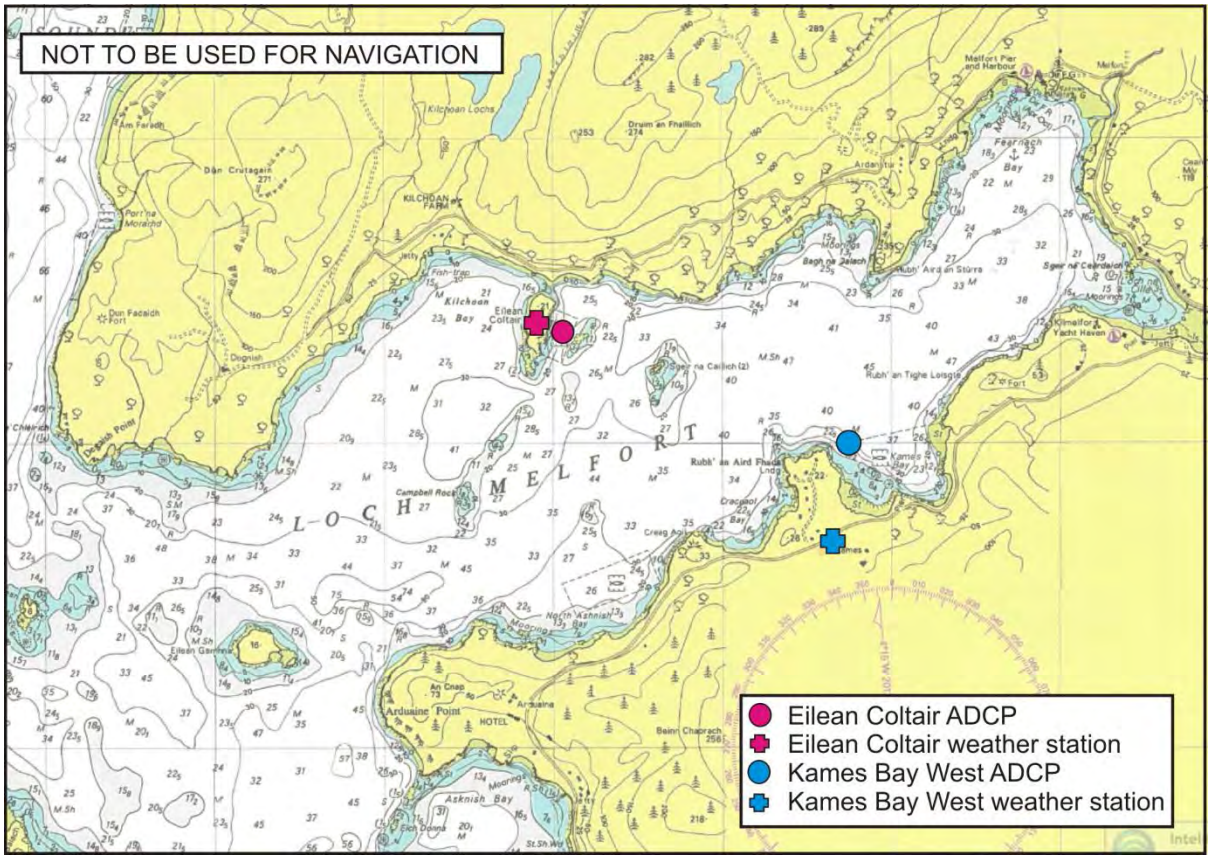
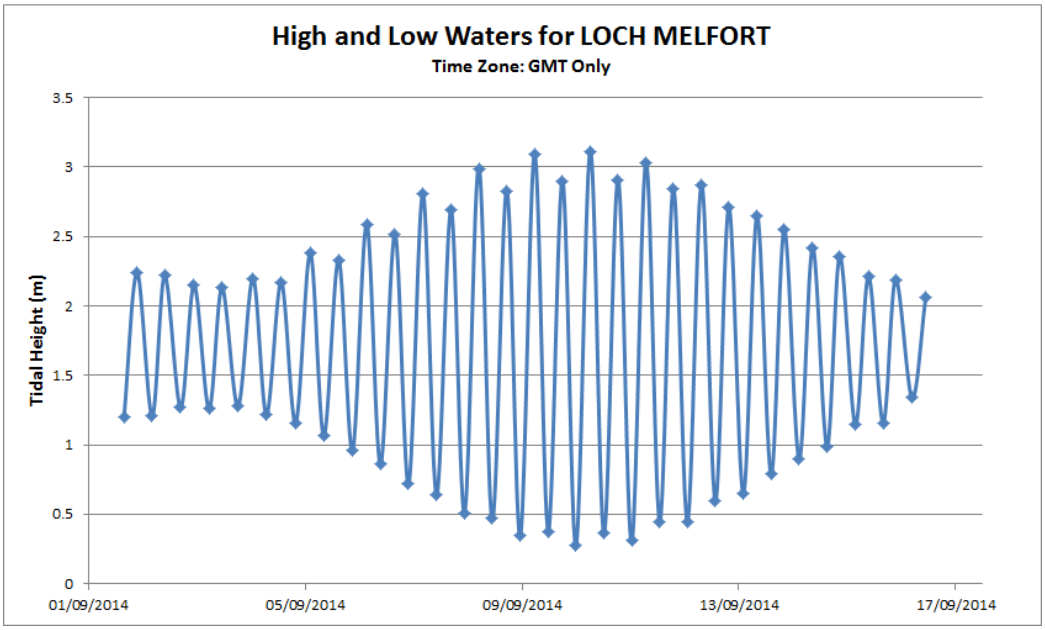


Figure 13.2 – Admiralty chart (SC5611:16) extract for Loch Melfort. Locations of ADCPs and weather stations within assessment area are shown.

The mean depth of the assessment area at low water is approximately 27.9 m, while the estimated low water volume is 2.61 x 10^8 m^3 (Edwards & Sharples, 1986).

13.2.2 Tides

Standard tidal data for Loch Melfort, centred around the survey date of 9th September 2014, are shown in Figure 13.3. Tidal predictions for Loch Melfort 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 Loch Melfort.

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

Mean High Water Springs = 2.80 m
Mean Low Water Springs = 0.60 m
Mean High Water Neaps = 2.10 m
Mean Low Water Neaps = 1.30 m

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

Springs: 2.05 x 10^7 m^3
Neaps: 7.44 x 10^6 m^3

13.2.3 Tidal Streams and Currents

There are no published tidal diamonds for this area. Charted current speeds available for the nearby Sound of Shuna, 4 km to the southwest of the assessment area, indicate a mean spring flood current speed of 0.5 m/s and a spring ebb speed of 1.0 m/s. However, this is a relatively constrained body of water. Within the more open assessment area, flow speed will generally be lower but local enhancement of the tidal streams may occur off headlands and around islands.

Current meter data were available at two specified sites within the assessment area: Eilean Coltair and Kames Bay West. Data were obtained from SEPA for the two sites, whose locations are shown in Figure 13.4.

Each survey spanned a period of at least fifteen days, focussing on a half-lunar period in order to capture a spring-neap cycle:

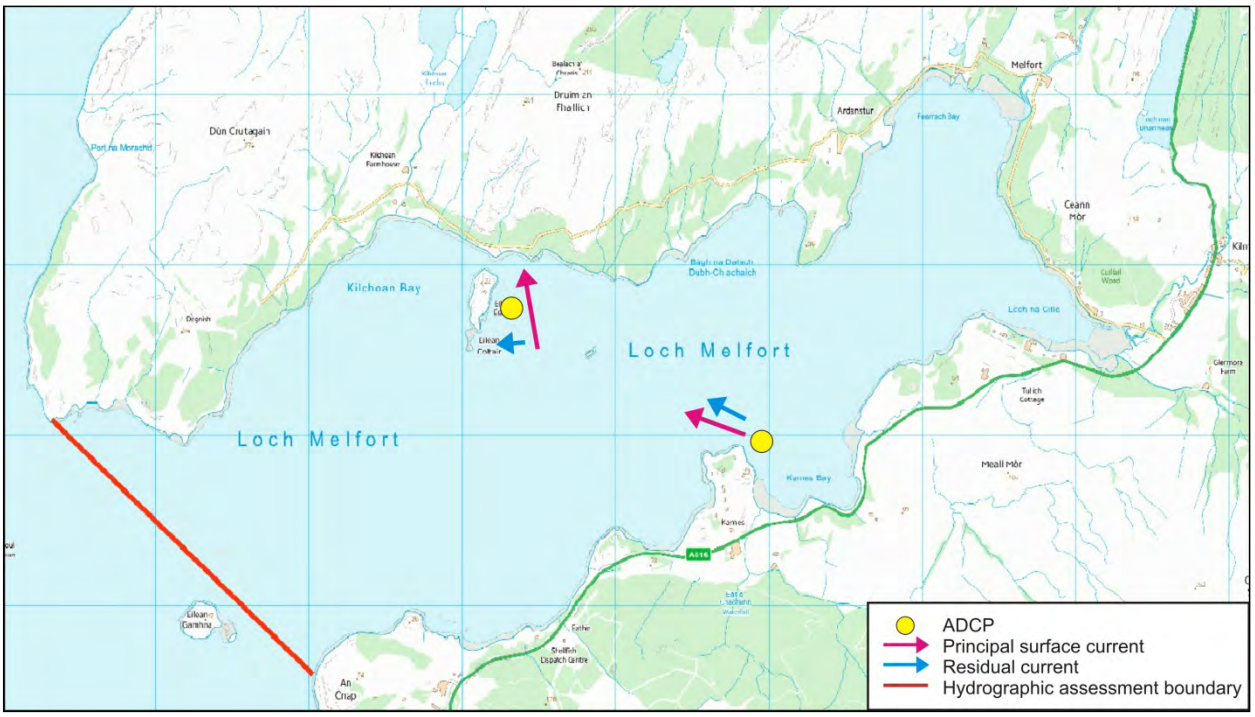


Figure 13.4 Map showing Loch Melfort ADCP sample sites within the assessment area.

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

Data from Eilean Coltair, OSGB36 NM 80335 12806, were collected between 17/02/09 and 05/03/09 and are summarised in table 13.1. The average water depth recorded for the duration of the survey was 25.3 m (TransTech Ltd., 2009).

Mean current speeds suggest that flow speeds decrease in proximity to the sea bed. Currents are generally characterised by flows along a north-south axis, in parallel with the channel between Eilean Coltair and the adjacent tidally exposed rocks.

