Scottish Sanitary Survey Report

Sanitary Survey Report
Kerrera Cockles
AB-697-1513, -1514 & -1515
May 2015

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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 cockle fishery at Isle of Kerrera 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). The survey was undertaken because the production area is new and had not yet received a sanitary survey.

Kerrera is an island in the Firth of Lorn, approximately 2 km west of Oban, in the Argyll & Bute council area. The island is separated from the mainland by the Sound of Kerrera and Oban Bay.

The fishery is for wild common cockles, which are hand raked from multiple sites around the Island of Kerrera. The harvester identified three main sites in the classification application: Slatrach Bay and Oitir Mhor on the northwest side of the island and Ardantrive on the northeast side of the island. During the shoreline survey, cockles were only found at the Slatrach Bay and Ardantrive sites.

The main sources (and predicted transport) of faecal contamination differ between the two sides of the island. The Ardantrive bed faces the Sound of Kerrera and is just to the south of Oban Bay. This water body receives continuous sewage effluent and combined sewer overflows from the Oban sewage treatment works, as well as effluent from a small community septic tank and a small number of private septic tanks. There is one private septic tank discharge to the cockle bed itself. Oban Marina is located a short distance north of the bed, and there are further moorings and anchorages located around the sound, including directly opposite the bed. Livestock kept at Ardantrive farm are likely to contribute additional faecal contamination to the bed, particularly if livestock are present on the foreshore. There were no recorded watercourses in the near vicinity. Due to the constrained nature of the sound, movement of contaminants was predicted to be mainly along the axis of the sound, though this would be complicated by the presence of inlets and small islands. The maximum predicted transport on a single tide for both areas was 1.6 km.

The beds on the west side of the island do not receive direct sewage impact from land-based sources, though they may be impacted by any overboard sewage discharges from tour boats and anchored yachts. The cockle beds lie approximately 4 km from the Oban STW discharge. Watercourses flow onto both cockle beds, with the largest watercourse discharging at Slatrach Bay. Livestock are kept around both beds, with the larger number seen near Slatrach Bay during the shoreline survey. No cockles were found at Oitir Mhor. The west side of Kerrera is open to the Firth of Lorn and the waters at both sites are anticipated to be well flushed.

Due to the differences in sources and transport mechanisms between the two sides of the island, it is recommended that two separate production areas be established: one along the northwest shore of the island and incorporating the Slatrach Bay and Oitir Mhor sites, and the other along the east shore of the island.

As cockles were only found at the Slatrach Bay site, it is recommended that the RMP for the Kerrera West production area be established at the outlet of the Leith Allt, which is the main watercourse discharging to the cockle bed and that a 75 m sampling tolerance be allowed in order to ensure sufficient cockles are available for sampling. The recommended RMP for the Kerrera East production area is at NM 8192 2719, on the west side of the bed and near to the private septic tank outfall. A sampling tolerance of 50 m is recommended at this site due to the smaller size of the bay and the relative abundance of cockles available for sampling.

II. Sampling Plan

Production Area	Kerrera West	Kerrera East
Site Name	Slatrach Bay	Ardantrive
SIN	AB-697-1515-04	AB-697-1513-04
Species	Common cockle	Common cockle
Type of Fishery	Wild harvest	Wild harvest
NGR of RMP	NM 8162 2970	NM 8404 2989
East	181620	184040
North	729700	729890
Tolerance (m)	75	50
Depth (m)	Not applicable	Not applicable
Method of Sampling	Hand	Hand
Frequency of Sampling	Monthly	Monthly
Local Authority	Argyll & Bute Council	Argyll & Bute Council
Authorised Sampler(s)	William MacQuarrie Ewan McDougall Christine McLachlan Allison Hardie Heather Harley	William MacQuarrie Ewan McDougall Christine McLachlan Allison Hardie Heather Harley
Local Authority Liaison Officer	Ewan McDougall	Ewan McDougall
Production Area Boundaries	The area bounded by lines drawn from NM 8028 2972 to NM 8182 3054 to NM 8421 7341 and extending to MHWS	The area bounded by lines drawn from NM 8419 2987 to NM 8408 2964 to NM 8300 2846 to NM 8213 2713 to NM 8192 2719 extending to MHWS

III. Report

1 General Description

Kerrera is an island in the Firth of Lorn, approximately 2 km west of Oban, in the Argyll & Bute council area. The island is separated from the mainland by the Sound of Kerrera and Oban Bay.

Kerrera is approximately 7 km long by 2 km wide, with small areas of intertidal sands and gravels in small inlets along its east and west shores. The island itself is sparsely inhabited with a population of 34 recorded in 2011. The town of Oban is situated opposite the north end of the island. Ardantrive (Ardentrive) Bay, on the northeast end of the island, serves as the main centre of recreational boating for the area.

A sanitary survey was undertaken on the proposed cockle fishery at Isle Of Kerrera on the basis recommended in the European Union Reference Laboratory publication: “Microbiological Monitoring of Bivalve Mollusc Harvesting Area Guide to Good Practice: Technical Application” (http://www.cefas.defra.gov.uk/nrl/information-centre/eu-good-practice-guide.aspx). This production area was selected for survey as it is a newly classified area.

Figure 1.1 Location of Kerrera

2 Fishery

Kerrera Cockles is a new wild common cockle (*Cerastoderma edule*) fishery. The harvester has identified that cockles are to be hand raked from multiple sites around the Island of Kerrera. Details of the sites given in the fast track application form submitted by the harvester are presented in Table 2.1. The site locations are given in Figure 2.1

Table 2.1 Area shellfish farms

Production area	Site	New site name	SIN	Species
Kerrera Cockles	Ardantrive	Ardantrive	AB-697-1513-04	Common cockles
Kerrera Cockles	Oitir Mhor	Oitir Mhor	AB-697-1514-04	Common cockles
Kerrera Cockles	Slatrach Bay	Slatrach Bay	AB-697-1515-04	Common cockles

The area also included Ganavan Sands, an area on the mainland north of Oban. However, the initial assessment of the area for the sanitary survey indicated that pollution sources and movement of contaminants would be very different for the two, and therefore Ganavan Sands has been considered as a separate survey.

Subsequent to consultation on the draft of this report, Argyll & Bute council identified that the site names as stated could lead to confusion and requested that they be amended to retain consistency with features identified on the OS base maps. The recommended changes are shown in Table 2.1.

Kerrera cockles was awarded a fast track classification for cockles from 19/12/2013 to 19/04/2014. The classification specified that samples were to be taken from within the designated boundary, which was given as:

> Area bounded by lines drawn between NM 8676 3378, NM 8028 2972, NM 8140 2645, NM 8218 2712, NM 8308 2838, NM 8484 2999, NM 8510 3143 extending to MHWS.

No monitoring point was established at that time. This area (excluding the northernmost extent at Ganavan Sands) is shown in Figure 2.1., together with the approximate locations of the sites identified in Table 2.1.

During the shoreline survey, cockles were only found in sufficient numbers to permit sampling at Ardantrive and Slatrach Bay, although it was noted that there were very few cockles present at Slatrach Bay and also very few empty shells. Subsequent to consultation, Argyll & Bute Council identified that most of the cockle bed at Oitir Mhor would have been underwater at the time of shoreline survey, which occurred approximately two hours after high tide. They further noted that the highest density of cockles is currently found at Oitir Mhor.

No information was found on stock assessments for the area surrounding the Isle of Kerrera. Cockles may be present throughout the intertidal zone but substrate type and

size will influence where cockles are likely to be present. No substrate information was available for the area around the island.

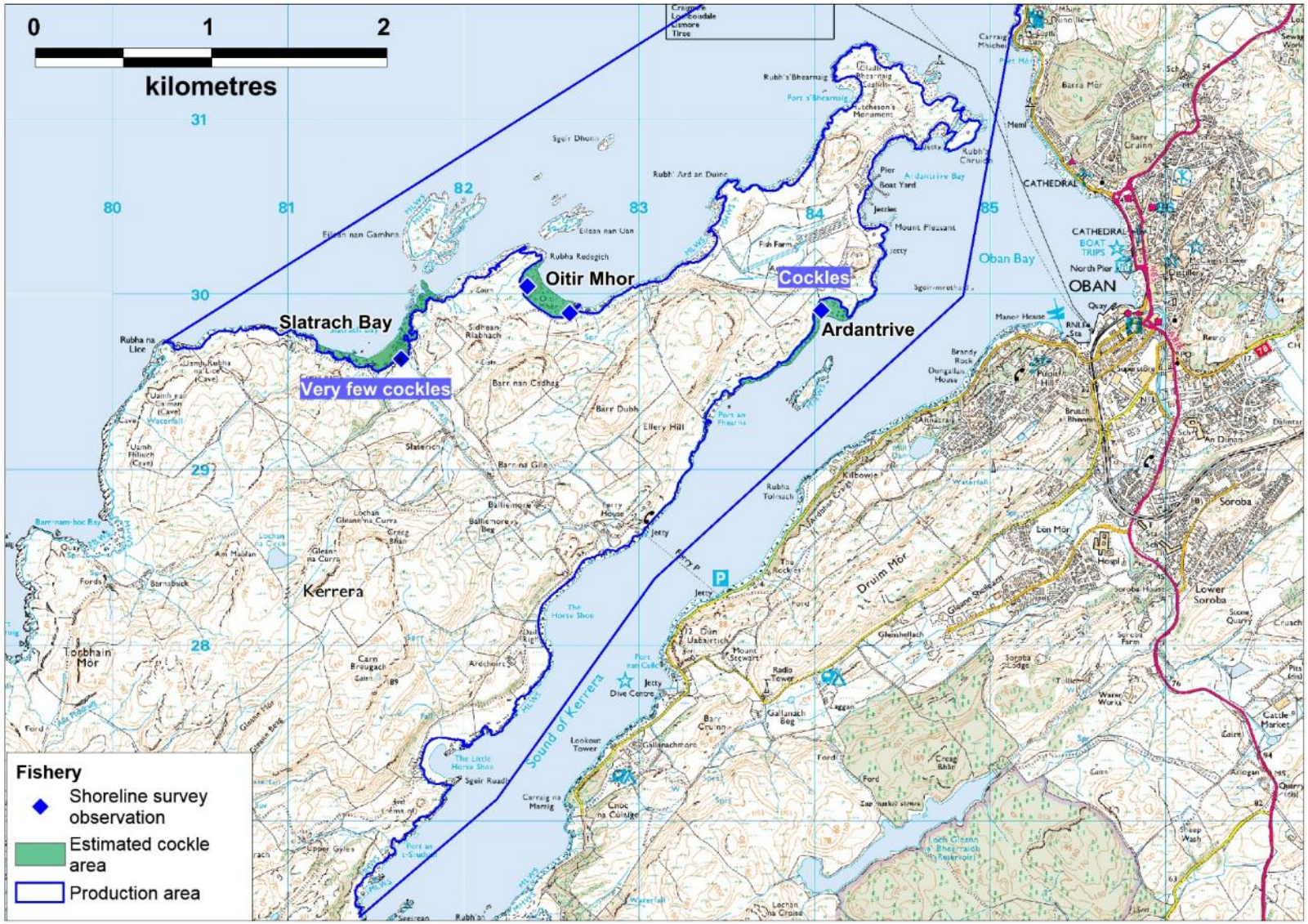

Figure 2.1 Isle of Kerrera Cockle Fishery

3 Human Population

Information was obtained on the population within the vicinity of the Island of Kerrera from the General Register Office for Scotland. The last census was undertaken in 2011. The census output areas adjacent to the shellfisheries are shown mapped by the 2011 population densities in Figure 3.1. Population density is very low on the Isle of Kerrera, however the town of Oban is located approximately 1.5 km to the east of the island. The most recent population estimate for the town is 8,540 (National Records of Scotland, 2014).

The northern end of the Isle of Kerrera is very sparsely populated and there are very few dwellings in the close proximity to the shellfisheries. At the time of the 2011 census, the entire island had a population of 34 residents. There are no main roads and only tracks for access. During the shoreline survey scattered dwellings were observed on the eastern shoreline of Kerrera. Tourist accommodation on the island is limited to a bed and breakfast in Ardantrive (Ardentrive Farm, 2015) and a bunkhouse (sleeps 9) on the southern end of the island (Kerrera Tea Garden and Bunkhouse, 2015).

Oban is a popular tourist destination and has good rail and road infrastructure, a large amount of tourist accommodation, a general hospital and three schools.

Oban Marina is located in Ardantrive bay and has 94 floating pontoon berths, 33 moorings, a fuel berth, 4 shower rooms, laundry facilities and a restaurant (Oban Marina & Yacht Services Ltd, 2014). The marina also runs a small passenger ferry to Oban. A second small passenger and car ferry is located approximately 2 miles south of Oban (Kerrera Ferry Ltd, 2015). Additional ferries operate from Oban to other islands along the Scottish west coast. Small cruise ships operate out of Oban from spring to autumn, and large cruise ships visit mainly during the summer months anchoring outside the harbour (http://www.cruisescotland.com/oban, Accessed 03/03/2015). There are five anchorages in the area surrounding the fisheries (Clyde Cruising Club, 2007), including one adjacent to the Oitir Mhor fishery on the northern shoreline. During the shoreline survey, one leisure yacht and one fishing boat were observed in Ardantrive Bay and Oban Marina had seventeen boats in dry storage and twenty three boats on the water. Three sailing boats and six other boats were observed in the water adjacent to Oban and more than fifty moorings were visible.

Overall, the local population on the Isle of Kerrera adjacent to the survey area is low and sparsely distributed in relation to the shellfisheries, however the presence of nearby boating activity in Ardantrive Bay and Oban Bay and the high density of dwellings and tourist accommodation in Oban may impact eastern side of the island.

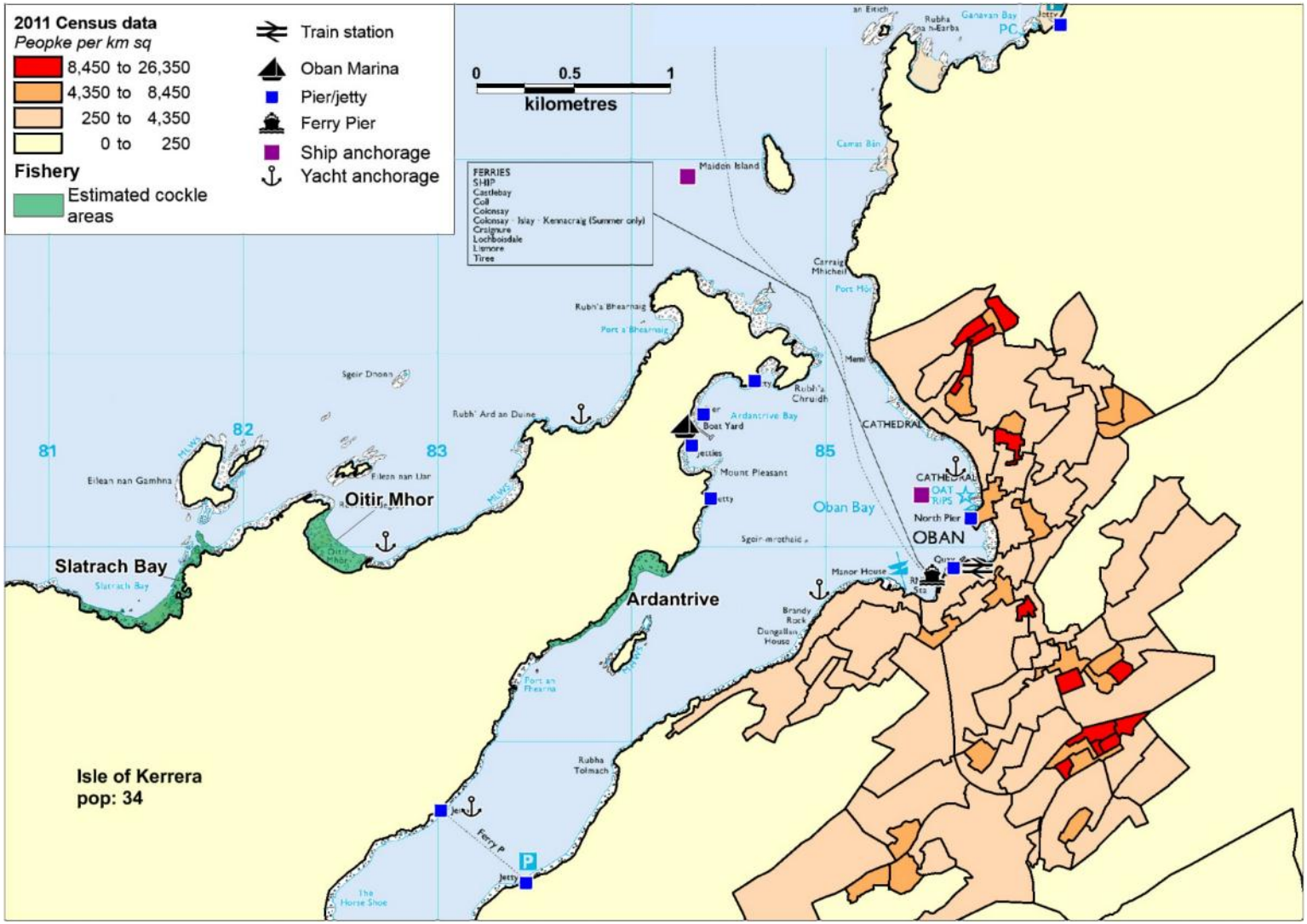

Figure 3.1 Population map for the area around the Sound of Kerrera

4 Sewage Discharges

Information on sewage discharges within an area 7 km around two points, NM 8850 3380 (a point on the North West of Kerrera) and NM 8300 3000 (Dunstaffnage Marina), 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 data, spill frequency, modelling or planned improvements.