Residual currents are strongest at mid-water depths and across all depths tend to flow in a north north-easterly to south south-westerly direction, except at the surface. At the surface, residual currents tend to flow in an east-west direction. Flow speeds were similar across the spring-neap tidal cycle, though the southerly and westerly components of currents were reduced during the spring tide period.

Near bed flows of < 0.03 ms^{-1} occurred over 76% of the survey duration, suggesting that this location is moderately quiescent (TransTech Ltd., 2009).

Table 13.1 Eilean Coltair current data measured in 2009

Average Depth	Near-bed (2.3 m above seabed)	Mid-water (17.3 m above seabed)	Sub-surface (21.3 m from seabed)
Mean Speed (ms^{-1})	0.023	0.036	0.30
Maximum Speed (ms^{-1})	0.09	0.28	0.10
Principal Axis Amp & Dir (ms^{-1}) & (°Grid)	0.033 (005)	0.049 (175)	0.038 (350)
Residual speed (ms^{-1})	0.005	0.019	0.013
Residual direction (°Grid)	19	202	265

A weather station was also deployed during the Eilean Coltair survey. Wind speeds were relatively low during the deployment, and the greatest recorded daily wind speed reached 6 ms^{-1} on one occasion. Winds came from all directions, but most frequently from the south during the deployment period.

Data were collected from Kames Bay West, OSGB36 NM 81906 11973 between 08/09/2011 and 24/09/2011 and are summarised in Table 13.2. The average water depth recorded during the survey was 22.2 m.

Mean current speeds suggest that currents flow at similar speeds throughout the water column at Kames Bay West. Mean current speeds are also similar to those recorded at Eilean Coltair, though currents at Kames Bay West flow in a north-westerly to south-easterly directions. Current speeds at this site tended to be greater during spring tides than during neap tides, with the northerly component of current flows increasing substantially at this time.

Near bed flows of < 0.03 ms^{-1} occurred over 63% of the survey duration, suggesting that this location is somewhat quiescent (Wells, 2007).

Table 13.2 Kames Bay West current data measured in 2011

Average Depth	Near-bed (2.6 m above seabed)	Mid-water (10.6 m above seabed)	Sub-surface (17.6 m from seabed)
Mean Speed (ms^{-1})	0.03	0.03	0.03
Maximum Speed (ms^{-1})	0.125	0.135	0.125
Principal Axis Amp & Dir (ms^{-1}) & (ºM)	0.034 (305)	0.036 (295)	0.041 (290)
Residual speed (ms^{-1})	0.02	0.02	0.02
Residual direction (ºM)	301	289	297

A weather station was also deployed during the Kames Bay West survey, and winds during the deployment averaged approximately 4.2 ms^{-1}. The maximum recorded wind speed was 11.7 m/s. While winds most frequently came from a south south-westerly direction, winds were recorded from all directions during the deployment.

In general, the current meter data from the above sites suggests that the assessment area of Loch Melfort is moderately quiescent with rather low current speeds.

Using recorded mean surface principal current speeds and assuming a uniform sinusoidal tide, the cumulative transport that might be expected during each phase of the tide (approximately 6 hours) is 0.52 km at Eilean Coltair and 0.41 km at Kames Bay West, as illustrated in Figure 13.4. No distinction is made here for variation in transport between springs and neaps.

Dispersion is an important property of a water body with respect to redistribution of contaminants over time. In a study by Symonds (2011), suspended particulate wastes from a fish farm in Seil Sound, to the north of the Loch Melfort assessment area, were shown to be transported most frequently in a westerly direction, and least frequently in a southerly direction. Re-suspension of particles over the tidal cycle meant that little waste accumulated on the seabed, and that dispersion was high around this and other fish farms modelled in this study (Symonds, 2011), though no sites were within the Loch Melfort assessment area. However, dispersion in Loch Melfort is likely to be locally enhanced by flows around any islands and tidally exposed rocks throughout the assessment area.

Dispersion of surface contaminants may be enhanced by wave energy within the assessment area. Sources of wave energy are most likely to be from short period waves generated within the area itself and nearby waters. The assessment area is sheltered by the islands of Seil, Shuna, and Luing, and so dispersion in the site will not be strongly affected by longer period swells originating from the open ocean.

13.2.4 River/Freshwater Inflow

The River Oude flows into the assessment area at the village of Melfort, while a further large stream flows into the assessment area at Loch na Cille. Numerous other small streams flow into Loch Melfort from the surrounding hills and freshwater

lochs. These lochs include the Kilchoan lochs on the north side of the assessment area, Loch nan Druimnean and Loch a'Phearsain to the east, and Loch a'Clachain to the south of the area.

The annual precipitation in the area is approximately 1750 mm and the annual freshwater runoff is estimated as 108.9 M m^3 yr^{-1} (Edwards & Sharples, 1986). The ratio of freshwater flow to tidal flow in Loch Melfort is low at 1:100, a relatively moderate ratio for Scottish sea lochs.

13.2.5 Meteorology

The nearest weather station for which a continuous rainfall dataset is available is located at Frackersaig Farm on Lismore. This station is situated approximately 25 km to the north of the assessment area.

While 2010 generally had the lowest daily rainfall, the highest rainfall for this time period was recorded in 2011 (2354 mm). High rainfall values of > 50 mm d^{-1} occurred in both 2009 and 2011, and a single rainfall event of 60 mm d^{-1} occurred in 2009. High rainfall events of > 40 mm d^{-1} occurred in January, March, and September. Daily rainfall varied seasonally, from lower values in the spring to higher values in winter (November, December, January). Mean rainfall at Frackersaig Farm peaks in November. For the duration of the dataset, daily rainfall below 1 mm occurred on 47% of days, while daily rainfall above 10 mm occurred on 17% of days.

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

Wind data were obtained from Glasgow, Bishopton, 74 km to the south east of the production area. Given the distance between this location and the assessment area, and varying topography, wind statistics may not be directly transferrable to the specific production area at Loch Melfort. 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 from the west. Seasonally the strongest winds occurred during the winter and came from the south and southwest. Typically the wind came from around the south and west throughout the year but spring in particular also saw stronger winds from the east. These two directions lie perpendicular to the axis of the assessment area. Nevertheless, local wind direction in the assessment area is likely to be influenced by the surrounding topography, and is likely to differ from that at Bishopton on any particular day, given the substantial distance between these locations. However, the overall prevailing wind direction is likely to be appropriate.

13.2.6 Model Assessment

The exchange characteristics of Loch Melfort have been assessed using a layered box model approach. The model represents the Loch as a box made up of three layers and was formulated according to the method of Gillibrand et al (2013). The

box layers are forced with surface wind stress, estimates of fresh water discharge, surface heat flux parameters and, at the open coastal boundary, profiles of temperature and salinity are prescribed from climatology compiled by the UK Hydrographic Office. This sets the model with climatological boundary conditions to represent an 'average' year. The model has been tuned and validated for Lochs Creran and Etive. A full validation for Loch Melfort was not done due to lack of seasonal data.

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

The ratio of Tidal volume flux to estuarine circulation volume flux is around 1. Values between 2.0 and 0.5 indicate a system where tidal and density driven exchanges are comparable (Gillibrand, et al., 2013). When the exchange characteristics of a location are tidally dominated then they will experience rather minimal variation in behaviour due to seasonal changes in the freshwater fluxes. In contrast, locations that are dominated by estuarine exchange will show a much greater sensitivity to the seasonal variation in freshwater fluxes. Those that are not dominated by either tidal or estuarine processes will likely show a more limited seasonal variation.

The flushing time for Loch Melfort is around 9 days which is comparable to the tidal prism model (Edwards & Sharples, 1986; Marine Scotland, 2012).

13.3 Hydrographic Assessment

13.3.1 Surface Flow

The assessment area does have a point source of freshwater towards the head of the loch but also has numerous smaller rivers discharging around the perimeter. The meteorological data indicate a moderate seasonal variation in freshwater discharge which will create seasonal variation in the degree to which the site is stratified by freshwater stratification.

It seems apparent that freshwater contributes to the exchange characteristics of the site. Indeed it the estuarine exchange appears to be as important as the tidal exchange so that the overall exchange properties of the assessment area will have a seasonal variation – being more readily exchanged during times of high run off. In addition, the formation of a distinct fresh surface layer makes it susceptible also to the influence of wind giving rise to current flow that can vary with depth. However, it is likely that these layers will become rather quickly mixed during periods of strong wind.

Loch Melfort is relatively simple in terms of the topography of the loch. Further, tidal flows are found to be relatively weak or moderate. From the current meter records it is clear that the flow of water is influenced strongly by the local bathymetry and it is

expected that the dominant flow within the assessment area will follow the axis of the loch with the flood tide tending to flow east whilst the ebb tide will flow west. The cumulative transport distance on each phase (flood/ebb) of the tide has been estimated to be typically 0.5 km within the assessment area.

The residual flows during the period of measurement are typically weak. Surface residual flows would be enhanced by winds blowing out of the loch and supressed by the statistically more likely westerly winds. .

Net transport of contaminants is related to the residual flow. The net transport over a tidal cycle of approximately 12 hours would be around 1.0 km or less. It is likely that any surface contaminant in the assessment area would be transported seaward under the influence of the estuarine circulation.

13.3.2 Exchange Properties

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

Current flow has been measured at two locations within the assessment area yet each current meter is only deployed for a relatively short period of the year, limiting detailed seasonal analysis. Nevertheless, the tidal flows are generally weak or moderate and residual flows are also moderate. There is rather little descriptive literature on exchange properties for the area. The box model provides consistent information on the exchange properties of the site. Consequently, the confidence level of this assessment is MEDIUM.

14. Shoreline Survey Overview

The Loch Melfort shoreline survey was carried out on the 9th and 10th September 2014. Scattered showers fell in the 48 hours prior to the survey. Weather on both survey days was predominantly dry and sunny, with several light showers reported and temperatures of 19-20ºC. No wind was reported and the sea state was calm.

The active mussel fishery consisted of a long line common mussel farm, with 13x300 m lines and 10 m droppers. Harvesting occurs occasionally, usually over the winter months. No observations were made of the new multi-species site for Pacific and native oysters and King and Queen Scallops. Mrs E. Martin from the company that owns the site (Celtic Sea) stated cultivation had not yet been successful. Rafts were visible inshore of the longlines in photographs taken during the shoreline survey, however their locations were not specifically noted.

The surrounding human population appeared to be low, though a cluster of homes was seen at Kames, where eight private dwellings were noted and two new buildings were under construction. The Loch Melfort Hotel was located approximately 500 m south of the production area. Two static caravans were observed at the Celtic Sea shore base. Septic tanks and/or outfalls were recorded at Kames. Three dry black pipes were also observed next to the pier at Celtic Sea shore-base.

Seventeen sheep were observed on the hillside adjacent to the production area, with wool and droppings also noted on the shore. Two horses were also observed in a field southwest of the fishery.

Land use around the loch was a mixture of farming, forestry and scattered housing. Pasture and coniferous forests dominated the surrounding land.

Five watercourses were sampled. Freshwater samples varied between <10 and 240 *E. coli* MPN/100 g. Five smaller watercourses were also noted, but were not measured or sampled.

Forty-eight eider ducks were noted around the northwest extent of the mussel farm, and five cormorants were seen on floats on the west side of the mussel farm. A common seal was also observed east of the mussel farm.

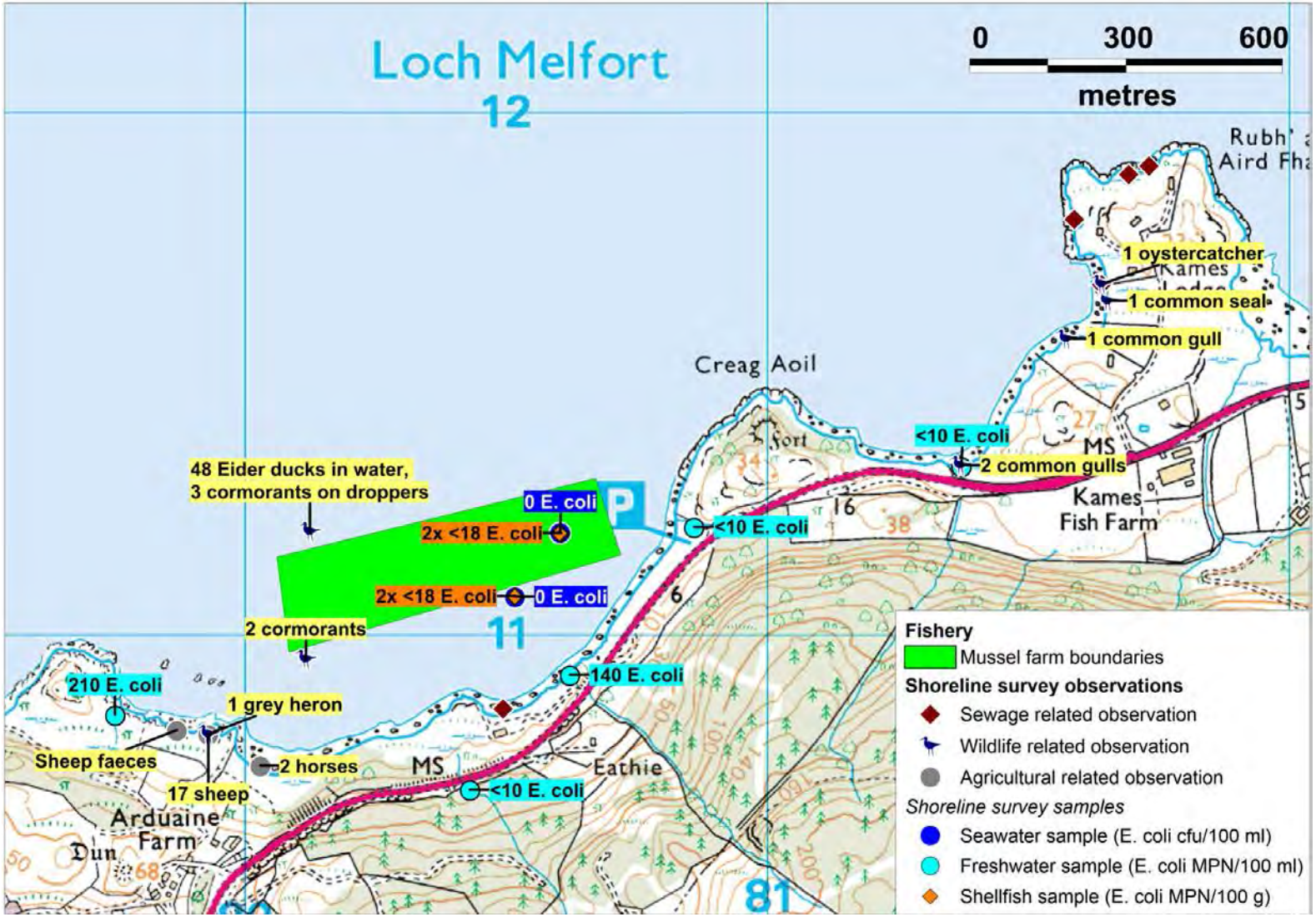


Figure 14.1 Map of shoreline survey observations at Loch Melfort

15. Bacteriological Survey

A bacteriological survey was undertaken at Loch Melfort to help inform the assessment of spatial impacts from potential sources of contamination in the area. Sampling was undertaken on two occasions at three locations that had been sampled during the shoreline survey. Sampling was undertaken from the upper 3 m of the lines. 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.

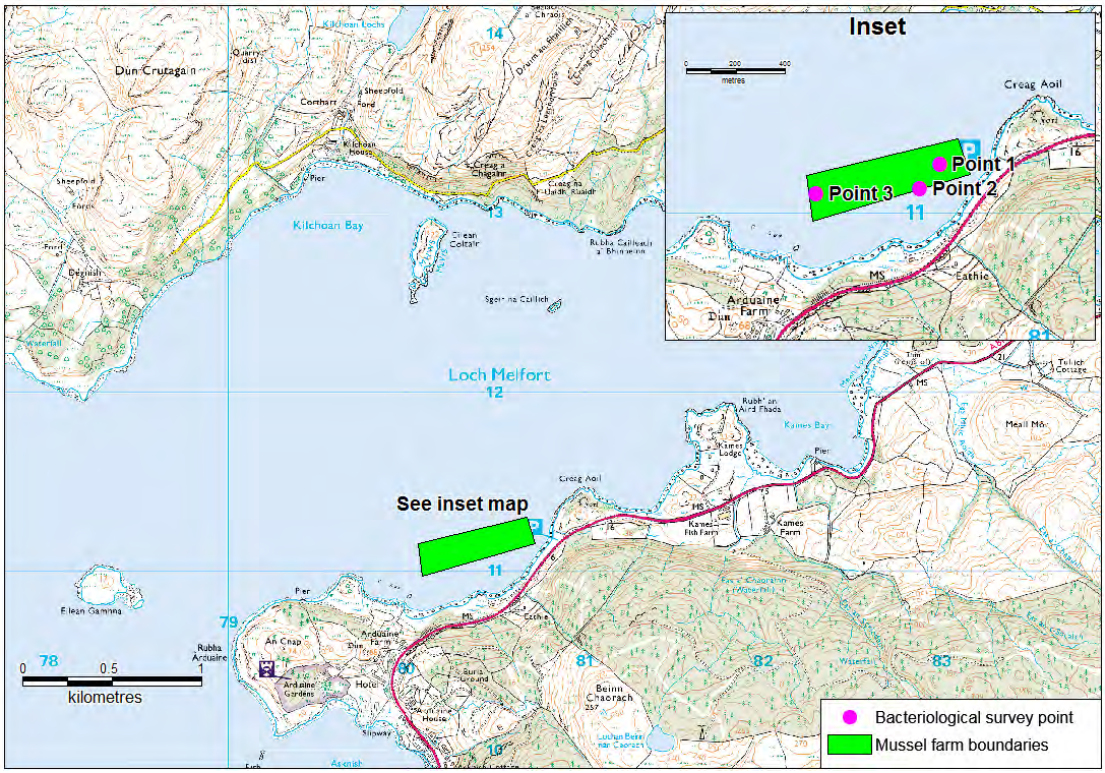


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Figure 15.1 Bacteriological survey sampling locations

Table 15.1. Bacteriological survey results

Sample point	Site name	NGR	*E. coli* MPN/100 g[1]				
			09/09/2014	12/11/2014	24/11/2014	Geometric mean	Maximum
1	East end	NM 8059 1120	<18	<18	<18	10	<18
2	RMP	NM 8053 1109	<18	20	<18	13	20
3	West end	NM 8010 1115	*	<18	45	**	45

[1]< values were assigned a nominal value of 10 for the determination of the geometric mean
* no sample result was available from this point ** not calculated

The highest result overall came from point 3, on the western end of the mussel farm. The geometric mean was higher at the RMP than at the east end of the farm.

16. Overall Assessment

Human sewage impacts

The main human sewage impacts to the shellfish farm come from private sewage discharges from the shore base south of the farm area and from homes at Kames, to the east of the farm. Sewage discharges arising at the head of the loch at Kilmelford and Melfort, are likely to contribute to background levels of contamination in the outer loch. Impacts from CSO and/or EO discharges were not assessed in the modelling study, and spills from these may result in impacts at the fishery. Discharges from Ardouaine to the south of the loch mouth could potentially reach the mussel farm on a flood tide, however no data was available on the movement of currents around this headland. Sewage from Croabh Haven are considered less likely to directly impact the fishery.

Yachts using moorings and anchorages near the fishery are likely to be a significant source of contamination when discharging heads overboard. Any impacts from these is considered most likely during the sailing season of approximately May to October and may be highest at the southwest end of the mussel farm when there are yachts at the nearby anchorage.

Agricultural impacts

Diffuse contamination from agricultural sources is likely to contribute significantly to faecal contaminant loadings at the fishery. The main impacts are expected to be from farms at Ardouaine and at Kames. Evidence of livestock use of the shoreline was seen to the southwest of the mussel farm, and impacts may be highest closer to shore at this end of the shellfish farm.

Wildlife impacts

Seals and seabirds were both seen in the vicinity during the shoreline survey, and the harvester reported issues with eider ducks at the mussel farm. Wildlife are therefore expected to contribute to background levels of faecal contamination at the shellfishery.

Seasonal variation

A slight increase was seen in *E. coli* monitoring results between late July and October, and statistically significant seasonal variation was found with results in autumn higher than in spring. However, the highest overall results occurred in summer and winter. The human population in the area is expected to increase significantly during the summer months due to the presence of relatively large amounts of tourist accommodation around the loch. In light of the large number of moorings and anchorages in the loch, there is likely to be a significant increase in human sewage contamination to the loch during the summer sailing season.

The number of sheep present in the area is expected to be roughly double in spring and summer, when lambs are present.

Daily rainfall values were found to be lowest in June and to increase from August through winter. Rainfall exceeding 40 mm/day occurred in August, January and February.