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.

Discharges which are considered to have an impact on the fisheries (those where the effluent entered the sea within 8 km of the harvesting area) were sub selected from this data and have been used in the assessment below.

4.1 Community Discharges

Scottish Water and SEPA provided information on two community discharges and a number of Emergency Overflows (EOs) and Combined Sewer Overflows (CSOs). Summary information for the continuous discharges is given in Table 4.1.

Table 4.1 Continuous Community Discharges

Licence Number	Location (NGR)	Discharge	Treatment Level	Discharges to	Dry Weather Flow (m3/day)	Population Equivalent
CAR/L/1003475	NM 85185 30824	Oban STW	Secondary	Oban Bay	4,958	13,597
WPC/W/12086 (Formerly CD12219)	NM 8420 2910	Dungallan Terrace Septic Tank	Primary	Sound of Kerrera	-	-

STW = Sewage Treatment Works -=No data given

Oban STW serves the majority of the population of Oban plus some of the surrounding area. The sewer network licence includes a map of the area served by the STW; this is given as Appendix 6 at the end of the document. This outfall for this sewage works lies approximately 1 km northeast of the Ardantrive cockle area.

No flow details were given for the Dungallan Terrace septic tank.

Summary data for the intermittent discharges under the Oban sewer network licence (CAR/L/1026157), is given in Table 4.2. The information provided by SEPA and Scottish Water differed in both the discharges reported and their discharge locations. These differences were not able to be reconciled, so Table 4.2 gives details from both providers. The full data reported by the providers is given in Appendix 5.

Table 4.2 Oban sewage network intermittent discharges – CAR/L/1026157

Scottish Water					SEPA			
Discharge Name	**Type**	**Outfall Location**	**Treatment Level**	**Note**	**Discharge Name**	**Type**	**Location***	**Discharges to**
Corran Esplanade PS	CSO	NM 849 306	6mm screen	o/f at 160 l/s storage 2,500 m^3	-	-	-	-
Corran Esplanade PS	CSO	NM 8581 2998	10mm screen	o/f at 160 l/s storage 500 m^3	Corran Esplanade PS, CSO	CSO	NM 85661 30620	Sound of Kerrera
Oban, Corran Park WWPS 1997 NM857306	EO	NM 8581 2998	15mm screen	storage 6 hours at DWF (1250 m^3)	Corran Esplanade PS	EO	NM 85661 30620	Sound of Kerrera
Oban George St CSO NM859299	CSO	NM 8581 2998	10mm screen	o/f at 900 l/s	George Street CSO	CSO	NG 85911 29990	Oban Bay
Oban, Alma Crescent CSO	CSO	NM 8555 2972	15mm screen	23 l/s	Alma Crescent CSO	CSO	NM 85499 29667	Oban Bay
Gallanach Pumping Station	CSO	NM 8483 2942	6mm screen	12 l/s	Gallanach PS	CSO/EO	NM 84832 29427	Sound of Kerrera
Oban Gallanach SPS 1998 NM848294	EO	NM 8481 2946	6mm screen	storage 6 m^3				
Oban Ganavan WWPS 2003 NM859323	EO	NM 8592 3259	10mm screen	storage 7 m^3	Ganavan TPS 3A	EO	NM 85921 32589	Ganavan Bay
Oban Heritage Centre SPS 1992 NM858299	EO	NM 8580 2993	-	-	Oban Heritage Centre PS	CSO/EO	NM 85795 29907	Oban Bay
Oban Manor House WWPS	EO	NM 8518 2982	6mm screen	storage 6 m^3	-	-	-	-
Historic sewer network assets which are no longer in place					Burnbank Terrace CSO	CSO	NM 85872 30606	U/T of Oban Bay
					1 The Greens/Glencrutten Rd PS	CSO/EO	NM 86759 29828	Alltan Tartach
					Soroba Road CSO	CSO	NM 8606 2930	Black Lynn Burn
					20 Nant Drive CSO	CSO	NM 86413 28472	Soroba Burn

Data not provided, *Outfall location (or asset location if no outfall location given)

The intermittent discharges are shown in Figure 4.1. Where the locations given by the different providers are close, the location given by SEPA has been used.

4.2 Consented Private Discharges – SEPA

SEPA also provided information regarding consented private discharges within the identified request area. 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 of private septic tanks 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 94 consented private discharges in the area considered likely to affect the fishery at Kerrera. These private discharges are manly located in the peripheral areas of Oban. The majority of these are very small, serving only 1 or 2 households. One discharge has a PE of 100 (CAR/L/1003316). This is associated with a caravan site at Ganavan Sands and discharges to sea.

Approximately 2/3 of the consented discharges go to soakaway or land. Of the other 1/3, 18 discharge to watercourses and 15 discharge to sea.

Private discharges within 100 m of mean high water springs (MHWS) are listed in Table 4.3. These are considered most likely to have an impact on the fishery.

Table 4.3 Private discharge consents within 2.5 km of the fishery

Licence Number	National Grid Reference	Discharge Type	Discharging to	PE
CAR/L/1003316	NM 86052 32694	Sewage (Private) Primary	Ganavan Bay	100
CAR/R/1009285	NM 84511 30847	Sewage (Private) Primary	Ardantrive Bay	6
CAR/R/1013629	NM 85399 32030	Sewage (Private) Primary	Firth of Lorn	5
CAR/R/1014140	NM 85380 32040	Sewage (Private) Primary	Firth of Lorn	5
CAR/R/1014557	NM 85370 32080	Sewage (Private) Primary	Camas Ban	5
CAR/R/1014806	NM 85335 31871	Sewage (Private) Primary	Firth of Lorn	5
CAR/R/1016245	NM 85412 31935	Sewage (Private) Primary	Soakaway	8
CAR/R/1016811	NM 85340 31760	Sewage (Private) Primary	Land	18
CAR/R/1034129	NM 84540 30890	Sewage (Private) Primary	Soakaway	5
CAR/R/1037465	NM 85370 32060	Sewage (Private) Primary	Firth of Lorn	5
CAR/R/1037975	NM 85740 32540	Sewage (Private) Primary	Firth of Lorn	5
CAR/R/1038157	NM 85740 32540	Sewage (Private) Primary	Firth of Lorn	10
CAR/R/1038293	NM 84043 29958	Sewage (Private) Primary	Sound of Kerrera	10
CAR/R/1038294	NM 84060 30070	Sewage (Private) Primary	Soakaway	5
CAR/R/1039308	NM 85340 31870	Sewage (Private) Primary	Camas Ban	6
CAR/R/1039611	NM 85640 32390	Sewage (Private) Primary	Soakaway	5
CAR/R/1039616	NM 82890 28670	Sewage (Private) Primary	Soakaway	5
CAR/R/1039639	NM 81704 27322	Sewage (Private) Primary	Soakaway	10
CAR/R/1081644	NM 84860 30860	Sewage (Private) Primary	Sound of Kerrera	6

Licence Number	National Grid Reference	Discharge Type	Discharging to	PE
CAR/R/1086894	NM 82810 27430	Sewage (Private) Untreated	Sound of Kerrera	5
CAR/R/1095399	NM 85225 31364	Sewage (Private) Primary	Oban Bay	13
CAR/R/1095791	NM 81731 27368	Sewage (Private) Primary	Soakaway	10
CAR/R/1097470	NM 84822 29382	Sewage (Private) Primary	UN/WC	5
CAR/R/1113552	NM 85370 32080	Sewage (Private) Primary	Camas Ban	5
CAR/S/1107891	NM 83080 27560	Sewage (Private) Tertiary	Soakaway	25

PE=Population Equivalent

In addition to the private sewage discharges, consents were received for two marine cage fish farms (MCFF) within the area requested. Working facilities on these may have toilets, but no information was provided regarding these. One of these is located on the west side of the island near Oitir Mhor, and publicly available aerial images of the area showed 10 cages located off the point within 1 km east of the cockle area. The second consented fish farm is located on the east side of the island, south of Ardantrive Bay.

4.3 Shoreline Survey Discharge Observations

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

Table 4.4 Discharge-associated observations made during the shoreline survey

No.	Date	NGR	Associated Photograph (Appendix 5)	Associated Sample	Description
1	08/12/2014	NM 82939 28653	Fig 3		Ferry landing. One compost toilet next to shore.
2	08/12/2014	NM 83018 28665			Long metal pipe with several joins leading out to sea.
3	08/12/2014	NM 84033 29913	Fig 4/Fig 5		One metal pipe, no flow.
4	08/12/2014	NM 84347 30408	Fig 8		20 cm diameter ceramic pipe with Mount Pleasant House on shore behind. No flow.
5	08/12/2014	NM 84213 29122	Fig 10	KCFW6	Raw sewage leaking from manhole cover on ground, no flow able to be measured.

Observation 1 reports a composting toilet serving the area around the ferry landing. Composting toilets can work in a number of ways, with faecal matter either being removed for composting or being composted on site. Pollution may arise from the toilet depending on its type, the quality of construction and suitability of the site.

Observation 2 may relate to an outfall from a small private sewage discharge; however the location does not match any reported discharge consent.

Observation 3 is in the approximate location of a private consented discharge with a PE of 10 (CAR/R/1038293). This discharges to the Ardantrive cockle bed.

Observation 4 may be a sewage discharge pipe from Mount Pleasant House. No corresponding consent was provided. No flow was recorded during the shoreline survey.

Observation 5 reports a sewage overflow at a manhole cover. A sample taken from the effluent returned a value of 500000 *E. coli* cfu/100ml which is consistent with sewage. This observation is in the same vicinity as the Dungellan Terrace septic tank.

4.4 Summary

Faecal contamination at the cockle beds on Kerrera will arise from both small private sources directly to the beds and large community sources further afield.

No sewage discharges were identified along the western side of the island where the Slatrach Bay and Oitir Mhor cockle beds are located. However, any discharges from vessels or barges used to service the MCFF to the northeast of Oitir Mhor could potentially contribute to contamination in the area, depending on their location. The farm appeared in satellite images to extend some distance to the southwest, which would bring it in closer proximity to the bed than the consent location shown in Figure 4.1 would suggest. Anchorages identified in Section 3 just off the Oitir Mhor bed and east of the MCFF would be potential sources of overboard discharges from yachts when in use. This would be most likely to occur during the summer cruising season of May to September.

The Ardantrive cockle bed, on the east side of the island, receives direct discharge of effluent from a small, private septic tank. It also lies on the Sound of Kerrera, which receives secondary treated effluent as well as any storm overflows from the Oban sewage network. The main outfall for Oban STW discharges approximately 1 km northeast of the cockle bed. The Dungallan Terrance Septic Tank also discharges to the sound, approximately 800 m south of the cockle bed.

A number of small private discharges to sea are recorded near the northern end of the sound. Depending on the predicted movement of contaminants, they may contribute to background levels of contamination in the either the sound or along the west side of the island.

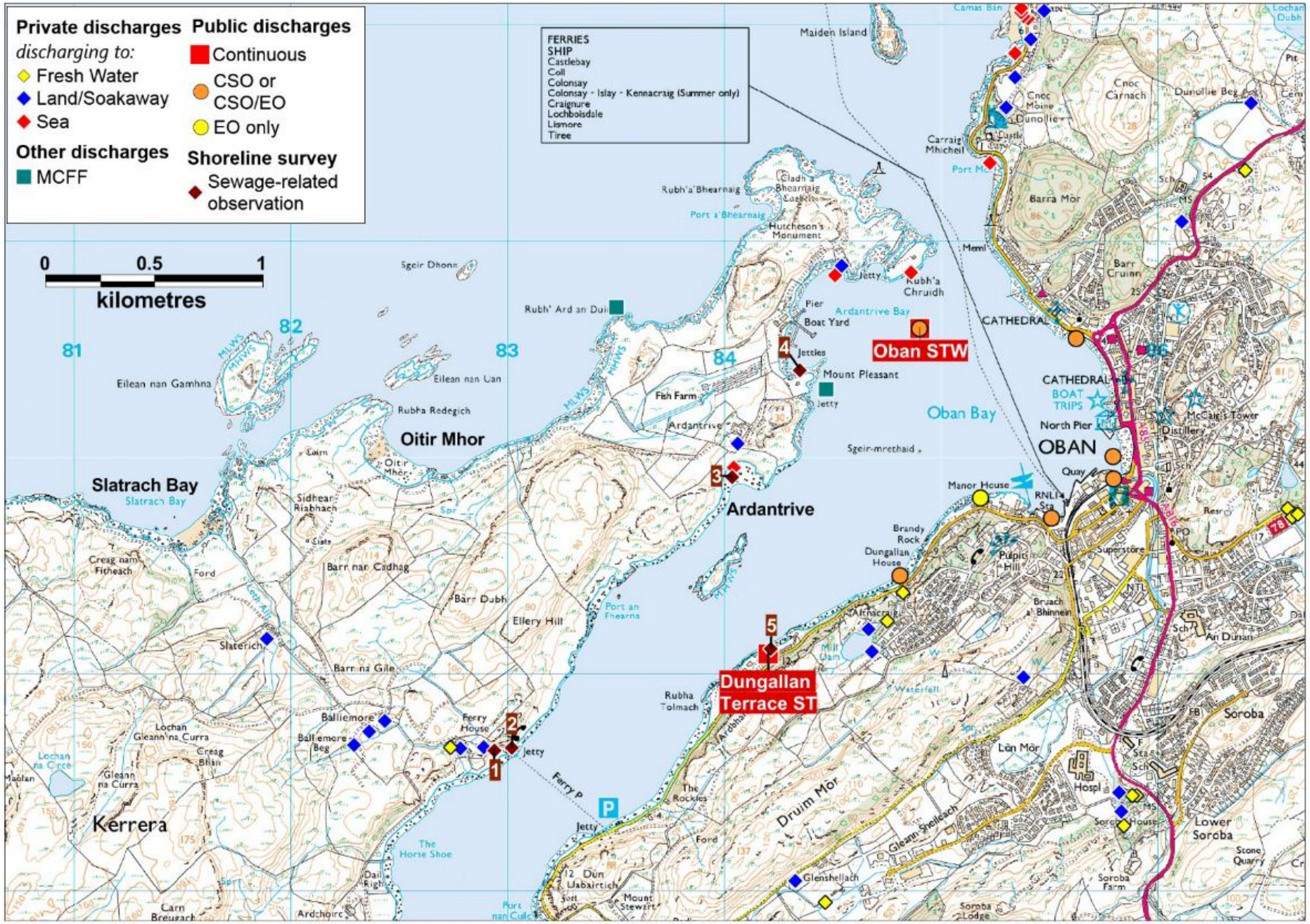

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Figure 4.1 Map of discharges for the area surrounding Kerrera

5 Agriculture

Information on the spatial distribution of animals on land adjacent to or near the shellfishery can provide an indication of the potential amount of organic pollution from livestock entering the shellfish bed areas. Parish-level agricultural census was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the Kilmore and Kilbride parish. Reported livestock numbers for 2013 are shown in Table 5.1.

Table 5.1 Livestock numbers in the Kilmore & Kilbride agricultural parish, 2013

	Kilmore & Kilbride	
	120 km^2	
	Holdings	Numbers
Pigs	5	22
Poultry	13	165
Cattle	23	816
Sheep	31	15049
Horses used in Agriculture	0	-
Other horses and ponies	0	-

Kilmore and Kilbride parish covers a large land area, including all of the island of Kerrera and the adjacent mainland, extending up to 14 km inland. Agricultural activity is unlikely to be evenly distributed throughout the parish. It is therefore not possible, on the basis of this data, to determine the spatial distribution of the livestock on the shoreline adjacent to the survey area or to identify how many animals are likely to impact the catchment around the shellfish beds. However, these figures can give an impression of the level of agricultural activity and numbers of livestock kept over the broader area. A large number of sheep was reported for the parish, with smaller numbers of other livestock animals reported.

A source of spatially relevant information on livestock population in the area was the shoreline survey (see Appendix 4) which only relates to the time of the site visits on the 8th & 15th December 2014. However, the observations made during the survey are dependent upon the viewpoint of the observer, and therefore some animals may have been obscured by the terrain.