Rivers and streams

The main freshwater inputs to the loch are the large watercourses discharging to its head, east of the shellfish farm. These are likely to help drive westward flow of surface water out of the loch, and are likely to contribute to background contamination levels at the fishery. Watercourses closer to the shellfish farm were found during the shoreline survey to carry only moderate estimated *E. coli* loadings. Loadings in these watercourses would be expected to increase significantly after rainfall due to the livestock kept in the catchment. Statistically significant correlations were found between results and rainfall during the 2- and 7-day periods prior to sampling, suggesting that rainfall-dependent sources are significant at this site. The nearest watercourses to the fishery are along the shoreline to the south and east of the mussel farm. These drain mainly wooded areas.

Larger watercourses were recorded at the head of the loch during the survey at Loch na Cille, and these may contribute to overall loadings at the fishery during periods of rainfall. Salinity profiles taken during the shoreline survey showed no appreciable increase in salinity with depth, and recorded salinity values were approximately that expected of full strength sea water.

Movement of contaminants

Assessment of hydrography suggests that current speeds are very low within the loch, and that particle transport distances would normally be less than 500 metres, and at most around 1 km. Sources arising at the head of the loch would tend to be transported toward the shellfish farm in freshwater flow moving westward out of the loch, and that this flow would be affected by wind direction with the predominant westerly winds tending to entrain contaminants at the head of the loch and easterly winds tending to drive them down the loch.

No assessment was available of potential northward movement of waters from outside the loch. It is presumed that contaminants arising in Asknish Bay could potentially be carried around the headland toward the mussel farm. The largest sewage discharge in the area is from Croabh Haven, approximately 4 km south of the mouth of the loch. Due to the distance and depths of water between the fishery and these sources, they are considered unlikely to have an impact at the fishery. However due to uncertainty regarding the flow of water between these area, impacts on at least background contamination levels cannot be discounted.

Temporal and geographical patterns of sampling results

It was only possible to assess temporal variation in mussel results, for which there was more than 12 months monitoring history. Overall, contamination levels remained consistently low throughout the period assessed. A greater number of results at or above 230 *E. coli* MPN/100 g occurred after 2012.

The two highest results in mussels were recorded near the nominal RMP. Results for samples reported against locations west of the RMP were very low. However, most results at this site have been very low, and there is little evidence to distinguish any geographical trends.

Conclusions

The fishery is subject to limited faecal contamination from a variety of diffuse human and animal sources, but including point source discharges to sea in the near vicinity. Seasonal variation was seen in results, with a trend toward higher results in late summer and autumn, coinciding at least in part with higher human and livestock populations as well as higher rainfall. The significant correlations found between rainfall and mussel *E. coli* results suggests that rainfall dependent diffuse sources are an important pathway for contamination at this site.

The RMP has been near the southeastern end of the farm, where there are more watercourses discharging to the bay. However, livestock impacts are likely to be higher at the western end of the farm, where sheep and their droppings were seen on the shoreline.

Predicted tidal excursions in the loch were very low, which suggests that sources nearest the fishery will be most significant in terms of contamination there and that once contaminants enter the area they may not disperse quickly. Due to some estuarine circulation arising from watercourses at the head of the loch, sources to the east of the fishery are likely to contribute to background levels of faecal contamination there. It is not clear whether sources outside the loch are likely to contribute similarly to contamination levels at the fishery.

Results were similar between the different species sampled at Creag Aoil, although it is not clear whether this area is in active production.

The bacteriological survey undertaken at the mussel farm showed little variation in results, with all but two results below the limit of detection. The highest result overall was at the east end of the farm, this was still a very low result. The highest geometric mean result came from samples taken at the current RMP.

17. Recommendations

Production area

As production is limited to the outer part of the loch, and to correct the overlap between the Loch Melfort and Loch na Cille production areas, it is recommended that the Loch Melfort boundaries be amended to exclude areas from Kames eastward.

The recommended production area is the area bounded by lines drawn between NM 7964 1097 to NM 7820 1196 and between NM 8100 1292 and NM 8100 1145 and extending to MHWS.

RMP

As there is no information to suggest that any other part of the fishery may be more contaminated, it is recommended that the current mussel RMP (NM 8061 1112) be maintained.

As the Creag Aoil multi-species site is currently based on rafts south of the mussel farm, it is recommended that any monitoring be undertaken from the rafts, at NM 8053 1095.

Tolerance

A sampling tolerance of 40 metres should be applied to allow for movement of the mooring lines.

Depth of sampling

Samples should be taken from between 1 and 3 metres depth in order to reflect contamination carried in surface water runoff.

Frequency

A monthly monitoring frequency should be maintained.

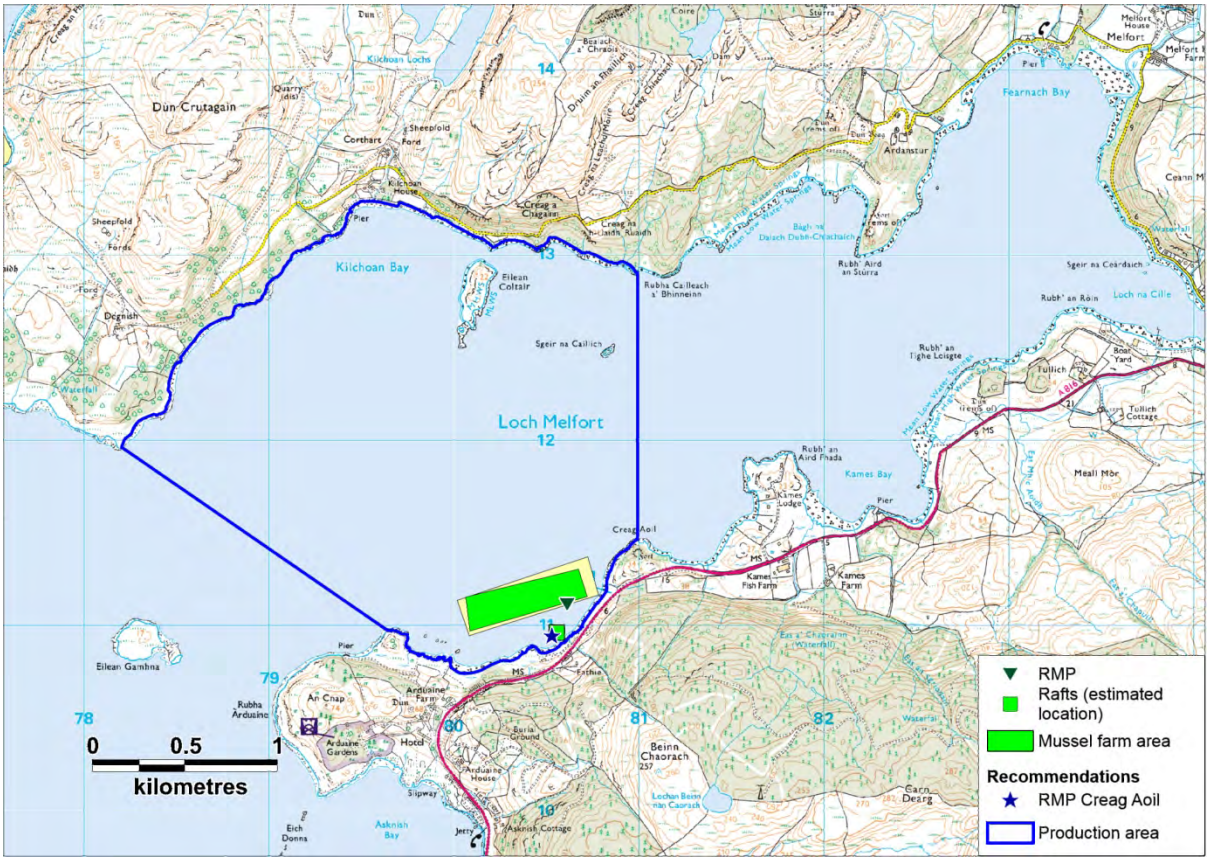

Figure 17.1 Map of recommendations at Loch Melfort

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4. **Hydrographic Section Glossary**
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1. General Information on Wildlife Impacts

Pinnipeds

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

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

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

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

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

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

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

Cetaceans

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

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

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

Birds

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

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

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

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

Deer

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

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

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

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

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.

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2. Tables of Typical Faecal Bacteria Concentrations

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

Indicator organism	Base-flow conditions				High-flow conditions			
Treatment levels and specific types: Faecal coliforms	n^c	Geometric mean	Lower 95% CI	Upper 95% CI	n^c	Geometric mean	Lower 95% CI	Upper 95% CI
Untreated	252	1.7×10^{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. Statistical Data

One-way ANOVA: logec versus season
Loch Melfort mussels

```
Method

Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05

Equal variances were assumed for the analysis.


Factor Information

Factor  Levels  Values
season       4  1, 2, 3, 4


Analysis of Variance

Source  DF  Adj SS  Adj MS  F-Value  P-Value
season   3   2.806  0.9354     3.44    0.022
Error   65  17.668  0.2718
Total   68  20.475


Model Summary

       S    R-sq  R-sq(adj)  R-sq(pred)
0.521366  13.71%      9.72%       2.51%


Means

season   N    Mean   StDev       95% CI
1       18  1.0836  0.1387  (0.8382, 1.3290)
2       17   1.430   0.672  ( 1.177,  1.682)
3       18   1.631   0.509  ( 1.386,  1.877)
4       16   1.442   0.618  ( 1.181,  1.702)

Pooled StDev = 0.521366
```

Tukey Pairwise Comparisons

```
Grouping Information Using the Tukey Method and 95% Confidence

season   N    Mean  Grouping
3       18   1.631  A
4       16   1.442  A B
2       17   1.430  A B
1       18  1.0836    B
```

n

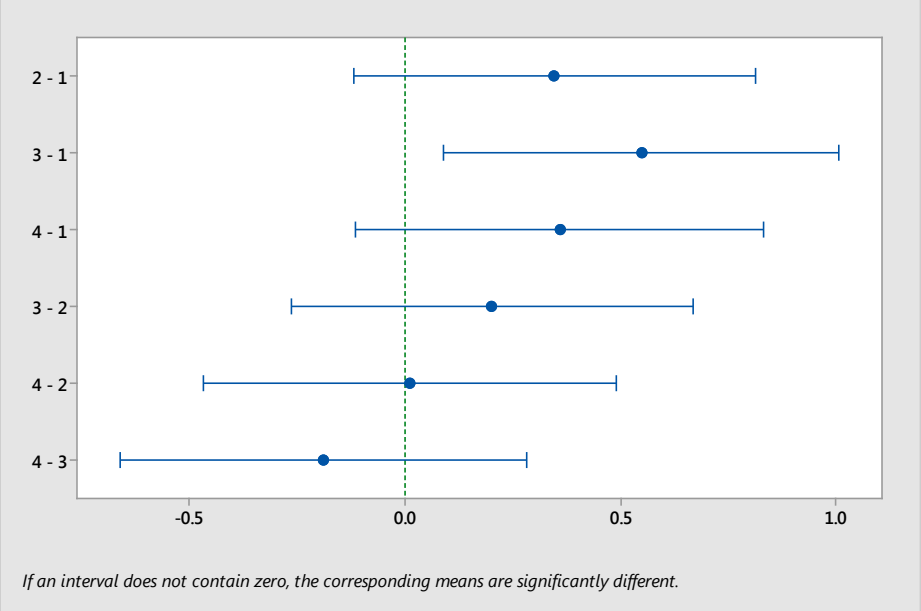

Figure 1 Tukey pairwise comparison test between sampling results and season

4. 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.