During the shoreline survey approximately 61 sheep, 1 cow and 1 goat were observed grazing along the eastern shoreline of the island. Of these, 50 sheep and a cow were seen west of the Ardantrive cockle bed. On the northern side of the island, livestock were recorded at the west end of the Slatrach Bay bed (84 animals), as well as at the northern end of the Oitir Mhor bed (14 animals). Two further cattle were seen approximately 1 km to the east of the Oitir Mhor bed. No other livestock were observed during the shoreline survey. During a 2010 shoreline survey undertaken at Oitir Mhor, cattle were noted on the beach adjacent to the Ardantrive cockle bed (Cefas and FSAS, 2011).

The 180 acre farm located at Ardantrive, on the east coastline of Kerrera has a fold of breeding highland cattle, a flock of breeding ewes and small flock of commercial sheep (Ardentive Farm, 2015).

Review of publicly available aerial images shows that sheep were present on pasture and rough grazing inland from the shoreline at areas identified on the map in Figure 5.1. (Bing Maps, accessed 05/02/2015 imaging date Apr-May 2012, http://mvexel.dev.openstreetmap.org/bing/). Two further areas of farm buildings were visible: one south of Slatrach Bay and another north of the ferry landing. Contributions of faecal contamination to the fisheries may therefore occur near these areas.

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 moderate, with the greatest impact to areas of the cockle beds closest to the shoreline at Ardantrive and Slatrach Bay, where larger concentrations of livestock were observed.

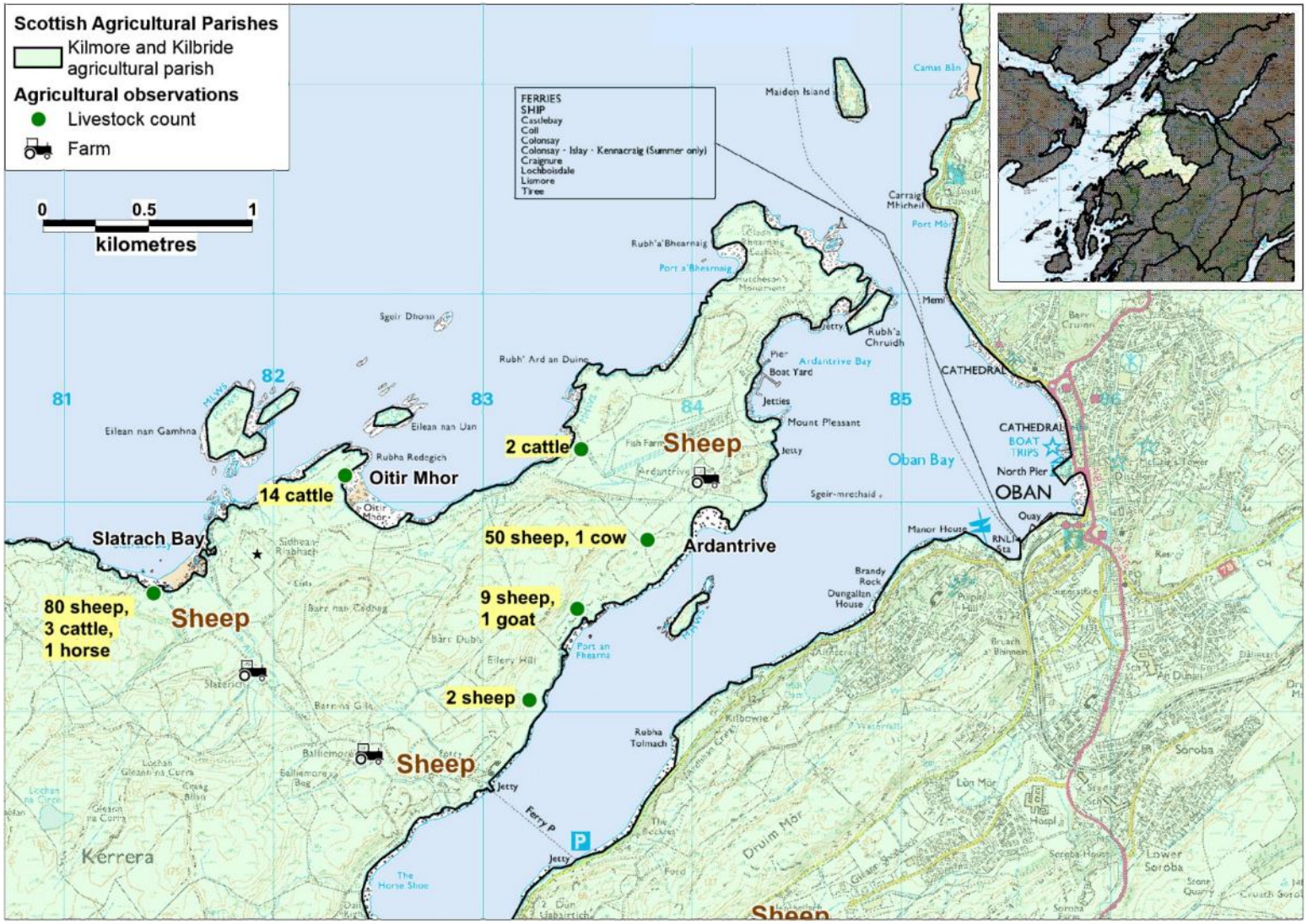

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Figure 5.1 Livestock observations at the Sound of Kerrera

6 Wildlife

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

The species most likely to contribute to faecal indicator levels around the common cockle fisheries at the Sound of Kerrera are considered below.

Pinnipeds

The Special Committee on Seals report (Special Committee on Seals, 2013) indicates seals were observed in the Firth of Lorn and Sound of Kerrera areas during August surveys conducted between 2007 and 2011. No seals were observed during the shoreline survey.

There is a seal colony reported near Oitir Mhor (Oitir Mhor), which draws tour boats from Oban. The seals were reported to be found mainly on the rocks at Sgier Dhonn and Eilean na Uan, northeast of the beach (Cefas and FSAS, 2011). Seals are therefore likely to contribute at least to background levels of faecal contamination at the Sidhead Riabhach bed.

Cetaceans

There are reported sightings of small pods of bottlenose dolphins, harbour porpoise, a minke whale and a sperm whale off of Kerrera and within Kerrera Sound (Hebridean Whale and Dolphin Trust, 2015). 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 fisheries are listed in Table 6.1.

Table 6.1 Seabird counts within 5 km of Sound of Kerrera

Common name	Species name	Count*	Qualifier	Accuracy
Herring Gull	*Larus argentatus*	1306	Occupied territory and nests	1 count estimate, 1 count unknown, 2 counts accurate
Great Black-Backed Gull	*Larus marinus*	44	Occupied territory and nests	1 count estimate, 1 count unknown, 1 count accurate
Lesser Black-Backed Gull	*Larus fuscus*	400	Occupied territory	Estimate
Common Gull	*Larus canus*	42	Occupied nests	1 count unknown, 1 count estimate, 3 counts accurate
Arctic Tern	*Sterna paradisaea*	36	Occupied nests	Estimate
Common Tern	*Sterna hirundo*	4	Occupied nests	Estimate
Black Guillemot	*Cepphus grylle*	6	Individuals on land	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)

The JNCC dataset indicates that gulls are the most common seabird species breeding in the area and the densest breeding colony is located on Bach Island, off the southern end of Kerrera.

During the shoreline survey, birds were the most common wildlife observed, though few individuals were seen. Species included gulls, swans, mallard ducks, herons and a cormorant.

Otters

The NBN gateway indicated that there were no records of the European otter (*Lutra lutra*) on Kerrera Island, though there records of otters in three locations along the adjacent mainland as recently at 2013 (https://data.nbn.org.uk/). Three otters were seen southwest of Ardantrive during the shoreline survey.

Deer

The NBN gateway indicated that there were roe deer present in a 1 km radius around woodland set back from the mainland shoreline at Kilbride (https://data.nbn.org.uk/). No deer were observed during the shoreline survey.

Conclusion

Wildlife species likely to contribute to contamination levels at the cockle beds around Kerrera Sound include seals, birds, cetaceans and deer. Direct inputs may arise from seals and birds that use the intertidal areas either to rest or feed. Impacts from wildlife sources of contamination are anticipated to be unpredictable and spatially variable, however the regular presence of seals near Oitir Mhor may result in particular impacts from this species at this site.

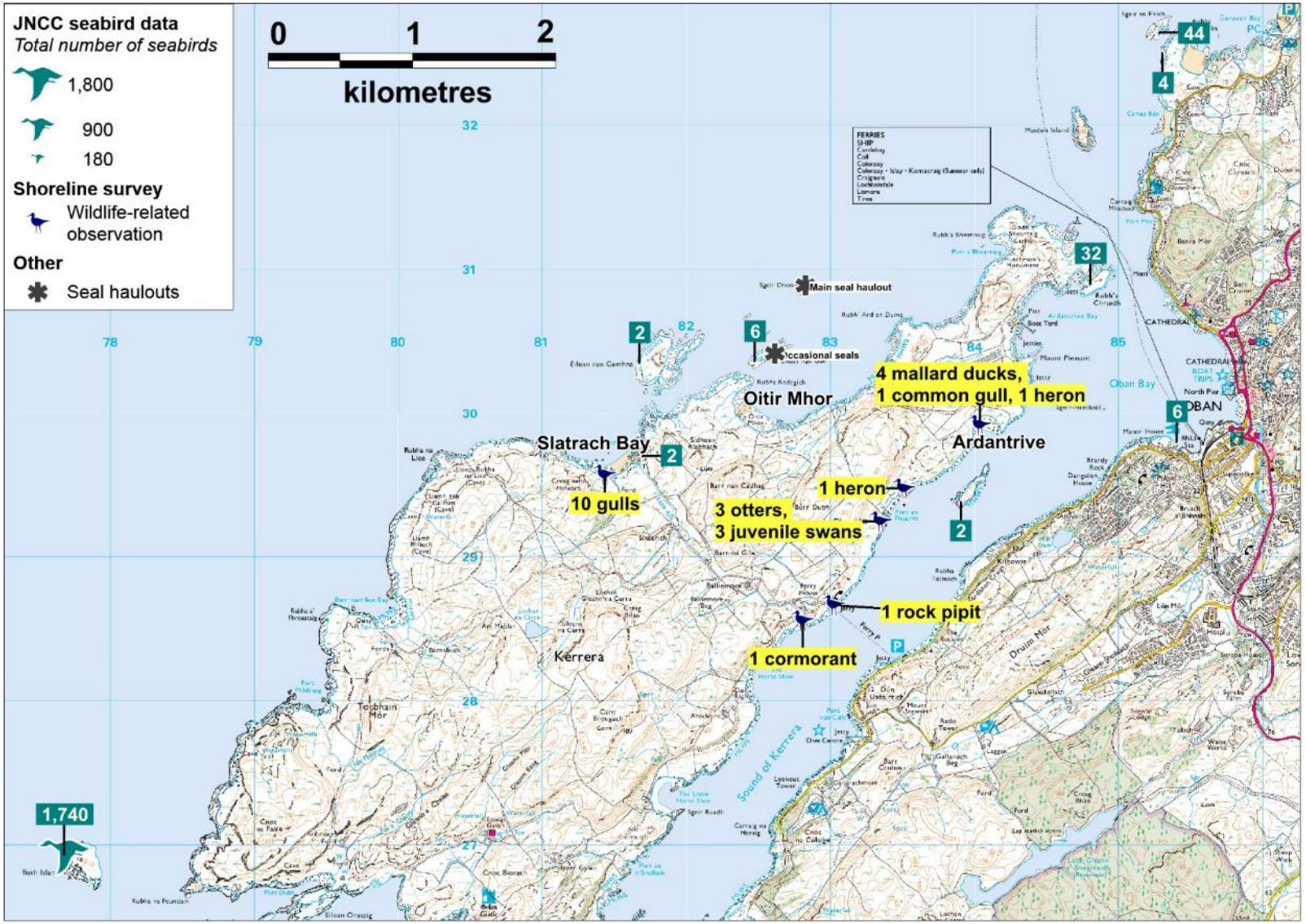

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Figure 6.1 Map of wildlife distributions around Sound of Kerrera

7 Land Cover

The Land Cover Map 2007 data for the area is shown in Figure 7.1. Much of the northern end of Kerrera is classified as improved grassland. Land adjacent to the identified cockle bed areas is classed mainly as improved grassland or rough grassland, with some coniferous woodland. Oban is represented as a built up/urban area. There are some apparent inconsistencies between the land cover classifications and land cover visible in satellite imagery. Small areas of fresh water identified along the north shore of Kerrera are presumed to be erroneously classified. No trees are apparent on the north end of Kerrera in satellite images, and therefore the areas of woodland at the north end of the Oitir Mhor bed and on the small island west of it also appear to be erroneously classified. The small built up area on the southeast side of the island is the boatyard at Oban Marina.

Faecal indicator organism export coefficients for faecal coliform bacteria have been found to be approximately 1.2 – 2.8×10^9 cfu km^{-2} hr^{-1} for urban catchment areas, approximately 8.3×10^8 cfu km^{-2} hr^{-1} for areas of improved grassland and approximately 2.5×10^8 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 highest potential contribution of contaminated run-off attributable to land cover is from built-up areas at Oban Marina and from the town of Oban itself. Runoff from these areas would be most likely to impact the Ardantrive cockle bed, but could contribute to background levels of contamination further afield, depending on the predicted movement of contaminants. Significant contributions are also expected from areas of improved grassland located directly adjacent to each of the cockle beds. Contributions from these sources would be expected to increase significantly after rainfall events.

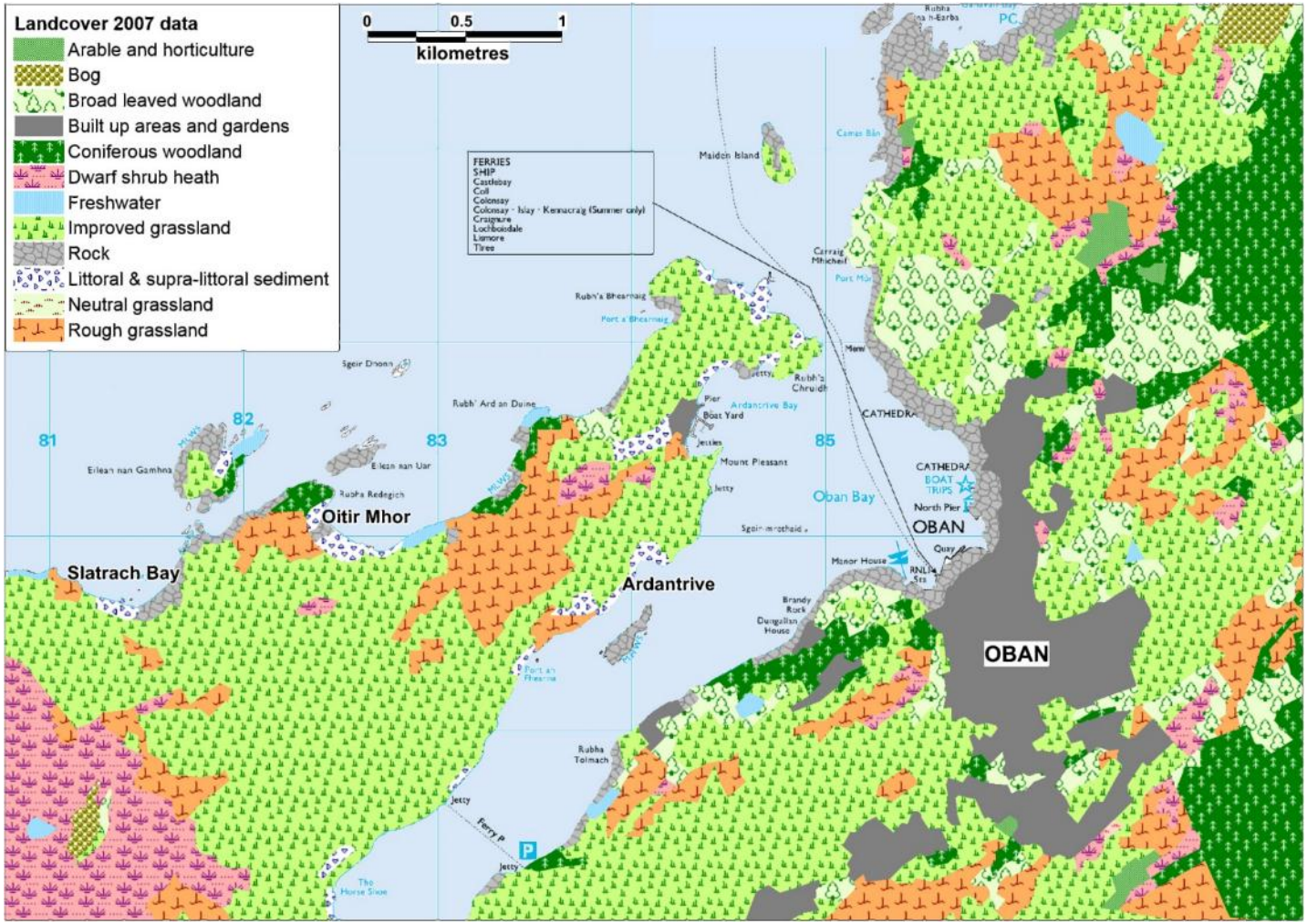


Figure 7.1 LCM2007 land cover data for the area around Sound of Kerrera

8 Watercourses

There are no gauging stations on watercourses entering the Sound of Kerrera.