5. Shoreline Survey Report

Shoreline Survey Report

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

Document Number	B0067_Shoreline 0040

Revision History

Revision	Changes	Date
A	Draft issue for internal review	16/09/2014
B	Second draft issue for internal review	24/09/2014
C	Third draft issue for internal review	26/09/2014
D	Fourth draft issue for internal review	10/10/2014
01	First formal issue to Cefas	10/10/2014
02	Second issue to client incorporating corrections from Issue01	

	Name & Position	Date
Author	Eilidh Cole & Debra Brennan	16/09/2014
Checked	Andrea Veszelovszki	22/10/2014
Approved	Mark Hart	24/10/2014

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

Production area:	Loch Melfort
Site name:	Loch Melfort
SIN:	AB-178-051-08
Species:	Common mussels (*Mytilus edulis*)
Site name:	Loch Melfort: Creag Aoil
SIN:	AB-178-051-08
Species:	Pacific oysters (*Crassostrea gigas*)
Status:	New Application
SIN:	AB-672-1449-12
Species:	European oysters (*Ostrea edulis*)
Status:	New Application
SIN:	AB-673-1450-07
Species:	King scallops (*Pecten maximus*)
Status:	New Application
SIN:	AB-674-1451-15
Species:	Queen scallops (*Aequipecten opercularis*)
Status:	New Application
Harvester:	Philippe Heiniger
Local Authority:	Argyll and Bute
Status:	Existing area
Date Surveyed:	09/09/2014 – 10/09/2014
Surveyed by:	Debra Brennan & Eilidh Cole
Existing RMP:	NM 8061 1112

Area Surveyed

Approximately 1.3 km of shoreline south of the production area near to Arduaine Farm and 1 km of shoreline northeast of the production area at Kames. Consented discharges from properties close to the production area were also surveyed.

Weather

There were scattered light showers recorded 48 hours prior to the survey. On Tuesday 9th September 2014there was a very light brief shower followed by dry, bright and sunny weather. The temperature was around 19°C with no wind. Cloud cover was approximately 60% and the sea state was calm.

On Wednesday 10th September 2014, conditions were similar to the previous day. It was bright and sunny with a temperature of 20°C and no breeze, sea state was calm. Cloud cover was approximately 20%, with no rainfall.

Stakeholder engagement during the survey

Prior to the survey the sampling officer, Miss Allison Hardie, was very helpfuland provided useful information regarding the survey site and fishery.

On the first day of the survey (9th September), the survey team met with the site manager, Mr. Iain Henderson, who provided further details regarding the site. Mr. Henderson kindly took the survey team out on his boat to collect seawater samples, shellfish samples and to collect CTD cast data.

Fishery

Common mussels (*Mytilus edulis*) were cultivated within the Loch Melfort fishery. Harvesting only occurs occasionally at this site, as the harvester's main site is at Loch Scridain, where harvesting occurs predominantly over the winter months. The Loch Melfort site has had problems with eider duck and starfish predation of the mussels, although Mr Henderson, the site manager, also noted that tube worms were less of a problem than he had experienced at Loch Scridain.

There were thirteen mussel lines in total, each approximately 300 m long with 10 m droppers. Mussel samples were collected from both the top and the bottom of the droppers, as requested.

There is currently an application in place for the cultivation and harvesting of Pacific and European oysters (*Crassostrea gigas* and *Ostrea edulis*) and also king and queen scallops (*Pecten maximus* and *Aequipecten opercularis*). The survey team were informed by a Celtic Sea employee, Mrs. Eleanor Martin, that there were no samples available as cultivation of these four species had not yet been successful.

Sewage Sources

Outflow pipes were observed from three of the properties close to the production area in the settlement of Kames. A brown plastic pipe was observed running into the loch on the west side of the headland at Kames (waypoint 7). Two metal pipes were also observed running into the loch from the north side of the headland at Kames, with the second pipe broken in places (waypoints 11 and 12). The ends of all three pipes were not accessible even at low tide. Three black pipes were observed next to the pier at the Celtic Sea fishery (waypoint 29) but no flow was observed from any of them. There was also a concrete structure observed at waypoint 8 on the western side of the Kames headland, but no pipes or outflow was observed. A resident of one of the properties informed the survey team that no changes had been made to any of the properties regarding sewage in over twenty

years. There were two new builds in the area but both were still under construction and it was not possible to observe the type of sewage system that they were to employ.

Seasonal Population

No official campsites or caravan parks were seen in the area surrounding the production area at Loch Melfort, however two static caravans were observed at the Celtic Sea site close to waypoint 29. The Loch Melfort Hotel was located approximately 500 m south of the production area.

There were eight private dwellings situated close to the shore to the northeast of the production area.

Boats/Shipping

No boats were observed out on the water at any point during the survey. There was a rib and a small pleasure boat moored on shore at waypoint 34.

Farming and Livestock

Seventeen sheep were observed at waypoint 32 on the hillside close to the production area, and there was also evidence that the sheep graze on the shore as wool and droppings were observed. There were two horses in a field above the shore at waypoint 31 close to the production area.

Land Use

Land use around the loch was a mixture of farming, forestry and scattered housing.

Land Cover

The predominant land cover surrounding Loch Melfort was rough pasture and coniferous forestry. The land was steep in places with low cliffs immediately next to the shore, at Creag Aoil and Rubh' an Aird Fhada.

Watercourses

Five unnamed watercourses were required to be sampled during the survey. All five were sampled at waypoints 1, 35, 37, 39 and 43. The watercourse associated with waypoint 37 proved very difficult to locate as it was overgrown and had very little flow. Five small burns were also observed during the survey that were not on the sampling plan. These were located at waypoints 3, 10, 30, 41 and 42. No additional freshwater samples were taken from

these sites as the burns had minimal or no flow and were less than 1 m in width.

Wildlife/Birds

One common seal (*Phoca vitulina*) was observed in the loch from waypoint 6. One oystercatcher (*Haematopus longirostris*) was observed on rocks on the shore from waypoint 7 and a single grey heron (*Ardea cinerea*) was observed on the shoreline at waypoint 32. A total of three common gulls (*Larus canus*) were observed out on the loch water with two at waypoint 2 and one at waypoint 5. Two cormorants (*Phalacrocorax carbo*) were observed resting on the mussel droppers at waypoint 14 and a further three at waypoint 17. A total of forty eider ducks (*Somateria mollissima*) were also observed on the water around the mussel farm at waypoint 17.

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

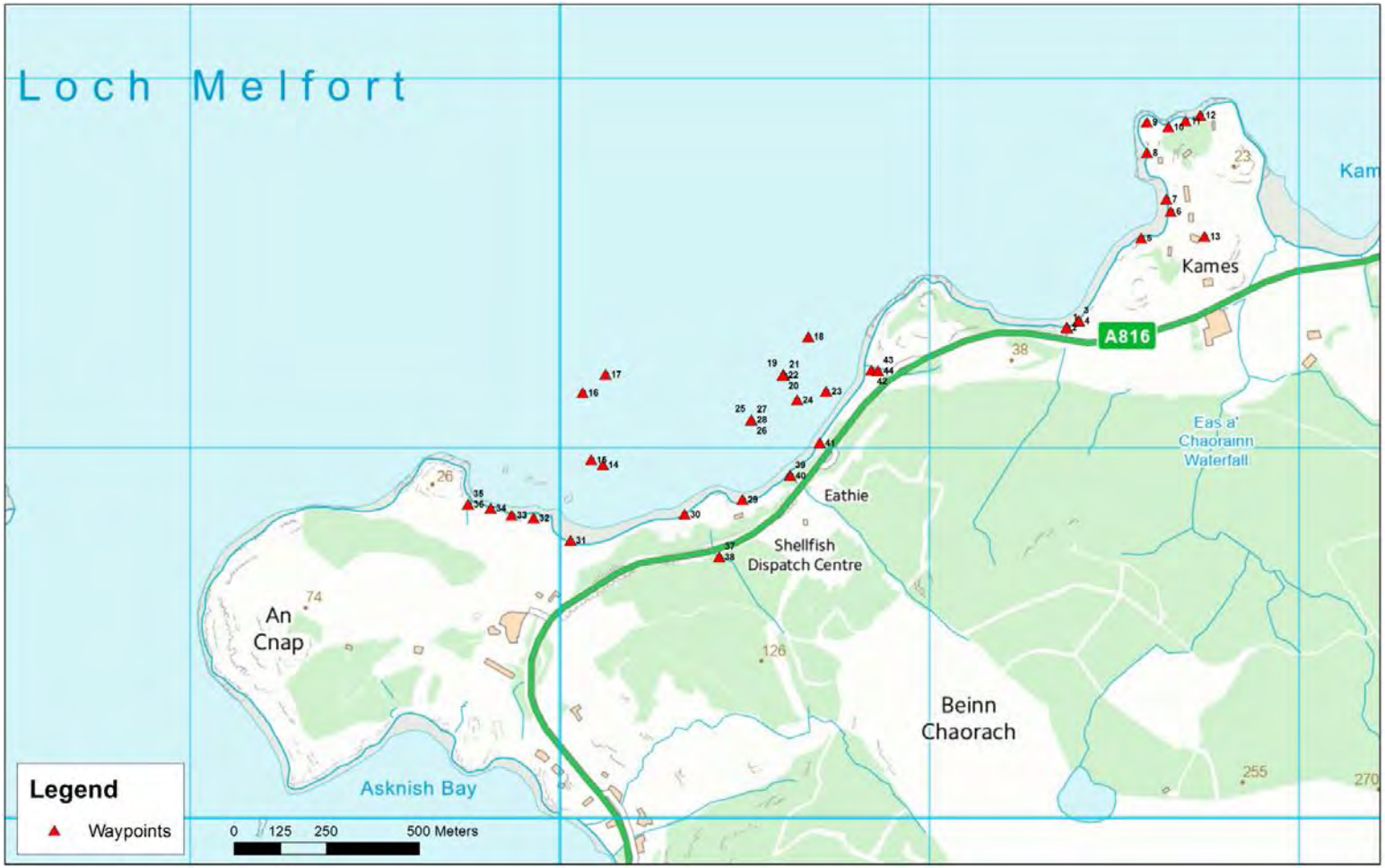

Figure 1. Loch Melfort waypoints.

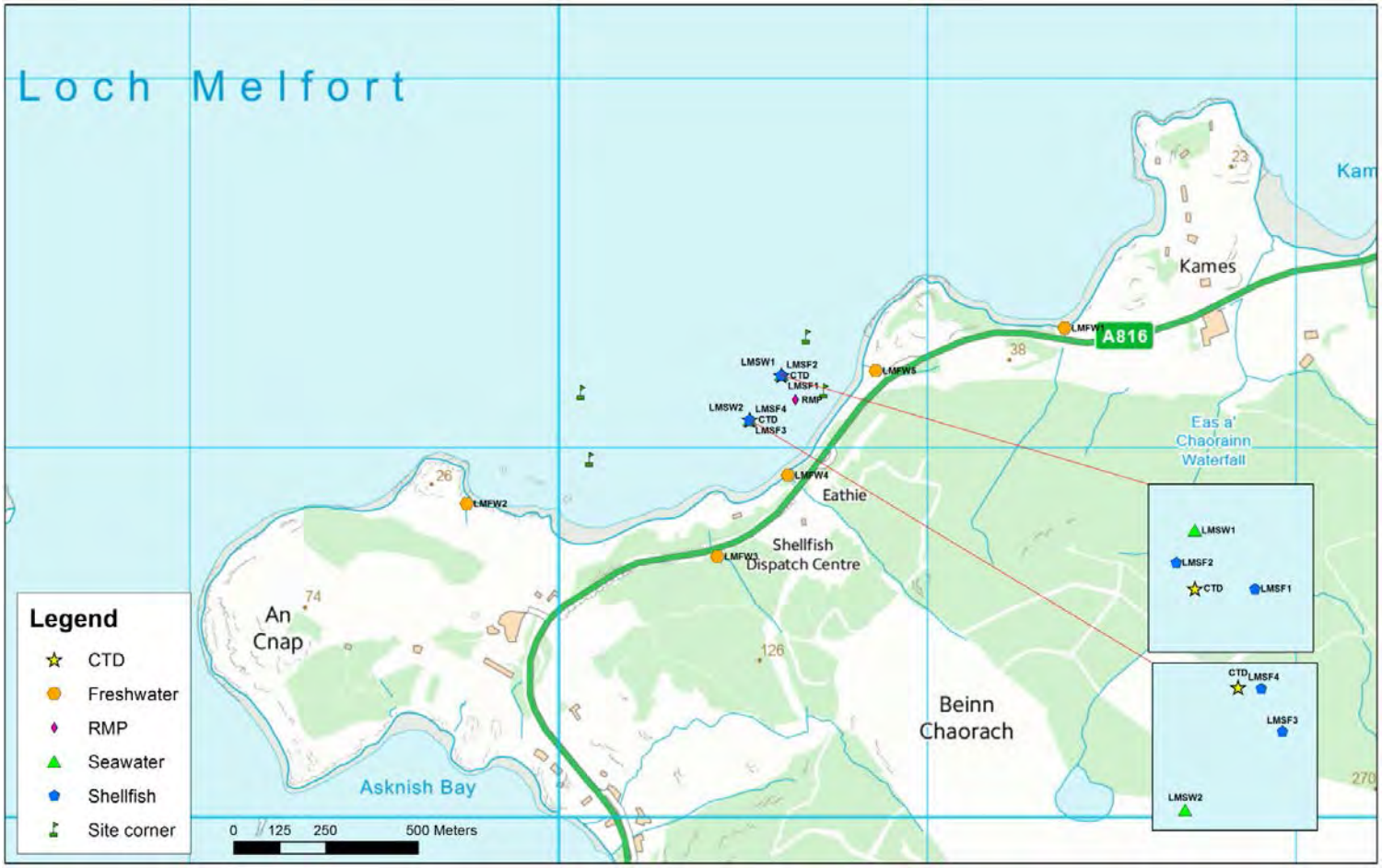

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Figure 2. Loch Melfort samples.

Table 1 Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	09/09/2014	9:40	NM 81372 11324	181373	711324		LMFW1	Start of survey at the west side of Kames. Planned freshwater sample. Unnamed watercourse.
2	09/09/2014	9:41	NM 81370 11325	181370	711326			Small burn running under road onto shore. Width - 110 cm, Depth - 6 cm, flow - 0.051 m/s, SD - 0.004. Two common gulls on the water. Associated with waypoint 1.
3	09/09/2014	9:51	NM 81402 11343	181402	711343			Small burn running under road onto shore. No sample as no farms or animals or sewage sources nearby. Also, it is in very close proximity to the burn sampled in waypoint 1.
4	09/09/2014	9:52	NM 81404 11344	181404	711344	Figure 3		View of mussel lines from shore looking West.
5	09/09/2014	10:03	NM 81572 11567	181573	711568			Six houses close to shore. One common gull on the water.
6	09/09/2014	10:14	NM 81652 11640	181652	711640			Two buoys out at sea. One common seal.
7	09/09/2014	10:17	NM 81641 11673	181641	711673	Figure 4		Discharge pipe (brown plastic) leading from house onto shore and far into the sea. One oystercatcher on the rocks.
8	09/09/2014	10:22	NM 81588 11798	181589	711798	Figure 5		Large concrete structure next to shore in front of house. No evidence of pipes or outflows.
9	09/09/2014	10:29	NM 81587 11881	181588	711881			House on shore.
10	09/09/2014	10:31	NM 81646 11868	181646	711868	Figure 6		Two very small burns converging with house behind. No flow observed.
11	09/09/2014	10:34	NM 81693 11884	181693	711884	Figure 7		Metal pipe leading from shore into loch with house behind.
12	09/09/2014	10:37	NM 81732 11899	181732	711900	Figure 8		Broken pipe leading from shore into loch. End of pipe was not accessible.
13	09/09/2014	10:52	NM 81744 11572	181744	711572			New build house unfinished, unoccupied. Has portaloos outside.
14	09/09/2014	11:41	NM 80116 10955	180116	710955			Two cormorants on mussel lines.
15	09/09/2014	11:41	NM 80084 10968	180084	710968			SW corner of mussel lines.
16	09/09/2014	11:43	NM 80061 11149	180061	711150			NW corner of mussel lines.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
17	09/09/2014	11:44	NM 80123 11199	180124	711199			Forty eider ducks on the water and three cormorants on the droppers. Six mussel lines observed.
18	09/09/2014	11:48	NM 80671 11301	180672	711301			NE corner of mussel lines.
19	09/09/2014	11:53	NM 80603 11198	180604	711199		LMSW1	Planned seawater sample. Unnamed watercourse.
20	09/09/2014	11:54	NM 80603 11196	180604	711196		CTD	CTD cast.
21	09/09/2014	11:55	NM 80606 11196	180606	711196		LMSF1	Planned shellfish sample. Mussels from top of line.
22	09/09/2014	11:55	NM 80602 11197	180603	711197		LMSF2	Planned shellfish sample. Mussels from bottom of line (~10 m deep).
23	09/09/2014	12:02	NM 80720 11153	180720	711154			SE corner of mussel lines. Seven mussel lines observed from here.
24	09/09/2014	12:04	NM 80641 11130	180642	711131			RMP.
25	09/09/2014	12:07	NM 80517 11075	180518	711076		LMSW2	Planned seawater sample.
26	09/09/2014	12:07	NM 80517 11076	180518	711076		CTD	CTD cast.
27	09/09/2014	12:07	NM 80518 11076	180518	711076		LMSF3	Planned shellfish sample. Mussels from top of line.
28	09/09/2014	12:07	NM 80517 11076	180518	711076		LMSF4	Planned shellfish sample. Mussels from bottom of line (~10 m deep).
29	09/09/2014	12:57	NM 80493 10860	180494	710861	Figure 9		Three black plastic pipes next to pier. No flow from any of the pipes was observed. Two static caravans next to Celtic Sea fishery.
30	09/09/2014	13:05	NM 80337 10821	180337	710821			Small burn, barely flowing. Not on sample list. Runs from direction of road onto shore.
31	09/09/2014	13:13	NM 80028 10750	180029	710751			Two horses in field above shore with house and barn next to field.
32	09/09/2014	13:19	NM 79928 10810	179929	710811			Seventeen sheep in field on hill above shore with one cabin next to it. One grey heron on shore. Two buoys out at sea.
33	09/09/2014	13:22	NM 79868 10818	179869	710819			Sheep droppings on shore.
34	09/09/2014	13:25	NM 79812 10837	179812	710838	Figure 10		Plastic pipe leading onto shore, small flow but cannot access. One small pleasure boat and one RIB on shore.
35	09/09/2014	13:30	NM 79751 10848	179751	710849		LMFW2	Planned freshwater sample.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
36	09/09/2014	13:31	NM 79751 10848	179751	710848			Large plastic pipe running onto shore with grassy fields behind. Pipe diameter - 22 cm, water width - 7 cm, depth - 2 cm, flow - 40 ml / sec. Flow measured using a graduated jug and stopwatch. Associated with waypoint 35.
37	09/09/2014	14:41	NM 80431 10705	180431	710706	Figure 11	LMFW3	Planned freshwater sample. Unnamed watercourse.
38	09/09/2014	14:41	NM 80430 10705	180431	710706			Very small burn from above road onto shore. Depth – 3 cm, width – 34 cm, Flow – 0.126 m/s, SD – 0.002. Associated with waypoint 37.
39	10/09/2014	10:17	NM 80622 10925	180622	710926		LMFW4	Planned freshwater sample. Unnamed watercourse.
40	10/09/2014	10:17	NM 80623 10925	180623	710926			Sampled from small burn opposite mussel farm. Width - 2.81 m, Depth - 7 cm, Flow - 0.037 m/s, SD - 0.003. Associated with waypoint 39.
41	10/09/2014	10:34	NM 80702 11013	180703	711014			Very small burn, barely flowing, not on sample list.
42	10/09/2014	10:52	NM 80842 11210	180843	711211			Dried up burn, no flow, not sampled. Can hear water running under rocks.
43	10/09/2014	10:54	NM 80860 11208	180860	711209		LMFW5	Planned freshwater sample.
44	10/09/2014	10:54	NM 80860 11209	180860	711209			Associated with waypoints 42 and 43. Dried up burn, flowing further upstream. Flow is directed through plastic pipe for a short section. Width - 63 cm, Depth - 5 cm, Flow - 0.105 m/s, SD - 0.002. Associated with waypoint 43.