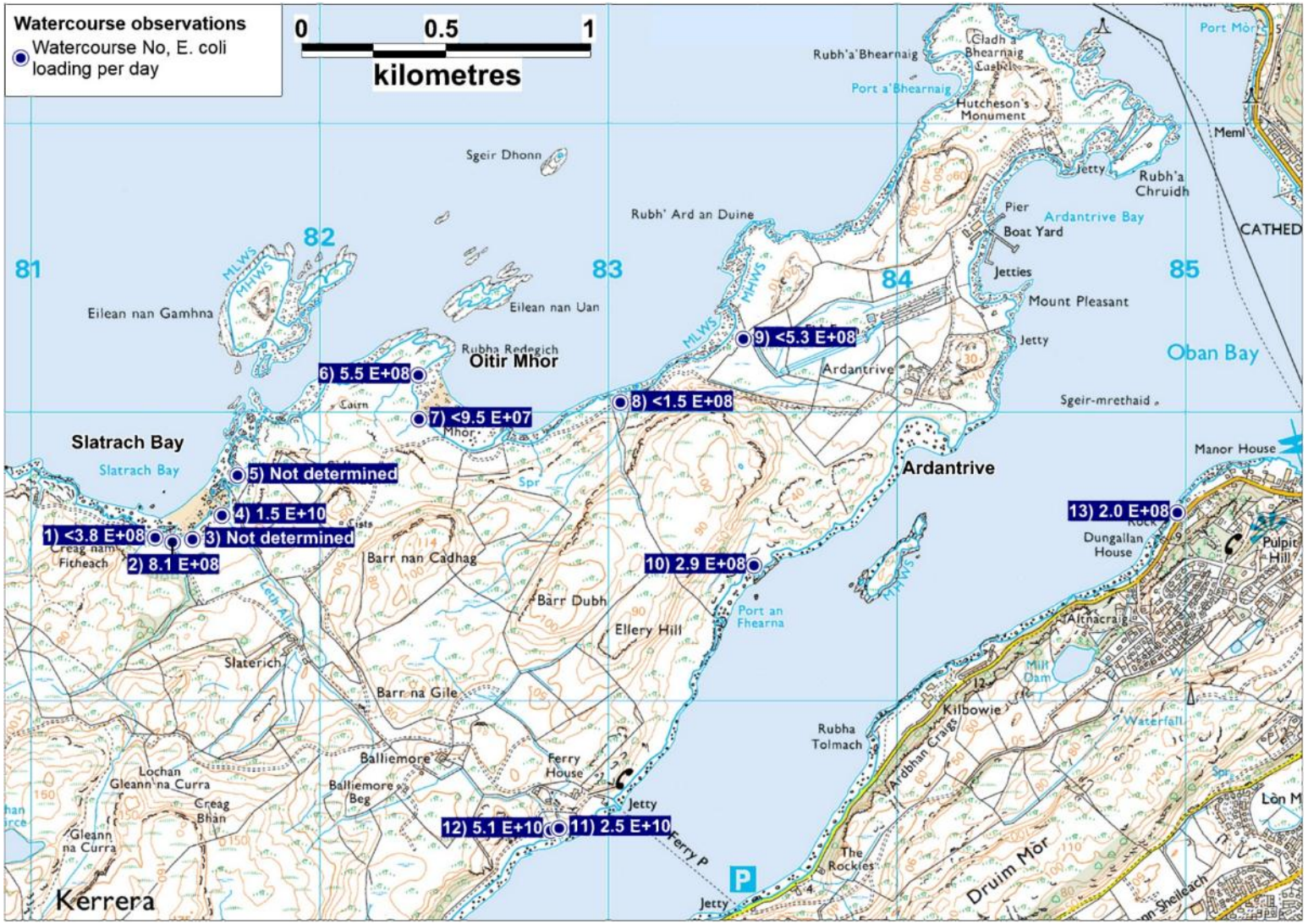
Spot measurements of flow and microbial content were obtained during the shoreline survey conducted on the 8th & 15th December 2014. Rain showers were recorded in the 48 hrs prior to both survey days. The watercourses listed in Table 8.1 are those recorded during the shoreline survey. Loadings were calculated based on the recorded measurements and sample results from the shoreline survey The locations and loadings of measured watercourses are shown in Figure 8.1.

Table.1 Watercourses entering the Sound of Kerrera

No.	Eastings	Northings	Description	Width (m)	Depth (m)	Flow (m^3/d)	Loading (*E. coli* per day)
1	181429	729570	Unnamed watercourse	1.66	0.09	3847	$<3.8 \times 10^{08}$
2	181489	729553	Unnamed watercourse	1.20	0.15	8056	8.1×10^{08}
3	181559	729563	Unnamed watercourse	Not measured or sampled			
4	181661	729647	Leith Allt	2.70	0.16	19260	1.5×10^{10}
5	181715	729785	Unnamed watercourse	Not measured or sampled			
6	182342	730133	Unnamed watercourse	0.97	0.08	1824	5.5×10^{08}
7	182344	729981	Unnamed watercourse	0.32	0.30	946	$<9.5 \times 10^{07}$
8	183042	730038	Unnamed watercourse	0.38	0.08	1452	$<1.5 \times 10^{08}$
9	183469	730259	Unnamed watercourse	1.05	0.32	5255	$<5.3 \times 10^{08}$
10	183506	729473	Unnamed watercourse	0.57	0.14	359	2.9×10^{08}
11	182829	728562	Unnamed watercourse	1.23	0.14	6204	2.5×10^{10}
12	182801	728555	Unnamed watercourse	0.97	0.11	6241	5.1×10^{10}
13	184974	729656	Unnamed watercourse	0.53	0.10	504	2.0×10^{08}

Five watercourses were found to be discharging to the Slatrach Bay cockle bed. Of these, the highest loading was from the Leith Allt, which carried a moderate loading at the time of survey. Loadings for two small watercourses in this area were not determined. Two watercourses discharged directly onto the Oitir Mhor bed and a further two watercourses were found approximately 500 m and 1km further to the east, respectively. Estimated loadings from all four were low. Three watercourses were recorded to the south of the Ardantrive bed, and of these the highest estimated loading was contributed by a watercourse south of the ferry landing. No watercourses were observed to discharge directly across the Ardantrive bed.

Overall, freshwater inputs would be expected to contribute low to moderate levels of faecal contamination to the shellfish beds. Impacts would be higher at the Slatrach Bay and Oitir Mhor shellfish beds, where the watercourses discharge directly to the beds.



Where the bacterial loading is labelled on the map, the scientific notation is written in digital format, as this is the only format recognised by the mapping software. So, where the formal scientific notation for 1000 is 1×10^3, in digital format it is written as 1E+3.

Figure 8.1 Map of watercourse loadings at Sound of Kerrera

9 Meteorological Data

The nearest weather station for which a nearly complete rainfall data set was available is located at Lismore; Frackersaig Farm, situated approximately 10 km to the north of the fisheries. Rainfall data was available for January 2008 – November 2013 inclusive. Data for the following dates were excluded from the analysis as values were either estimated or accrued across date ranges: 11-14/01/2008, 31/03/2008, 01/04/2008, 04/06/2008, 05/06/2008, 16/06/2008-19/06/2008, 04/05/2009, 05/05/2009, 17/05/2009, 18/05/2009, 10/08/2009, 11/08/2009, 01/12/2010, 02/12/2010, 16/08/2011-20/08/2011, 22/08/2011, 29/10/2011, 30/10/2011, 22/08/2013, 29/10/2011, 30/10/2011, 22/08/2012, 23/08/2012, 04/12/2012 and 05/12/2012. Data for the entire month of December 2013 was unavailable.

The nearest wind station is situated in Tiree, located 86 km west of the production area. Conditions may differ between this station and the fisheries due to the distances between them. However, this data is still shown as it can be useful in identifying seasonal variation in wind patterns.

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

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 *.

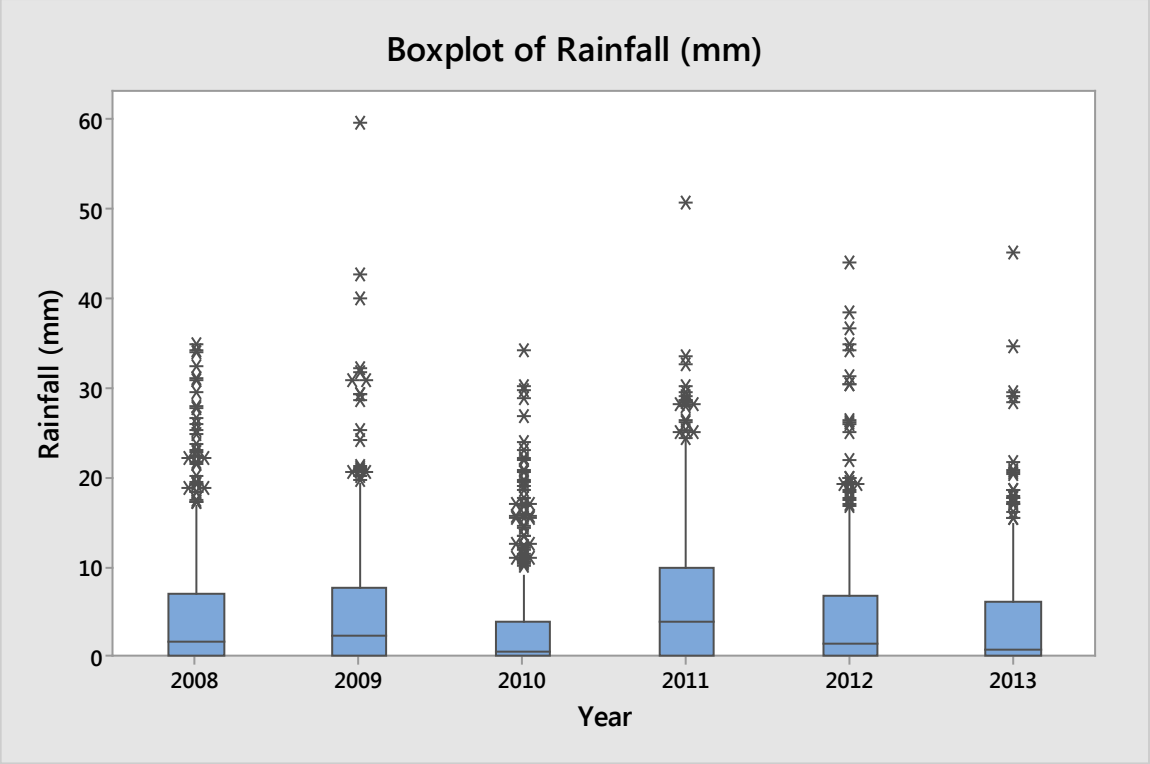


Figure 9.1 Box plot of daily rainfall values by year at Lismore; Frackersaig Farm (2008 – 2013)

Total rainfall values varied from year to year, with 2010 being the driest (1199 mm) and 2011 the wettest (2354 mm). Very high rainfall values exceeding 40 mm/d occurred in 2009, 2011 and 2013.

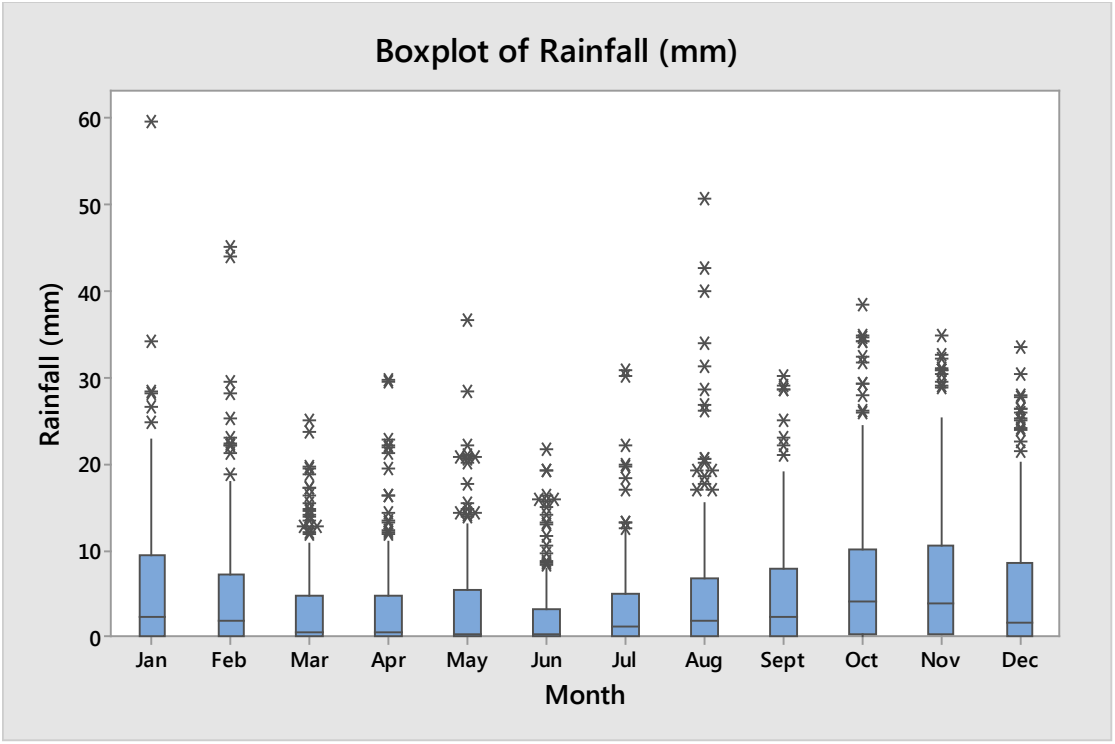


Figure 9.2 Box plot of daily rainfall values by month at Lismore; Frackersaig Farm (2008 – 2013)

Monthly rainfall totals over the period 2008-2013 were higher during the autumn and winter. Rainfall generally increased from August peaking in October (1348 mm). Weather was driest in June (429 mm). Rainfall values exceeding 30 mm/d were seen in all months except March, April and June.

For the period considered here (2008 – 2013) 46 % of days received daily rainfall of less than 1 mm and 17 % of days received daily rainfall of over 10 mm. Care needs to be taken with the assessment of rainfall patterns by both year and month due to the excluded data.

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.

Overall, the winds were predominantly from between south-southeast and west. The strongest wind tended to be from the south. Seasonally, the strongest winds occurred during the autumn and winter. A greater proportion of northerly winds were seen in the spring and summer than in autumn and winter.

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.