Photographs referenced in the table can be found attached as Figures 3 – 11.

Sampling

Seawater and freshwater samples were collected at the sites marked in Figure 2. A total of five freshwater and two seawater samples were collected, covering all the planned sampling locations.

Four common mussel (*Mytilus edulis*) samples were taken. Shellfish were sampled from both the surface and the ends (10 m) of the droppers at waypoints 21 and 22 and waypoints 27 and 28 as requested.

All the samples were transferred to a Biotherm 30 box with ice packs and posted to Glasgow Scientific Services (GSS) for *E. coli* analysis. All samples were received by GSS within 24 hours of collection. The sample temperatures on arrival at GSS ranged between 1.6°C and 5.2°C.

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:

Salinity (ppt) = 0.0018066 X Cl^- (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	09/09/2014	LMFW1	NM 81372 11324	Freshwater	<10	-
2	09/09/2014	LMSW1	NM 80603 11198	Seawater	0	34.33
3	09/09/2014	LMSW2	NM 80517 11075	Seawater	0	34.87
4	09/09/2014	LMFW2	NM 79751 10848	Freshwater	210	-
5	09/09/2014	LMFW3	NM 80431 10705	Freshwater	<10	-
6	10/09/2014	LMFW4	NM 80622 10925	Freshwater	140	-
7	10/09/2014	LMFW5	NM 80860 11208	Freshwater	<10	-

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	Sample depth (m)	*E. coli* (MPN/100g)
1	09/09/2014	LMSF1	NM 80606 11196	Shellfish	0 (surface)	<18
2	09/09/2014	LMSF2	NM 80602 11197	Shellfish	~10m	<18
3	09/09/2014	LMSF3	NM 80518 11076	Shellfish	0 (surface)	<18
4	09/09/2014	LMSF4	NM 80517 11076	Shellfish	~10m	<18

Salinity Profiles

Two CTD profiles were taken, one at the northeast end of the site and the second at the southwest side of the site. The gathered data will be sent to Cefas, as agreed previously, on a separate Excel sheet.

Photographs – Loch Melfort

Figure 3. Overview of Production area. Associated with waypoint 4.

Figure 4. Plastic pipes from house onto shore. Associated with waypoint 7.

Figure 5. Large concrete structure on shore, no pipes observed. Associated with waypoint 8.

Figure 6. Two very small burns converging with house behind, no flow. Associated with waypoint 10.

Figure 7. Metal pipe leading from shore into loch with house behind. Associated with waypoint 11.

Figure 8. Broken pipe leading from shore into loch. Associated with waypoint 12.

Figure 9. Black plastic pipes next to pier. No flows. Associated with waypoint 29.

Figure 10. Plastic pipes, small flow but cannot access (see insert for detail). One small pleasure boat and one RIB on shore. Associated with waypoint 34.

Figure 11. Very small overgrown burn from above road onto shore. Associated with waypoint 37, sample location of LMFW3

6. SEPA Discharge Consents

Licence No.	NGR	Discharge Type	Discharges to	RB Code	PE
CAR/R/1013536	NM 84169 12719	Sewage (Private) Primary	Land	L/S	5
CAR/R/1018019	NM 84074 14428	Sewage (Private) Primary	River Oude	FW	5
CAR/R/1034207	NM 82705 07926	Sewage (Private) Secondary	U/T of Staing Mhor	FW	5
CAR/R/1037427	NM 77030 09420	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1037432	NM 77040 09170	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1037433	NM 77189 09040	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1037435	NM 76743 09233	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1037444	NM 81750 11180	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1037445	NM 81724 11293	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1037446	NM 82232 11613	Sewage (Private) Primary	Kames Bay	SW	5
CAR/R/1037498	NM 84060 12770	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1037727	NM 81610 11690	Sewage (Private) Primary	Loch Melfort	SW	5
CAR/R/1037797	NM 83990 12770	Sewage (Private) Primary	Loch Melfort	SW	5
CAR/R/1038097	NM 81663 11708	Sewage (Private) Primary	Loch Melfort	SW	5
CAR/R/1038678	NM 83747 07296	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1038801	NM 82580 08329	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1038823	NM 81317 08543	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1039159	NM 81630 11588	Sewage (Private) Primary	Loch Melfort	SW	5
CAR/R/1039451	NM 79534 06700	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1039632	NM 80247 09965	Sewage (Private) Primary	U/T of Asknish Bay	FW	5
CAR/R/1039648	NM 82310 08190	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1039709	NM 83980 07980	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1039730	NM 75970 12560	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1039790	NM 79587 06741	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1039797	NM 79320 06520	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1039798	NM 79120 06500	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1039800	NM 79776 06556	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1039803	NM 79600 06630	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1039807	NM 79650 06540	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1039810	NM 79624 06530	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1039813	NM 79630 06930	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1040155	NM 81060 08250	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1040943	NM 83560 08483	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1041583	NM 83790 12570	Sewage (Private) Primary	Loch Na Cille	SW	5
CAR/R/1071022	NM 82702 07648	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1071929	NM 82990 14370	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1076812	NM 84983 12120	Sewage (Private) Primary	Eas a Choire	FW	5
CAR/R/1077967	NM 85033 13280	Sewage (Private) Primary	Abhainn na Cille	FW	5
CAR/R/1078761	NM 82207 07446	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1078769	NM 82589 07506	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1083436	NM 80410 09250	Sewage (Private) Primary	Soakaway	L/S	5
CAR/R/1104101	NM 84156 14552	Sewage (Private) Primary	River Oude	FW	5
CAR/R/1110330	NM 82800 13790	Sewage (Private) Secondary	Loch Melfort	SW	5
CAR/R/1119011	NM 83219 14160	Sewage (Private) Secondary	U/N W/C	FW	5
CAR/R/1015978	NM 79110 06660	Sewage (Private) Primary	Sound of Jura	SW	6
CAR/R/1017088	NM 80380 09300	Sewage (Private) Primary	Soakaway	L/S	6
CAR/R/1022276	NM 81050 07890	Sewage (Private) Secondary	Soakaway	L/S	6
CAR/R/1024586	NM 80379 09337	Sewage (Private) Primary	Soakaway	L/S	6
CAR/R/1027042	NM 80080 09980	Sewage (Private) Primary	Asknish Bay	SW	6
CAR/R/1035029	NM 80190 10050	Sewage (Private) Primary	Soakaway	L/S	6
CAR/R/1036697	NM 83917 12513	Sewage (Private) Secondary	Loch na Cille	SW	6
CAR/R/1037640	NM 81570 11560	Sewage (Private) Primary	Loch Melfort	SW	6
CAR/R/1038286	NM 79929 10120	Sewage (Private) Primary	Soakaway	L/S	6
CAR/R/1039161	NM 81638 11628	Sewage (Private) Primary	Loch Melfort	SW	6
CAR/R/1039196	NM 81685 11873	Sewage (Private) Primary	Loch Melfort	SW	6
CAR/R/1039684	NM 81730 11910	Sewage (Private) Primary	Loch Melfort	SW	6

Licence No.	NGR	Discharge Type	Discharges to	RB Code	PE
CAR/R/1039707	NM 83950 07970	Sewage (Private) Primary	Soakaway	L/S	6
CAR/R/1039729	NM 81556 11779	Sewage (Private) Primary	Loch Melfort	SW	6
CAR/R/1039732	NM 78199 12595	Sewage (Private) Primary	Soakaway	L/S	6
CAR/R/1039974	NM 83440 12330	Sewage (Private) Primary	Soakaway	L/S	6
CAR/R/1064791	NM 84060 12690	Sewage (Private) Primary	Loch na Cille	SW	6
CAR/R/1108584	NM 81905 11481	Sewage (Private) Primary	East an Sgriodain	FW	6
CAR/R/1037057	NM 79791 10518	Sewage (Private) Primary	Soakaway	L/S	7
CAR/R/1039981	NM 80174 10058	Sewage (Private) Primary	U/N W/C	FW	7
CAR/R/1115700	NM 84800 12170	Sewage (Private) Primary	Land	L/S	7
CAR/R/1015362	NM 83010 14150	Sewage (Private) Tertiary	Coastal Waters	SW	8
CAR/R/1036374	NM 77355 09234	Sewage (Private) Primary	Coastal Waters	SW	8
CAR/R/1095793	NM 80660 10820	Sewage (Private) Secondary	Soakaway	L/S	8
CAR/R/1111382	NM 80050 10240	Sewage (Private) Primary	Soakaway	L/S	8
CAR/R/1023271	NM 80168 09925	Sewage (Private) Primary	U/T of Asknish Bay	SW	10
CAR/R/1038432	NM 83528 12670	Sewage (Private) Primary	Loch na Cille	SW	10
CAR/R/1039792	NM 79570 06870	Sewage (Private) Primary	Soakaway	L/S	10
CAR/R/1039794	NM 79440 06790	Sewage (Private) Primary	Soakaway	L/S	10
CAR/R/1039795	NM 79369 06708	Sewage (Private) Primary	Soakaway	L/S	10
CAR/R/1039805	NM 79740 06510	Sewage (Private) Primary	Soakaway	L/S	10
CAR/R/1039962	NM 79510 06390	Sewage (Private) Primary	Soakaway	L/S	10
CAR/R/1039966	NM 79200 06630	Sewage (Private) Primary	Soakaway	L/S	10
CAR/R/1039970	NM 79360 06690	Sewage (Private) Primary	Soakaway	L/S	10
CAR/R/1039977	NM 79420 06430	Sewage (Private) Primary	Soakaway	L/S	10
CAR/R/1040141	NM 79273 06931	Sewage (Private) Primary	Soakaway	L/S	10
CAR/R/1013783	NM 80342 09322	Sewage (Private) Primary	Land	L/S	11
CAR/R/1039644	NM 83990 12960	Sewage (Private) Primary	Land	L/S	12
CAR/R/1079474	NM 80590 10880	Sewage (Private) Tertiary	Coast	SW	12
CAR/R/1015600	NM 80100 09977	Sewage (Private) Secondary	Land	L/S	14
CAR/R/1033010	NM 79410 10290	Sewage (Private) Primary	Soakaway	L/S	15
CAR/R/1033059	NM 79597 10394	Sewage (Private) Primary	Soakaway	L/S	15
CAR/R/1039936	NM 80860 07990	Sewage (Private) Primary	Soakaway	L/S	15
CAR/R/1040170	NM 80278 08189	Sewage (Private) Primary	Soakaway	L/S	15
CAR/R/1040211	NM 84236 07917	Sewage (Private) Primary	Barbreck River	FW	15
CAR/R/1039816	NM 79210 06820	Sewage (Private) Primary	Soakaway	L/S	16
CAR/R/1039933	NM 81050 08260	Sewage (Private) Primary	Soakaway	L/S	20
CAR/S/1109585	NM 79500 08000	Sewage (Private) Private	Loch Melfort	SW	20
CAR/R/1038778	NM 84871 13060	Sewage (Private) Primary	Abhainn na Cille	FW	22
CAR/R/1038782	NM 84795 12775	Sewage (Private) Primary	Eas na Caillich	FW	25
CAR/R/1039972	NM 79910 10080	Sewage (Private) Primary	Asknish Bay	SW	25
CAR/S/1098154	NM 81990 11240	Sewage (Private) Secondary	Soakaway	L/S	26
CAR/R/1041585	NM 83730 12620	Sewage (Private) Primary	Loch na Cille	SW	30
CAR/S/1013937	NM 83260 14060	Sewage (Private) Tertiary	Fearnach Bay	SW	32
CAR/R/1039788	NM 79540 06790	Sewage (Private) Primary	Soakaway	L/S	37
CAR/R/1039785	NM 79490 06500	Sewage (Private) Primary	Soakaway	L/S	38
CAR/R/1025513	NM 79730 10460	Sewage (Private) Primary	Soakaway	L/S	50
CAR/S/1030803	NM 79720 10250	Sewage (Private) Primary	Soakaway	L/S	91
CAR/L/1027691	NM 79220 07360	Sewage (Private) Primary	Firth of Lorn	SW	1200

LS=Land/Soakaway, SW= Seawater Body, FW= Freshwater Body, PE= Population Equivalent, - = Not applicable

7. Loch Eishort CTD data

Loch Melfort CTD data

Data obtained during the shoreline survey. The locations of the casts are shown in Figure A7.1.

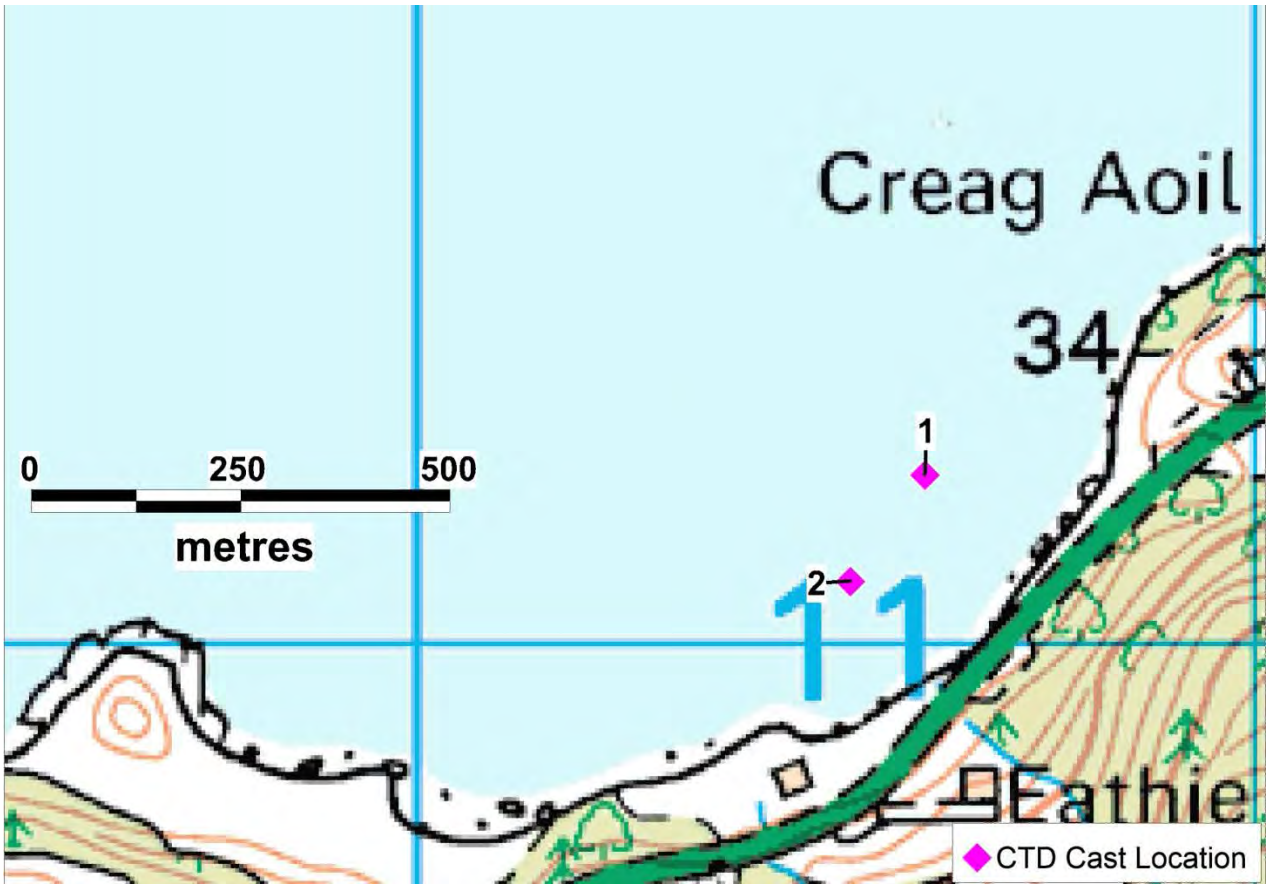

Figure A7.1 Location of CTD cast

CAST 1

Data Header

% Device	10G100653
% File name	10G100653_20140909_105219
% Cast time (local)	09/09/2014 11:52
% Sample type	Cast
% Cast data	Processed
% Location source	GPS
% Start latitude	56.2425384
% Start longitude	-5.542274
% Start GPS horizontal error(Meter)	3.799999952
% Start GPS vertical error(Meter)	5.46999979
% Start GPS number of satellites	5
% Cast duration (Seconds)	113
% Samples per second	5
Calibration Date	March 2013
Calibration offset for Temperature	-0.033
Calibration offset for Salinity	0.029

CTD data (calibration offsets applied)

Depth (Meter)	Temperature (Celsius)	Salinity (Practical Salinity Scale)
0.149045575	14.10388369	33.88225892
0.447118866	14.08391957	33.87167802
0.745198342	14.06790397	33.86844808
1.043275799	14.0570634	33.87941685
1.341349024	14.03466327	33.89418532
1.639420657	14.02739682	33.88260809
1.937497341	14.03795004	33.84713626
2.235580526	14.0379858	33.82460923
2.533665763	14.02810685	33.82323514
2.831750475	14.02338409	33.82237434
3.129833166	13.99920765	33.83047426
3.427912871	14.00365499	33.84067484
3.72599118	14.01460918	33.84410302
4.024070332	14.02641349	33.83635566
4.322150137	14.02719573	33.83873071
4.620228596	14.01360434	33.84192083
4.918305276	14.0172378	33.84892454
5.216381078	14.00307474	33.84392661
5.514456592	13.99652607	33.84294624
5.81253025	13.98898048	33.85367571
6.110602029	13.99024261	33.85503746
6.408672916	13.98058319	33.85638719
6.706742081	13.97823054	33.86416273
7.004809728	13.97933193	33.86661419

7.302877443	13.97279695	33.85913195
7.600948955	13.97140285	33.82770494
7.899025408	13.97174388	33.81187668
8.197104567	13.97571736	33.80180801
8.495184419	13.97491638	33.80360847
8.793263137	13.96900337	33.80713141
9.145161876	13.97641908	33.81194778

CAST 2

Data Header

% Device	10G100653
% File name	10G100653_20140909_110822
% Cast time (local)	09/09/2014 12:08
% Sample type	Cast
% Cast data	Processed
% Location source	GPS
% Start latitude	56.2413616
% Start longitude	-5.543606
% Start GPS horizontal error(Meter)	1.669999957
% Start GPS vertical error(Meter)	2.700000048
% Start GPS number of satellites	6
% Cast duration (Seconds)	98.8
% Samples per second	5
Calibration Date	March 2013
Calibration offset for Temperature	-0.033
Calibration offset for Salinity	0.029

CTD data (calibration offsets applied)

Depth (Meter)	Temperature (Celsius)	Salinity (Practical Salinity Scale)
0.149057611	14.24456023	33.81269934
0.447154948	14.25147157	33.81421705
0.745256271	14.24000888	33.82545804
1.043353574	14.23381312	33.84225658
1.341447053	14.20918914	33.84816241
1.639534036	14.16829199	33.87930747
1.937611832	14.1310641	33.90577416
2.235683641	14.11469689	33.91511704
2.533753546	14.10377538	33.91235451
2.831819559	14.08178294	33.9378996
3.129882749	14.07060096	33.92554051
3.427943745	14.041916	33.94367983
3.726001021	14.03317636	33.94557993
4.024057595	14.03177646	33.94422978
4.322112598	14.02432002	33.95420718

4.620165843	14.01781005	33.95316369
4.918219103	14.01287147	33.94800513
5.216270865	13.99455982	33.95725987
5.514320019	13.98961978	33.96199908
5.812366996	13.97815255	33.96924732
6.110412666	13.97444922	33.96658576
6.408457428	13.96886298	33.97186868
6.706501567	13.97765001	33.97004129
7.004545601	13.96864111	33.96977648
7.302589193	13.97245045	33.96961933
7.600632022	13.97990698	33.97665588
7.898674469	13.977923	33.97154342
8.19671704	13.96996151	33.96990063
8.494759037	13.97379063	33.97257942
8.792800656	13.97922817	33.97280886
9.090842961	13.97611555	33.96414168
9.430367714	13.98575347	33.9714158
0.149057611	14.24456023	33.81269934