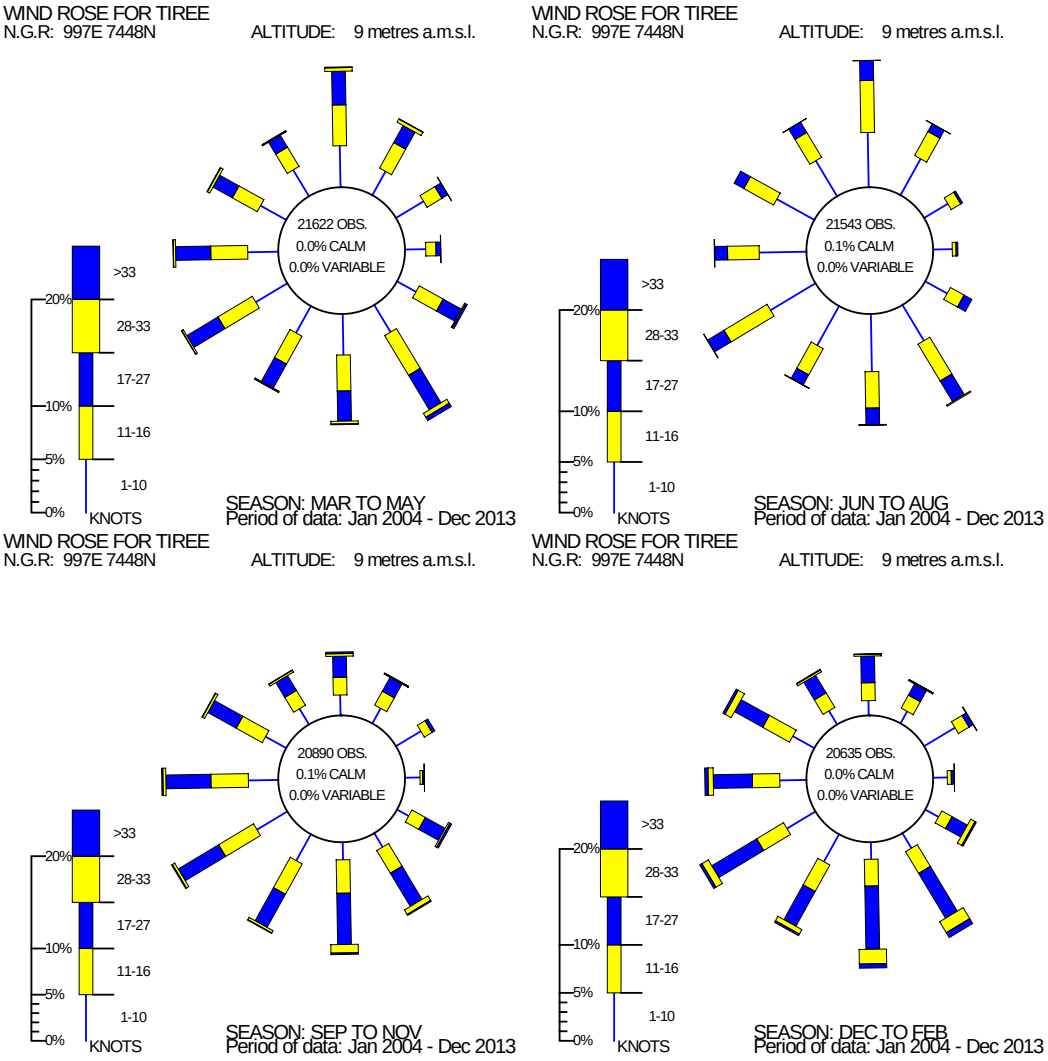


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Figure 9.3 Seasonal wind roses for Tiree

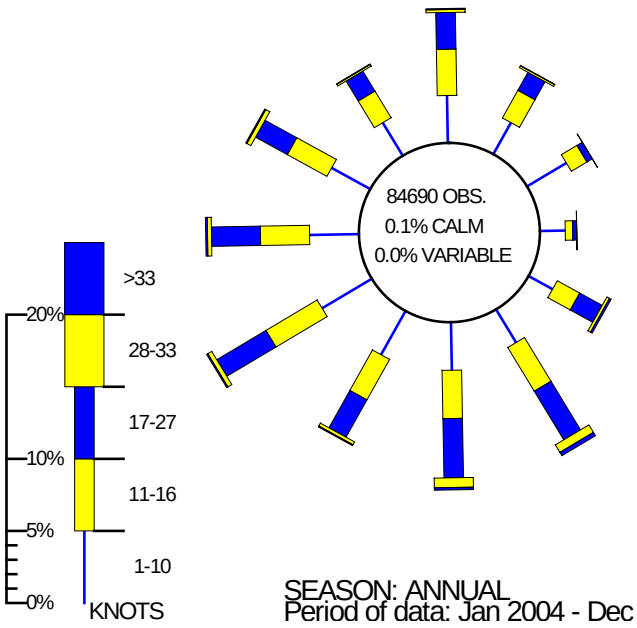

Figure 9.4 Annual wind rose for Tiree

10 Classification Information

Kerrera Cockles was classified as B from September 2014 onward for common cockles (*Cerastoderma edule.*).

The nearest classified shellfishery is for farmed Pacific oysters at Oitir Mhor. The classification history for this area since 2009 is shown in Table 10.1.

Table 10.1 Oitir Mhor (Pacific oyster) classification history

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

The Oitir Mhor production area has regularly been classed B during the summer and autumn months.

11 Historical *E. coli* Data

11.1 Validation of historical data

Results for all samples assigned against Sound of Kerrera production area for the period 01/01/2009 to the 04/02/2015 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 from the database on 04/02/2015. All *E. coli* results were reported as most probable number (MPN) per 100 g of shellfish flesh and intravalvular fluid.

One sample result reported as <18 was reassigned a value of 10 *E. coli* MPN/100 g and a sample result reported as >18000 was reassigned a value of 36000 *E. coli* MPN/100 g, for the purposes of statistical evaluation and graphical representation.

All samples were reported as valid and were received at the laboratory within 48 hours since collection. All samples had box temperatures ≤8^{o}C, with the exception of one which did not have a box temperature recorded. All samples plotted at Ganavan, to the north of Kerrera.

11.2 Summary of microbiological results

A summary of samples and results at Sound of Kerrera are listed in Table 11.1.

Results from the Oitir Mhor oyster fishery have been included here to give an impression of contamination levels present at the Oitir Mhor cockle bed. However, due to differences between the physiology and ecology of the two different species, results are not directly comparable between them.

Table 11.1 Summary of historical sampling and results

Sampling Summary		
Production area	Sound of Kerrera	Oitir Mhor Bay
Site	Ganavan	Oitir Mhor
Species	Common cockles	Pacific oysters
SIN	AB-697-1512-04	AB-308-701-13
Location	NM 855 324	
Total no of samples	18	
No. 2009		10
No. 2010		12
No. 2011		14
No. 2012		12
No. 2013	4	12
No. 2014	13	12
No. 2015	1	2
Results Summary		
Minimum	<18	<18
Maximum	>18000	9200
Median	330	155
Geometric mean	283	172
90 percentile	4311	2680
95 percentile	36000	5400
No. exceeding 230/100g	12 (67%)	27 (36%)
No. exceeding 1000/100g	1 (6%)	16 (22%)
No. exceeding 4600/100g	1 (6%)	5 (7%)
No. exceeding 18000/100g	1 (6%)	0

11.3 Overall geographical pattern of results

The geographical locations of all sample results assigned to Sound of Kerrera are mapped thematically in Figure 11.1.

All samples have been taken at Ganavan, to the northeast of Sound of Kerrera.

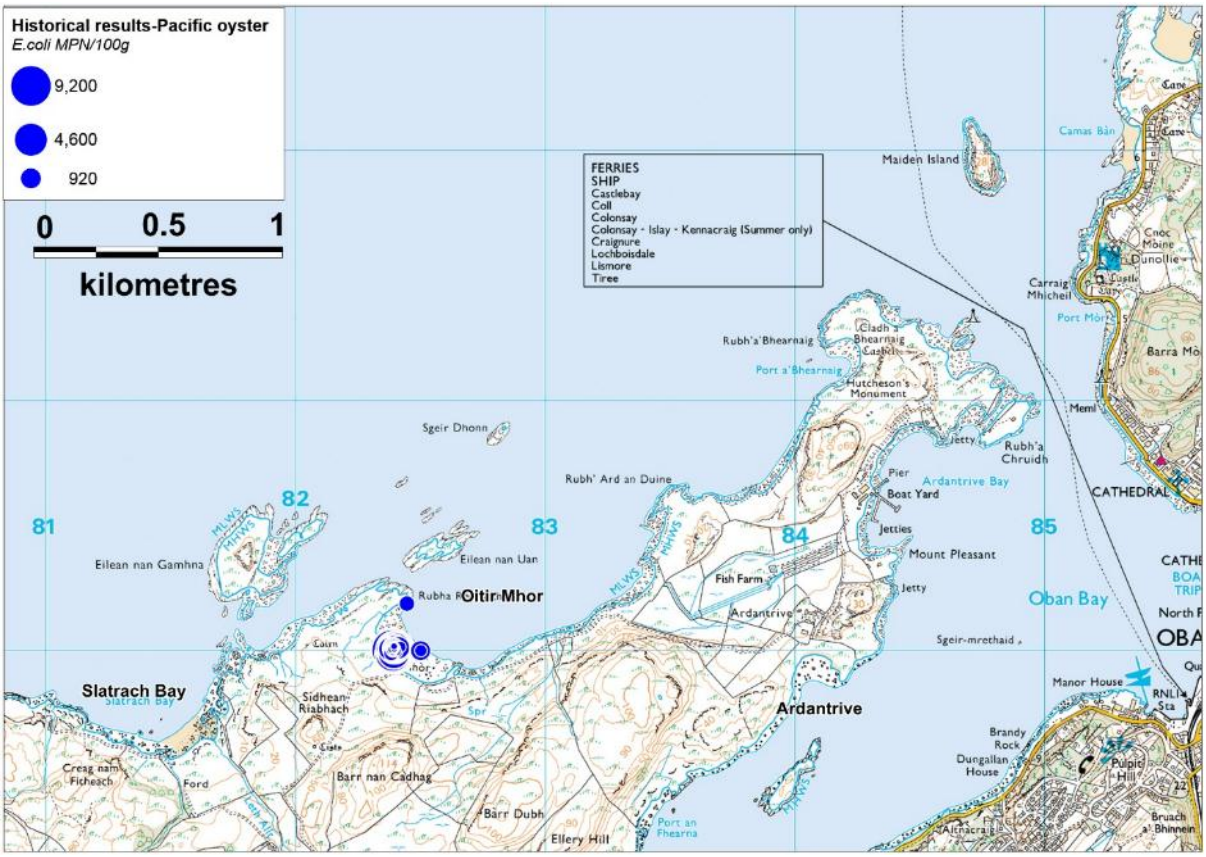

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Figure 11.1 Map of reported sampling locations for common cockles at Sound of Kerrera

All sampling for the Kerrera cockle beds has been undertaken at Ganavan, which lies outside the Sound of Kerrera, approximately 4 km northeast of the Oitir Mhor cockle bed. Due to the distance between the sampled area at Ganavan and the anticipated differences in local contaminating sources, these results are not considered likely to be representative of conditions at the island cockle beds. Therefore, no further analysis of these results has been undertaken here. For further information on results at Ganavan, please refer to the sanitary survey report for that area.

11.4 Summary and conclusions

No historical sampling results were available for the cockle beds around Kerrera. Results in Pacific oysters at Oitir Mhor suggest that contamination levels present are sufficiently high to cause the area to exceed class B limits (4600 *E. coli* MPN/100 g) on occasion. Highest results tended to occur during the summer and early autumn (data not presented). However, due to differences between species, direct comparison is not possible.

12 Designated Waters Data

Shellfish Water Protected Areas

The Shellfish Waters Directive (2006/113/EC) has been repealed (as at 31 December 2013) and equivalent protection for areas previously designated under that Directive is given by The Water Environment (Shellfish Water Protected Areas: Environmental Objectives etc.) (Scotland) Regulations 2013. The Kerrera and Sound of Kerrera Shellfish Water Protected Areas (SWPA) have the same boundaries as the previous Kerrera and Sound of Kerrera Shellfish Growing Waters (SGW).

The Kerrera SWPA is located on the northern shoreline of the island of Kerrera and covers the Oitir Mhor shellfish bed. The Sound of Kerrera SWPA is located approximately 500m south of the Ardantrive shellfish bed, between the island of Kerrera and the mainland. The Shellfish Growing Waters site report, prepared by SEPA, identified that there were no community settlements in the vicinity of the Kerrera area, and that the most likely cause of repeated faecal coliform failures was diffuse contamination from livestock farming and/or sewage disposal.

The designated SWPA for Kerrera and the Sound of Kerrera are shown in Figure 12.1. Since 2007, assessment of the bacteriological status of shellfish waters has been undertaken using the shellfish hygiene *E. coli* data and this data has been reviewed in Section 11.

Figure 12.1 Designated shellfish water protected area – Kerrera and Sound of Kerrera

Bathing Waters

There are no designated bathing waters along the northern shoreline of Kerrera or within the Sound of Kerrera.

13 Bathymetry and Hydrodynamics

13.1 Introduction

The Isle of Kerrera is situated in Argyll and Bute on the west coast of Scotland. It is separated from the mainland by the Sound of Kerrera to the south and east. Oban Bay joins the northern end of the Sound of Kerrera, while the southern end opens to the Firth of Lorn. The northern and western shores of the Isle of Kerrera are open to the Firth of Lorn, a large body of water bounded by the Isle of Mull to the north and open to the North East Atlantic ocean to the west. Few small streams flow into the assessment area from the Isle of Kerrera itself and the adjacent mainland.

The assessment area encompasses the northern part of the Sound of Kerrera, Oban Bay, and adjacent waters in the Firth of Lorn extending from Rubha na Lice, on the Isle of Kerrera, northwards to Camas Rubha na Liathaig. The assessment area extends 3-4 km offshore in to the Firth of Lorn from the Isle of Kerrera and the mainland. At its widest, the Sound of Kerrera is approximately 2 km in width, while Oban Bay is approximately 1.5 km^2 in area.

Figure 13.1 Extent of the Isle of Kerrera hydrographic study area

Coordinates for Isle of Kerrera: 56°25.120'N 005°30.770'W, OS NM 8343 3070

13.2 Bathymetry and Hydrodynamics

13.2.1 Bathymetry

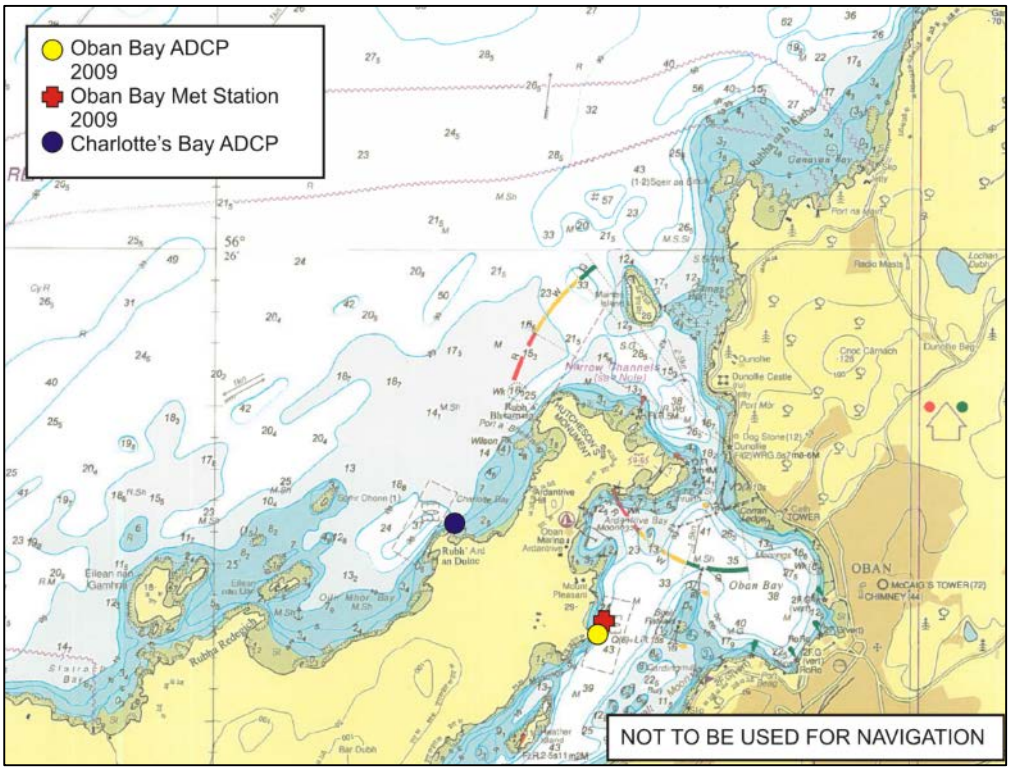


Figure 13.2 Admiralty chart (2387) extract of the Isle of Kerrera assessment area with ADCP stations shown. Meteorological station associated with the Charlotte Bay ADCP deployment is situated outwith the assessment area to the northeast, and is not shown on this map. © Crown Copyright and/or Database rights. Reproduced by permission of the Controller of her Majesty's Stationary Office and the UK Hydrographic Office (www.ukho.gov.uk).

Figure 13.2 shows the bathymetry of the Isle of Kerrera assessment area. To the north and west of the Isle of Kerrera the bathymetry slopes gently towards the central axis of the Firth of Lorn, apart from two isolated deep patches immediately offshore of the points Rubh'Ard an Duine and Rubha Bhearnaig on the western coast of the island. These patches reach depths of 38 m and 25 m, respectively. Several islands and tidally exposed rocks are also found along the western coast of the Isle of Kerrera, including Wilson Rock, Sgeir Dhonn, Eilean nam Uan, and Eilean nan Gamhna.

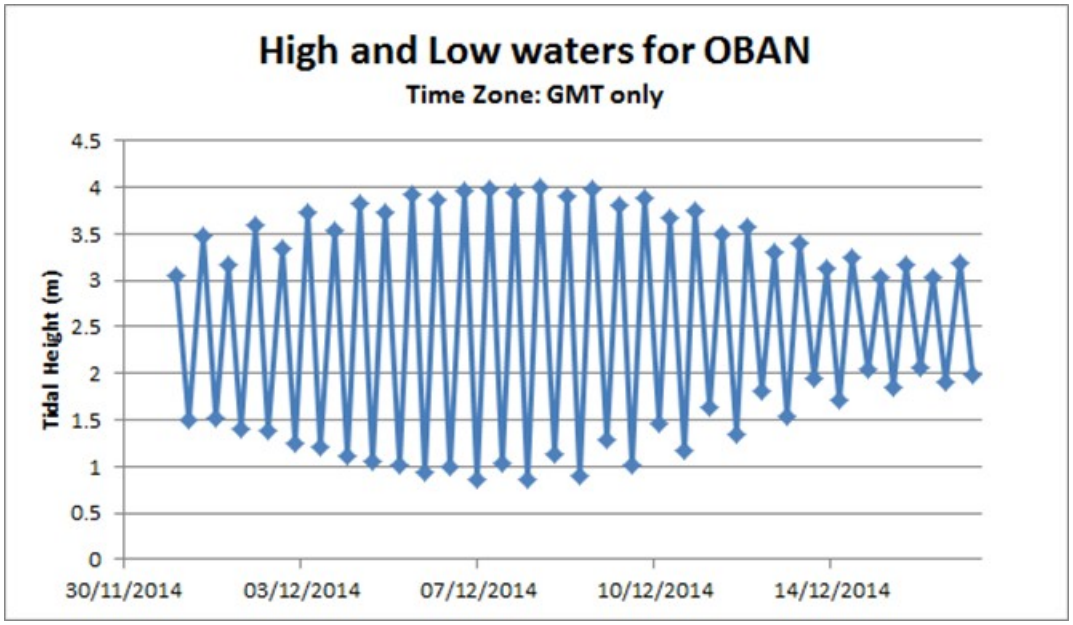
A narrow channel of relatively deep water is found at the northern tip of the Isle of Kerrera, with a maximum depth of 38 m. At its narrowest, the channel shallows to a sill of approximately 7 m depth, stretching between the Corran Ledge on the mainland and Rubha Chruidh on the Isle of Kerrera. To the south of this sill, Oban Bay reaches depths of 41 m, shoaling towards the Sound of Kerrera to the south.

The Sound of Kerrera is a narrow channel punctuated by tidally exposed rocks and small islands. Within the assessment area it reaches a maximum depth of 38 m, and is shallowest around the Ferry Rocks to the southwest of Rubha Tolmach.

13.2.2 Tides

Data on tidal information is provided based on tidal characteristics determined from Oban, within the assessment area.

Standard tidal data for Oban, centred around the survey date of 8th December 2014, are shown in Figure 13.3. Tidal predictions for Oban 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 Oban.

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

Mean High Water Springs = 3.96 m
Mean Low Water Springs = 0.84 m
Mean High Water Neaps = 3.02 m
Mean Low Water Neaps = 1.78 m

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

Springs: 4.99 x 10^7 m^3
Neaps: 1.98 x 10^7 m^3

13.2.3 Tidal Streams and Currents

There are no published tidal diamonds within the assessment area, but charted tidal ebb and flood speeds are available for multiple locations around the Isle of Kerrera. To the north and west of the island, both flood and ebb tides flow at 0.5 m/s, while within the Sound of Kerrera tidal currents reach 0.5 m/s on the flood tide and 0.75 m/s on the ebb.

Tidal currents reach greater speeds through the narrow channel at the northern entrance to Oban Bay, reaching speeds of 0.75 m/s on the flood tide and 1.25 m/s on the ebb tide. Some enhancement of the speed of the tidal streams caused by shallow areas and tidally exposed rocks will be important within the assessment area.

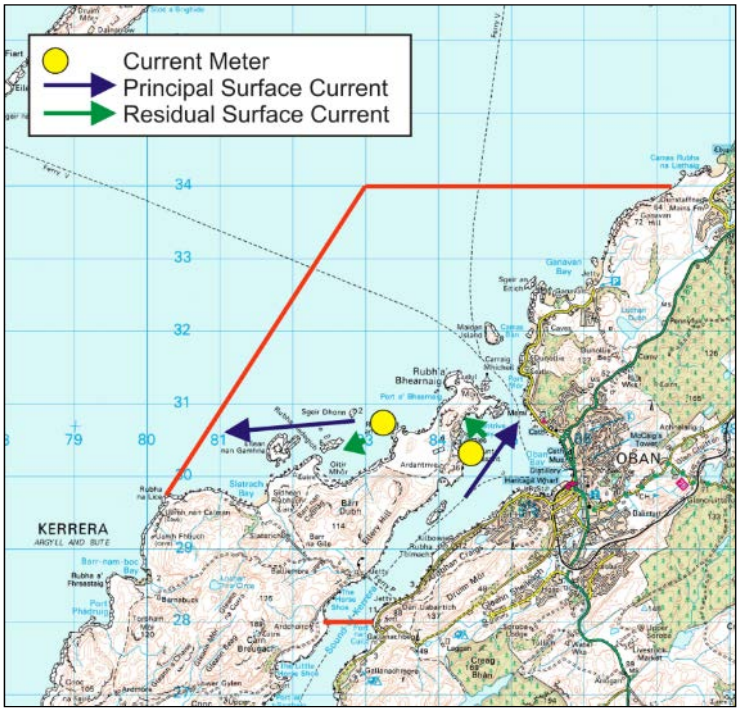


Figure 13.4 Map showing Charlotte Bay and Oban Bay ADCP current meter sample sites within the assessment area.

Using the surface principal current amplitude and the assumption of a uniform sinusoidal tide, the cumulative transport distance and residual transport distance, and direction that might be expected during each phase of the tide is shown above. The boundary of the assessment area is indicated by the red line.

Current meter data were available at Charlotte's Bay and Oban Bay, along the western and eastern coastlines of the Isle of Kerrera, respectively. Data were obtained from SEPA for a current meter deployment in Charlotte's Bay in 2005

(SAMS Research Services Ltd., 2006), and in Oban Bay in 2009 (Anderson Marine Surveys Ltd, 2010). A further dataset were available for a current meter deployments carried out in 1995 (Scottish Association for Marine Science, 1996), but no current meter data coordinates are supplied. As a result, the findings of the 1995 survey are only used as a general characterisation of Oban Bay in support of the 2009 survey, and are not specifically dealt with in detail. The location of the 2009 Oban Bay current meter data is shown in Figure 13.4.

The 2005 survey at Charlotte's Bay spanned a period of 22 days, and therefore captured a spring-neap cycle. An ADCP was positioned 1 m above the seabed, in a location with a water depth of 31 m (SAMS Research Services Ltd., 2006). Current data from Charlotte's Bay are summarised in table 13.1.

Mean current speeds at Charlotte's Bay are strongest at the sea surface than at the seabed. Current speeds showed some spring-neap variation at all depths, though this was most evident near the seabed. Current flows had a more strongly directional nature at mid-water depths than at both the sea surface and the seabed, and flowed along a north-easterly – south-westerly axis. While currents most frequently flowed in a north-westerly direction at the sea surface, currents flowed in all directions, and may have been influenced by two significant wind events which occurred during the survey. Near-bed currents were strongest in a north to north-westerly direction, but flowed more strongly in the opposite direction (south to south-easterly) two days following a strong wind event on the 24th of November.

Table 13.1 Charlotte's Bay current data measured in 2005

	Near-bed (3 m above seabed)	Mid-water (21 m above seabed)	Surface (29 m above seabed)
Mean Speed (ms^{-1})	0.0627	0.0552	0.0835
Maximum Speed (ms^{-1})	0.2370	0.2490	1.020
Principal Axis Amp & Dir (ms^{-1}) & (^oM)	0.0891 (096)	0.0870 (252)	0.1290 (265)
Residual speed (ms^{-1})	0.0104	0.0119	0.0264
Residual direction (^oM)	340.1	257.8	248.6

The 2009 survey at Oban Bay spanned a period of 15 days, and therefore captured a spring-neap cycle. Three Valeport current meters were deployed at a location with a water depth of 42.6 m, at depths of 2.0 m, 28.0 m, and 36.7 m above the seabed (Anderson Marine Surveys Ltd, 2010). Current data from Oban Bay are summarised in table 13.2.

Mean current speeds at Oban Bay are stronger at the sea surface than at the seabed. Current speeds showed some spring-neap variation at all depths, particularly in the east-west component. This variation was most pronounced near the seabed. Current speeds near the seabed flowed predominantly along an east

north-east to west south-west axis, while currents closer to the surface (at 21 m and 29 m above the seabed) had a stronger north-south component, flowing mainly along a north-east to south-west axis. This axis was in parallel to the adjacent coastline, and to the axis of the Sound of Kerrera.

Table 13.2 Oban Bay current data measured in 2009

	Near-bed (2 m above seabed)	Mid-water (28 m above seabed)	Surface (36.7 m above seabed)
Mean Speed (ms^{-1})	0.027	0.057	0.064
Maximum Speed (ms^{-1})	0.148	0.158	0.160
Principal Axis Amp & Dir (ms^{-1}) & (^oM)	0.047 (070)	0.085 (035)	0.093 (035)
Residual speed (ms^{-1})	0.017	0.009	0.009
Residual direction (^oM)	046	348	316

A wind meter was deployed during the Oban Bay 2009 current meter deployment. Strong winds above 10 ms^{-1} were only recorded on two of the 15 survey days, and average wind speeds generally averaged between 1.7 ms^{-1} and 5.5 ms^{-1}. Winds generally came from the south-west, along an axis parallel to that of the Sound of Kerrera.

Current meter data recorded in Oban bay in 1995 is in broad agreement with that of the 2009 survey. In both surveys, surface residual currents tend to flow with a westerly component, and at approximately 0.009 – 0.010 mm^{-1} (Scottish Association for Marine Science, 1996). However, maximum recorded current speeds were substantially greater in 2009, and may have been a result of local topography, though this is difficult to assess as no geographical coordinates were provided for the 1995 survey.

Current meter data from Charlotte's Bay suggests that this location is relatively well flushed. Its open nature and exposure to wave action within the Firth of Lorn suggests that dispersion may be rapid at this location. Sources of wave energy are from both short period waves generated within the Firth of Lorn and longer period swells originating from offshore. However, it is important to note that the nature of the current flows will vary significantly throughout the assessment area, particularly within the more enclosed Sound of Kerrera and Oban Bay. In these areas, flow over sills, around headlands, and around the numerous shallow and/or tidally exposed rocks is likely to enhance dispersion, and these areas may be less exposed to longer period swells.

Using the largest recorded mean surface principal current of 0.129 m s^{-1} and assuming a uniform sinusoidal tide, the cumulative transport that might be expected during each phase of the tide (approximately 6 hours) has been estimated for the

Isle of Kerrera assessment area as 1.8 km. No distinction is made here for springs and neaps.

13.2.4 River/Freshwater Inflow

No major rivers flow into the Isle of Kerrera assessment area. Several small streams flow into the assessment area from the surrounding hills on the mainland and from the island itself. There can be significant discharge into Oban Bay from the Black Lyne River. Though outside the assessment area, more substantial freshwater discharges from nearby sea lochs (e.g. Loch Etive, Loch Linnhe, Loch Creran, Loch Feochan) may influence the waters in and around the Isle of Kerrera assessment area.

Annual precipitation is approximately 1875 mm per year based on data for nearby Loch Feochan (Edwards & Sharples, 1986).

13.2.5 Meteorology

The meteorological station at Frackersaig Farm, Lismore is the nearest weather station and is situated approximately 10 km to the north of the fishery. Rainfall data was available for the period from January 2008 to November 2013 inclusive.

While 2010 generally had the lowest daily rainfall, the highest rainfall for this time period was recorded in 2011 (2354 mm). Very high rainfall events of > 40 mm d^{-1} occurred once in 2009, 2011, 2012 and 2013 while rainfall events of > 30 mm d^{-1} were recorded in all years. These rainfall events (>30 mm d^{-1}) occurred in all months but were much fewer in January, October and November. Daily rainfall values varied seasonally, and were generally lower in late spring and in the summer months (March - July) with the lowest of them being June and higher in winter months (October - December). For the duration of the dataset (2008-2013), daily rainfall below 1 mm occurred on 46% of days, while daily rainfall above 10 mm occurred on 17% of days.

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

Wind data were obtained from Tiree, located 86 km to the west of the assessment area. Given the distance between these two locations and varying topography, wind statistics may not be directly transferrable to the specific production area around the Isle of Kerrera. 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 south-southwest and west and the strongest winds tended to be from the south. Seasonally the strongest winds occurred during autumn and winter. Typically the wind came from around the south and west predominantly and in lesser proportion from the north and southeast,

throughout the year whilst the summer also saw winds from the north in a slightly higher proportion than in winter. Nevertheless, local wind direction on Kerrera are likely to be somewhat influenced by the surrounding topography.

13.2.6 Model Assessment

Due to the paucity of data for this location and the unconstrained nature of the study area, it was not considered appropriate to set up a box model run for the Kerrera assessment area.

13.3 Hydrographic Assessment

13.3.1 Surface Flow

The site and meteorological data indicate that the discharge of freshwater into the surface will be highly variable around the assessment area and seasonal. Therefore the role of freshwater is likely to be highly localised. A distinct freshwater layer may develop within Oban Bay, but otherwise it will probably be well mixed except under periods of calm and heavy rainfall. However, such a layer would probably be short-lived.

Kerrera and adjacent waters are relatively complex in terms of bathymetry and flow. Tidal flows are relatively fast and dispersion is likely to be high. From the current meter record in Charlotte Bay it is clear that the flow of water is variable in both speed and direction through the water column. The flow of water in shallow areas will be modified by the prevailing meteorological conditions, particularly when prevailing winds blow for prolonged periods. The cumulative transport distance on each phase (flood/ebb) of the tide has been estimated at around 1.8 km at the ADCP site in Charlotte Bay and 1.3 km at the ADCP site in Oban Bay.

The current meter data in Oban Bay are indicative of a variable surface layer that can be modified by wind. Deeper currents appear to follow the bathymetry as expected. However, there are numerous small bays in the sound of Kerrera, the largest in the assessment area is Ardentrive in the northeast of the Island of Kerrera. Here one might also expect eddies circulating within the bay. This will tend to retain any surface pollutants within the area.

Surface residual flows would be enhanced by prevailing winds from the southwest. Further residual flow will occur due to the asymmetry of flow through Oban Bay on the flood and ebb tides. Using the largest value of residual flow speed measured at the surface in Charlotte Bay (0.026 m/s), the net transport over a tidal cycle of approximately 12 hours would be around 1.1 km. In Oban Bay the equivalent residual flow over 12 hours would be around 0.5 km.

13.3.2 Exchange Properties

Tidal flow will dominate the exchange properties of the Kerrera assessment area. Given the open nature it is likely to have a very small flushing time. Even in Oban Bay it is likely that through flow of the tide will result in rather rapid flushing. The prevailing winds from the south west quadrant will enhance surface flushing rates.

It is expected that the Kerrera assessment area be a well flushed system throughout most of the year with surface contaminants being effectively dispersed in the residual flow.

There is just one data set available for a rather complex area. The paucity of additional hydrographic data renders the confidence level of this assessment as LOW.

14 Shoreline Survey Overview

The Sound of Kerrera shoreline survey was conducted on 8th and 15th December 2014. The survey was postponed after the first day due to unsafe weather conditions. Rainfall was recorded in the 48 hours prior to both survey days, though the survey days themselves were dry. Cockles were found at Ardantrive, however very few cockles were present at Slatrach Bay and no cockles were available at Oitir Mhòr Bay. However, it is noted that the local authority identified that the times recorded for the shoreline visit coincided with two hours past high tide, and therefore the cockles would not have been accessible. Two cockle samples were collected; one from Ardantrive (130 *E. coli* MPN/100 g) and the second from Slatrach Bay (140 *E. coli* MPN/100 g).

The Island of Kerrera was sparsely populated. A Scottish Sea Farms shore-base and static caravan were noted at Ardantrive. The area of mainland opposite to the island was developed with houses and holiday accommodation noted.. No campsites or caravan parks were observed. Four outfall pipes were noted along the south side of Kerrera. They included a dry metal pipe and a dry ceramic pipe from Mount Pleasant House, as well as a metal pipe and a plastic pipe that were submerged at the time of the survey. A composting toilet was also observed next to the ferry landing. A leaking manhole cover was noted near Kilbowie Outdoor Centre on the mainland. A freshwater sample taken of the overflow returned a result of 500,000 *E. coli* cfu/100 ml. A sailing boat and a fishing boat were seen at Ardantrive, near a slipway associated with Scottish Sea Farms shore-base. Mount Pleasant and Ardantrive Bay Marina contained 17 boats ashore, with a further 23 boats moored in the water. From the adjacent mainland, three sailing boats and six other boats were observed at sea and >50 moorings were visible.

Livestock were only observed on Kerrera, with 11 sheep and a goat noted on the southern shore, with >50 sheep and a cow in fields around Ardantrive farmhouse. Along the northern shoreline, three cows, a horse and 80 sheep were noted in fields at Slatrach Bay, 14 cows next to the shoreline were noted at Oitir Mhor Bay and two highland cattle on the shoreline were noted further east.

Kerrera Island appears to be mostly used for rough grazing with some lowland fields used for pasture. The land is steep in places with some rocky sections immediately next to the shore. The adjacent mainland area is also predominantly rough grazing with pockets of populated areas, particularly northeast in the large town of Oban.

Eleven watercourses were measured and sampled, with freshwater sample results varying between <10 and 810 *E. coli* cfu/100 ml. The highest result was from a sample taken at the unnamed watercourse at Slatrach Bay.

Birds were the most common wildlife observed during the survey. Common gulls were the most frequently observed bird species. Three European otters were also observed playing on the rocks south of Ardantrive.

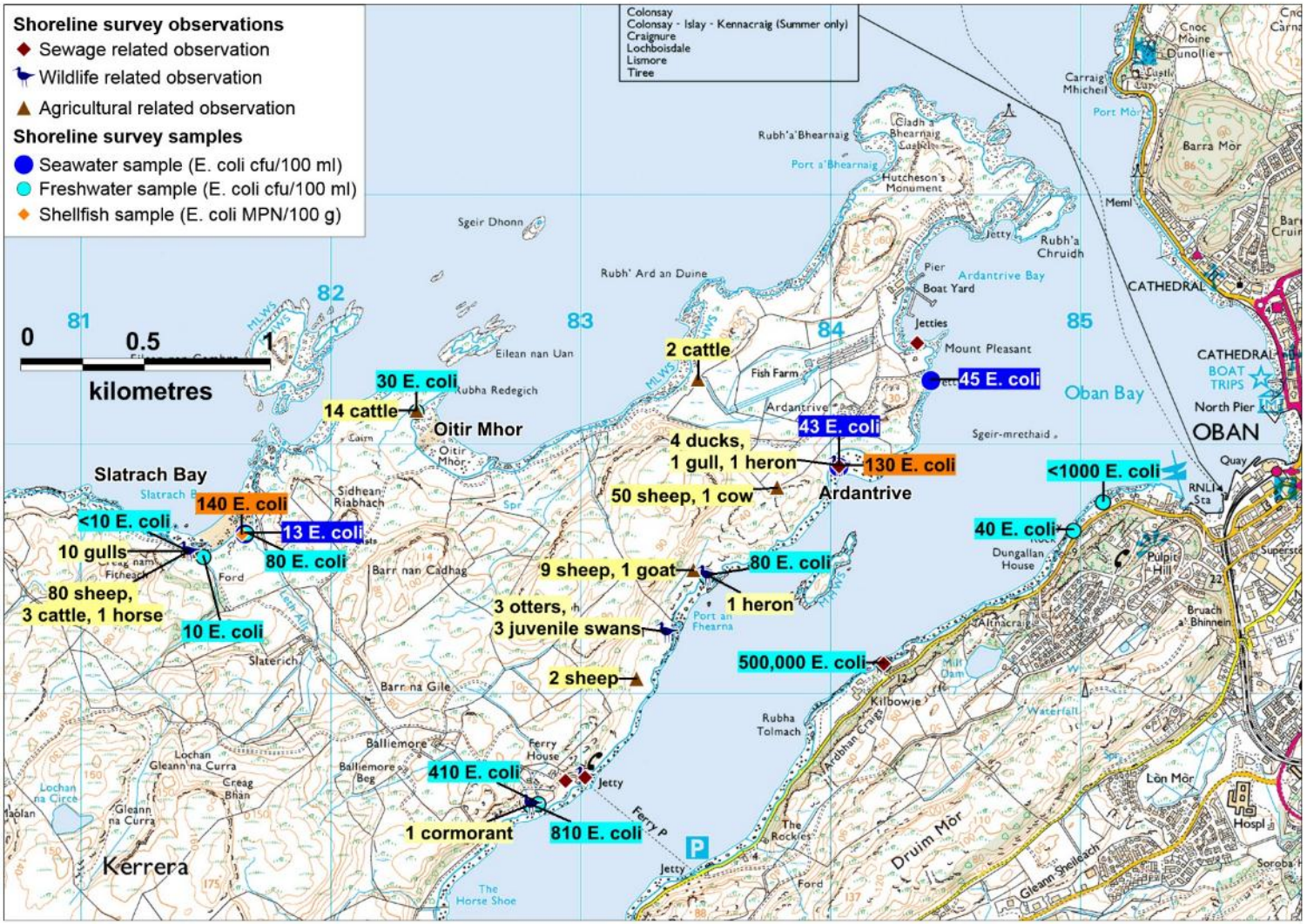


Figure 14.1 Map of shoreline survey observations at Sound of Kerrera

15 Bacteriological Survey

No bacteriological survey was planned for this area due to the uncertainty regarding locations and extents of exploitable cockle stocks.

16 Overall Assessment

Human sewage impacts

No sewage discharges were identified along the western side of the island where the Slatrach Bay and Oitir Mhor cockle beds are located. However, any discharges from boats servicing the fish farm or using the nearby anchorages could potentially contribute to contamination in the area.

The Ardantrive cockle bed, on the east side of the island, receives direct discharge of effluent from a small, private septic tank. It also lies on the Sound of Kerrera, which itself receives secondary treated effluent as well as any storm overflows from the Oban sewage network. The main outfall for Oban STW discharges approximately 1 km northeast of the cockle bed. The Dungallan Terrance Septic Tank also discharges to the sound, approximately 800 m south of the cockle bed. Of the three Kerrera sites, Ardantrive is likely to be the most impacted by these sources.

A number of small private discharges to sea are recorded near the northern end of the sound. Depending on the predicted movement of contaminants, they may contribute to background levels of contamination in the either the sound or along the west side of the island.

No direct sewage discharges were identified to the west side of the island. However, tour boats, yachts and commercial boats servicing the fish farm could all contribute to faecal contamination levels on this side of the island through overboard discharge of toilet waste. These sources are likely to arise closest to the Oitir Mhor bed and therefore may have a greater impact at this site, although there is an anchorage very near the Slatrach Bay bed.

Agricultural impacts

The northern part of the island is used for rough grazing, mainly of sheep. The largest concentrations of livestock were seen around Ardantrive and to the south of Slatrach Bay, where there are farms. Cattle had previously been seen on the beach at Ardantrive, and therefore there is the potential for direct impacts from livestock with beach access at this site.

Livestock are also kept on land on the east side of the Sound of Kerrera, though the main concentrations of these, based on satellite images, is to the south of the ferry crossing and therefore relatively distant from the cockle bed at Ardantrive.

Wildlife impacts

Small numbers of birds, mainly gulls, present in area. Nearest significant breeding colony at south end of island, seabirds likely to contribute to background levels.

Seal colony off Oitir Mhor is likely to contribute to faecal contamination levels at that site.

Seasonal variation

Seasonal variation is anticipated in the levels of faecal contamination on both sides of the island. Yachts are more likely to be present at the anchorages and at Oban Marina during the summer cruising season of May to September, and tour boats are also more likely to run frequently during this period.

Oban receives large numbers of tourists, and therefore seasonal variation in demand on the sewage network is anticipated. The overall population of the area, including visitors, is likely to be highest during the peak summer tourism months of July and August.

A seasonal increase in livestock numbers is expected, with higher numbers of animals likely to be present from spring through autumn.

Seasonal variation is seen in daily rainfall amounts, with lowest rainfall occurring in early summer and highest in autumn.

The Oitir Mhor production area is currently seasonally classified, and has generally received a lower classification (B or C) during the summer and autumn months, which is indicative of seasonal variations in results.

Rivers and streams

There is relatively little direct freshwater input to the cockle areas. Watercourses in the area are likely to carry diffuse faecal contamination from livestock, wildlife, and potentially human sources. The greatest impacts will be from those discharging directly across the cockle beds, with the Slatrach Bay and Oitir Mhor beds most affected in this manner. Of the two, the Slatrach Bay site receives output from a greater number of watercourses as well as the largest watercourse with the highest estimated loading. Loadings for all watercourses measured and sampled during the shoreline survey were low to moderate. The highest loadings were found in Leith Allt at Slatrach Bay and a watercourse discharging near the ferry landing on the east side of the island.

Movement of contaminants

Currents in Oban Bay and the Sound of Kerrera were predicted to differ from those found in the less constrained waters to the west of Kerrera. The waters on the west side of the island are likely to be more well flushed than those on the east side of it. Current movements inside the Sound of Kerrera were predicted be mainly along the axis of the sound, but more complex around headlands, small islands and bays. The maximum predicted transport distance on each phase of the tide is 1.6 km. This

suggests that direct contamination impacts are likely to come only from local sources, although sources beyond 1.6 km could potentially contribute to background contamination levels throughout the area. This would include sources outside the assessment area used for this survey, such as around the mouth of Loch Etive, Loch Creran and Loch Linnhe.

Temporal and geographical patterns of sampling results

No historical monitoring results were available for the cockle sites around Kerrera. The cockle samples taken to date have all come from Ganavan, approximately 4 km away from the nearest of the Kerrera cockle areas and which is subject to a separate sanitary survey. Therefore, these results were not considered sufficiently representative of conditions at the Kerrera sites.

Cockle samples taken during the shoreline survey from Slatrach Bay and Ardantrive returned similarly low results. No cockles were found at Oitir Mhor.

Conclusions

The principal potential sources of faecal contamination, as well as the factors affecting their circulation, differ between the west and east sides of the island. The Ardantrive site receives direct discharge of sewage from a small private septic tank, and is also relatively near the Oban STW discharge and Oban Marina. It is therefore anticipated to be more directly impacted by human sewage than the two sites on the west side of the island.

All three areas are likely to be affected by diffuse contamination from livestock sources.

17 Recommendations

Due to the differences in cockle availability and identified sources of contamination between the two sides of the island, it is recommended that two production areas be established: one for the west side of the island and incorporating the Slatrach Bay and Oitir Mhor beds and the other for the east side of the island and incorporating the Ardantrive bed. Boundaries and RMPs are shown mapped in Figure 17.1

Kerrera West

Production area

It is recommended that the Kerrera West production area be established with the following boundaries:

> The area bounded by lines drawn from NM 8028 2972 to NM 8182 3054 to NM 8421 7341 and extending to MHWS.

RMP

It is recommended that the RMP be established at the northeast end of the Slatrach Bay site, at NM 8162 2970. This lies nearest the main freshwater input to the bay.

Tolerance

A 75 m sampling tolerance is recommended to allow sufficient scope to obtain a sample, as this area had few cockles at the time of the shoreline survey.

Depth

Not applicable

Frequency

Monthly sampling is recommended.

Kerrera East

Production area

It is recommended that the Kerrera East production area be established with the following boundaries:

The area bounded by lines drawn from NM 8419 2987 to NM 8408 2964 to NM 8300 2846 to NM 8213 2713 to NM 8192 2719 extending to MHWS.

Due to the location of the cockle bed, it is not practical to exclude the identified septic tank outfall from the production area.

RMP

It is recommended that the RMP be established at NM 8404 2989, which will reflect sewage arising from the private discharge near that location.

Tolerance

A 50 m tolerance is recommended due to the small overall size of the bed and the higher number of cockles seen there during the shoreline survey.

Depth

Not applicable

Frequency

Monthly sampling is recommended.

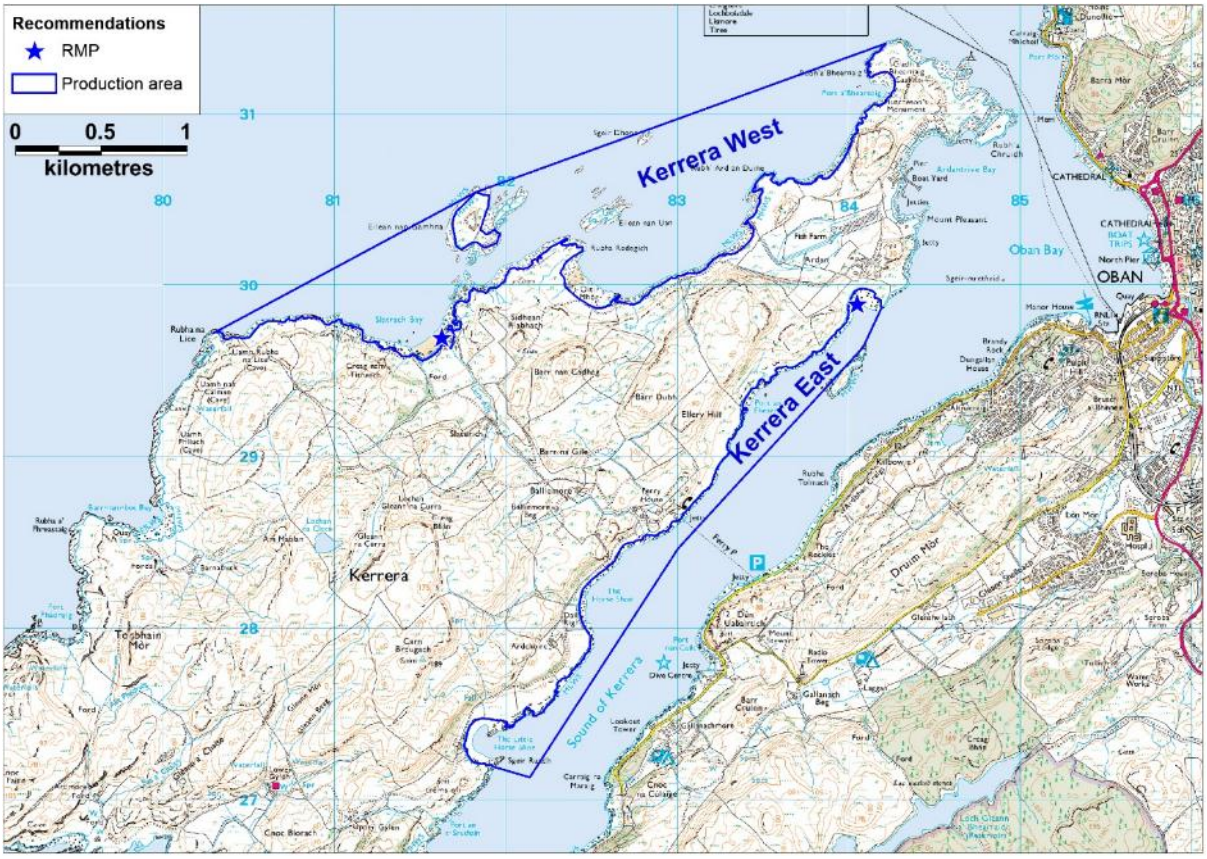


Figure 17.1 Map of recommendations at Isle of Kerrera Cockles

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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)

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3. Hydrographic Assessment Glossary

The following technical terms may appear in the hydrographic assessment.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4. Shoreline Survey Report

Shoreline Survey Report

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

Document Number	B0067_Shoreline 0045

Revision History

Revision	**Changes**	**Date**
A	Issue for internal review	08/01/2015
B	Second issue for internal review	12/01/2015
01	First official issue to Cefas	12/01/2015
02	Second official issue to Cefas	26/01/2015
03	Third official issue to Cefas	29/01/2015
	Name & Position	**Date**
Author	Eilidh Cole & Debra Brennan	08/01/2015
Checked	Andrea Veszelovszki	29/01/2015
Approved	Mark Hart	29/01/2015

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

Production area:	Kerrera Cockles
Site name:	Ardantrive
SIN:	AB-697-1513-16
Site name:	Oitir Mhor
SIN:	AB-697-1514-04
Site name:	Ballimore Cockles
SIN:	AB-697-1515-04
Existing RMP:	Not yet assigned

Species:	Common cockles
Harvester:	Douglas MacArthur
Local Authority:	Argyll & Bute Council
Status:	Awaiting classification
Date Surveyed:	08/12/2014 & 15/12/2014
Surveyed by:	Debra Brennan & Eilidh Cole

Area Surveyed

Approximately 3.5 km of the southwest shoreline of Kerrera was surveyed beginning from the ferry port at Slatrach Bay heading north to end at Mount Pleasant. This was followed by approximately 3 km of shoreline on the northwest shoreline beginning at Slatrach Bay and heading north reaching just south of Rubh' Ard an Duine. These two shoreline sections were interlinked by approximately 1 km inland towards the northeast of the island at Ardantrive.

A short section of approximately 1 km was also surveyed on the western shoreline of the mainland between Dungallan House and the Kilbowie Outdoor Centre, southwest of Oban.

Weather

Rainfall was recorded 48 hours prior to both the first and second survey days.

The first survey day was dry but cold with temperatures of around 3°C and a light south-westerly breeze. It was overcast with cloud cover of 90%. The sea state was calm.

The second day of the survey was also dry and cold with temperatures of around 4°C. Cloud cover was around 50% and there was a light westerly breeze with a calm sea state.

It should be noted here that there was a period of a week between survey days due to extremely stormy weather and gale force winds preventing access to the island of Kerrera during this period of time.

Stakeholder engagement during the survey

Prior to the survey, the sampling officer Mr Ewan MacDougall was very helpful and provided useful information regarding the survey site and fishery. Unfortunately the survey team were unable to meet with Mr MacDougall during the course of the survey.

The harvester for the area, Mr Douglas MacArthur, was also contacted prior to the survey and was helpful in providing information about his shellfishery area. Unfortunately the survey team were unable to meet with Mr MacArthur during the course of the survey.

Fishery

The survey plan listed the following three sites; Ardantrive, SIN: AB-697-1513-16; Oitir Mhor, SIN: AB-697-1514-04 and Ballimore Cockles, SIN: AB-697-1515-04. Unfortunately it was not possible to determine the exact location of these sites.

Common cockles (*Cerastroderma edule*) are harvested at the three sites listed above. A cockle sample was collected from the site on the southeast shoreline of Kerrera at waypoint 14 near Ardantrive. A further cockle sample was collected at waypoint 34 at Slatrach Bay on the northwest side of Kerrera although there were very few cockles here and little evidence of shells. The third and final cockle sample was required to be collected at the bay at Oitir Mhòr, also on the northwest side of the island, but there were insufficient numbers available and only two cockles were found.

Sewage Sources

The island of Kerrera is sparsely populated with only a few dwellings scattered across the island and no septic tanks were observed throughout the course of the survey. The short section of shoreline surveyed on the mainland between Dungallan House and the Kilbowie Outdoor Centre is more heavily populated with houses, restaurants and guesthouses the length of this section of shoreline.

Several pipes were observed however only one pipe at waypoint 21 had any flow and this was sampled. Two pipes were observed leading out to sea at

waypoints 6 and 12 and broken pipes with no discharge were observed at waypoints 16, 20 and 23. A seeping manhole cover was sampled at waypoint 27 near to the Kilbowie Outdoor Centre and it appeared to be leaking raw sewage.

A compost toilet was observed on Kerrera just next to the jetty at the ferry landing but no other public facilities were seen nor were any cafés or restaurants observed on Kerrera.

Seasonal Population

No official campsites or caravan parks were seen on the island of Kerrera or the section of mainland survey. However, a few hotels and B&Bs were observed along the section of mainland surveyed but not on Kerrera. Several dwellings were also observed along the mainland section which could also have included holiday lets.

Boats/Shipping

A passenger ferry runs a regular service throughout the day at the southernmost point of the survey area, close to waypoint 1. Two speed boats were in the water close to the ferry. The Calmac ferry route to the island of Colonsay runs along the southeast shore of Kerrera and the Calmac ferry route to Mull and surrounding islands passes by the north and northwest shores of Kerrera (Fig 12). One sailing boat and one fishing boat were in the water close to waypoint 16. There is a boatyard and marina at Ardantrive Bay and on the first day of the survey there were seventeen boats moored on land and twenty three boats in the water, waypoint 19 (Fig 7). On the mainland side of the survey area, close to waypoint 25, there were three sailing boats and six other boats in the water. More than fifty moorings were visible.

Farming and Livestock

There were two sheep seen at waypoint 7, and a further nine sheep and one wild goat were observed at waypoint 9. In the fields surrounding Ardantrive farmhouse, one cow and more than fifty sheep were counted. On the north shore of the island, close to waypoint 30, one horse, three cows and approximately eighty sheep were observed scattered across the hillside. There were fourteen cows next to the shore at waypoint 41 and two highland cows at waypoint 49 (Fig 13).

Land Use

The survey area of the Island of Kerrera appears to be mostly used for rough grazing with some lowland fields used for pasture (Fig 4). There is no evidence of forestry and dwellings are few and very scattered.

Land Cover

The predominant land cover of Kerrera is rough pasture with lowland fields. The land is steep in places with rocky sections immediately next to the shore.

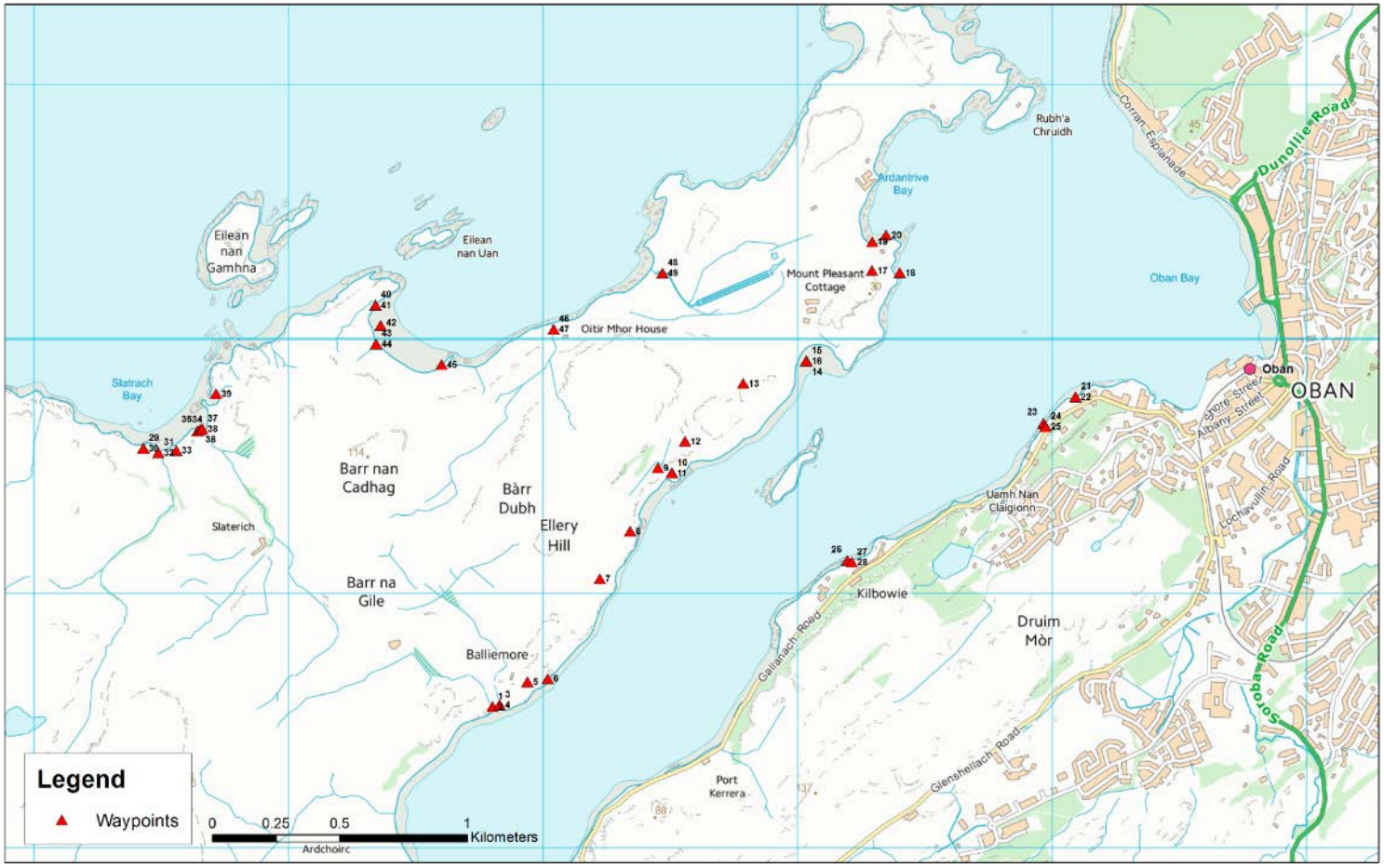
Watercourses

Ten watercourses were marked on the survey map to be sampled during the course of the survey. All watercourses were unnamed with the exception of Leth Allt at waypoint 37. All ten of the watercourses were located and sampled. An extra three unplanned samples were taken at the following sites: waypoint 21, sample taken from a pipe with a significant flow onto the shore (Fig 9); waypoint 27, sample taken from a manhole cover which was overflowing and running onto shore (Fig 10) and waypoint 29, sample taken from a watercourse which was 1.66 m in width.

Wildlife/Birds

One cormorant (*Phalacrocorax carbo*) was observed perched on a buoy at waypoint 2 and one rock pipit (*Anthus spinoletta*) was seen on the shore at waypoint 6. Three European otters (*Lutra lutra*) were playing on the rocks by the shore at waypoint 8 before entering the water and there were three juvenile mute swans (*Cygnus olor*) on the water. One grey heron (*Ardea cinerea*) was observed in the water at waypoint 11. Four mallards (*Anas platyrhynchos*), one common gull (*Larus canus*) and one grey heron were observed in the water at waypoint 16. There were ten common gulls on the rocks at waypoint 30.

Specific observations made during the survey are mapped in Figure 1 and listed in Table 1. Water and shellfish samples were collected at the locations marked on Figure 2. Bacteriology results are given in Tables 2 and 3. Photographs are presented in Figures 3 – 13.



Contains Ordnance Survey data © Crown Copyright and Database right (2015).

Figure 1. Kerrera Cockles waypoints.

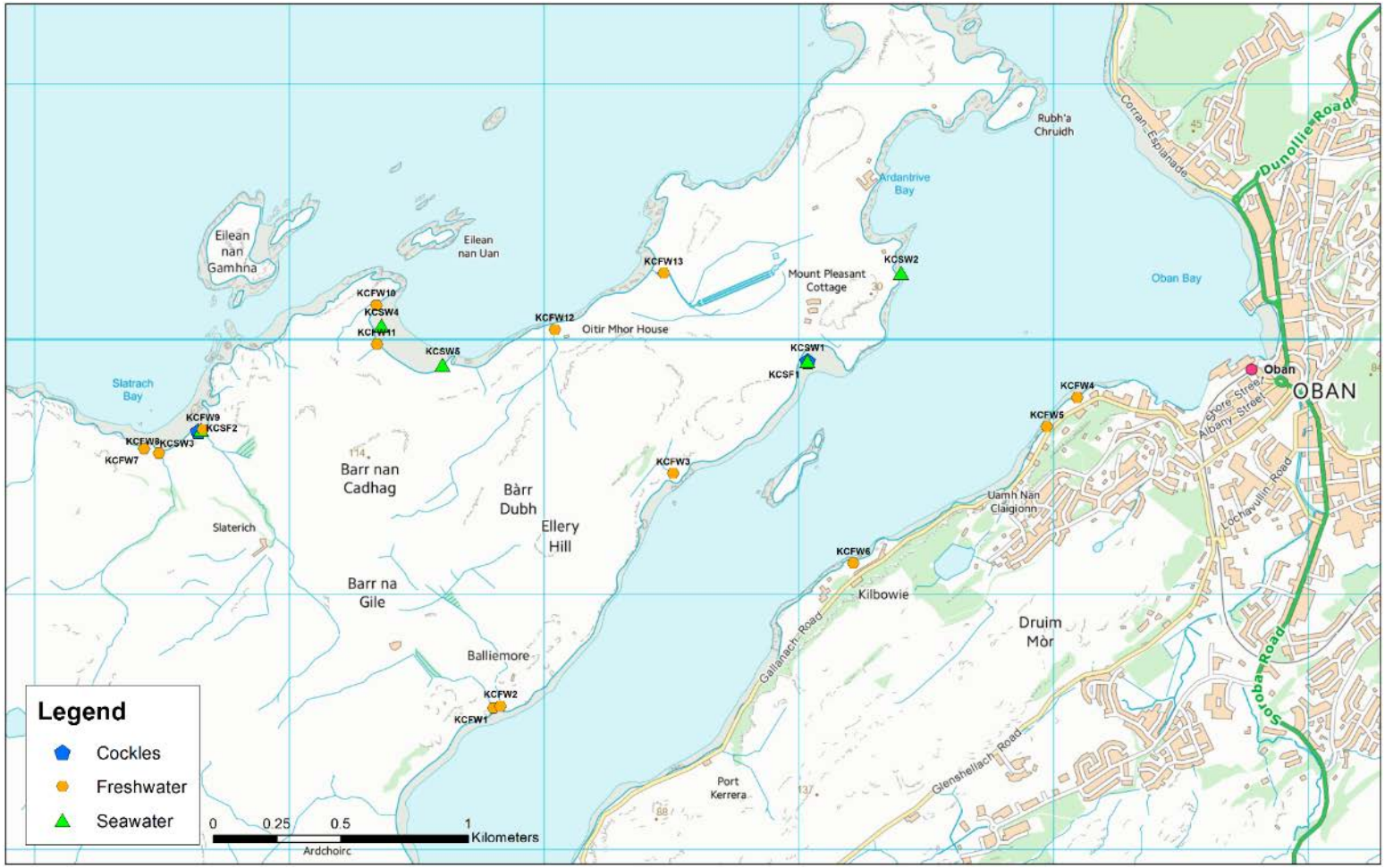


Figure 2. Kerrera Cockles samples.

Table 1 Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	08/12/2014	10:48	NM 82801 28554	182801	728555		KCFW1	Planned freshwater sample taken from unnamed watercourse below houses.
2	08/12/2014	10:48	NM 82801 28554	182801	728555			Associated with waypoint 1. Width - 97 cm; Depth - 11 cm; Flow - 0.677 m/s; SD - 0.014. Two houses on shore above watercourse. One powerboat on shore. One cormorant on mooring buoy.
3	08/12/2014	10:56	NM 82829 28562	182829	728562		KCFW2	Planned freshwater sample from unnamed watercourse.
4	08/12/2014	10:56	NM 82829 28562	182829	728562			Associated with waypoint 3. This watercourse very close in proximity to watercourse at waypoint 1. Width - 1 m 23 cm; Depth - 14 cm; Flow - 0.417 m/s; SD - 0.011.
5	08/12/2014	11:05	NM 82939 28653	182939	728653	Fig 3		Ferry landing. One compost toilet next to shore. Two speed boats on water and one smaller boat on shore out of water. Three buoys out at sea.
6	08/12/2014	11:10	NM 83018 28665	183018	728666			Long metal pipe with several joins leading out to sea. One rock pipit on shore.
7	08/12/2014	11:20	NM 83222 29057	183223	729058			Two sheep on shore.
8	08/12/2014	11:27	NM 83342 29244	183343	729245			Three otters and three juvenile swans on shoreline.
9	08/12/2014	11:38	NM 83450 29493	183451	729494			Nine sheep and one goat on grassy shore.
10	08/12/2014	11:41	NM 83505 29474	183506	729474		KCFW3	Planned freshwater sample from small unnamed watercourse.
11	08/12/2014	11:41	NM 83505 29473	183506	729473			Associated with waypoint 10. Small river. Width - 57 cm; Depth - 14 cm; Flow - 0.052 m/s; SD - 0.003. One heron on shore.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
12	08/12/2014	11:54	NM 83558 29598	183558	729598			Slim blue pipe leading from a wooden shed to shore and into sea.
13	08/12/2014	12:02	NM 83786 29824	183787	729825			More than fifty sheep and one cow in field next to farmhouse.
14	08/12/2014	12:11	NM 84034 29914	184035	729915	Fig 4	KCSF1	Cockle sample from small bay on SE side of island, south of Ardantrive Bay.
15	08/12/2014	12:17	NM 84033 29913	184034	729914	Fig 4	KCSW1	Seawater sample from bay on SE side of island.
16	08/12/2014	12:17	NM 84033 29913	184034	729914	Fig 4/Fig 5		Four mallard ducks and one common gull on water. One heron on rocks close to shore. One sailing boat and one fishing boat on water. One metal pipe, no flow. Litter and debris on beach.
17	08/12/2014	12:44	NM 84292 30268	184293	730269			Scottish Sea Farms station with slipway. One static caravan next to station.
18	08/12/2014	12:54	NM 84401 30260	184402	730260	Fig 6	KCSW2	Seawater sample from jetty.
19	08/12/2014	13:15	NM 84293 30382	184293	730382	Fig 7		Mount Pleasant and Ardantrive Bay Marina. Seventeen boats moored out of water and twenty three boats in the water.
20	08/12/2014	13:17	NM 84347 30408	184348	730408	Fig 8		20 cm diameter ceramic pipe with Mount Pleasant House on shore behind. No flow.
21	08/12/2014	14:19	NM 85092 29771	185093	729772	Fig 9	KCFW4	Unplanned freshwater sample from pipe.
22	08/12/2014	14:23	NM 85091 29772	185091	729773			Associated with waypoint 21. PVC pipe diameter - 11 cm; Water width - 4 cm; Depth - 2 cm; Flow estimated using bucket, flow 250ml/s.
23	08/12/2014	14:36	NM 84965 29668	184966	729668			Broken disused metal pipe leading into sea.
24	08/12/2014	14:38	NM 84974 29657	184974	729657		KCFW5	Planned freshwater sample from unnamed watercourse.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
25	08/12/2014	14:39	NM 84973 29655	184974	729656			Associated with waypoint 24. Width - 53 cm; Depth - 10 cm; Flow - 0.110 m/s; SD - 0.018. Three sailing boats and six other boats at sea. More than fifty moorings visible.
26	08/12/2014	14:54	NM 84196 29129	184196	729129			Kilbowie Outdoor Centre. Approximately 10 houses on shore.
27	08/12/2014	14:58	NM 84213 29122	184213	729122		KCFW6	Unplanned contaminated freshwater sample from leaking manhole.
28	08/12/2014	14:58	NM 84213 29122	184213	729123	Fig 10		Associated with waypoint 27. Raw sewage leaking from manhole cover on ground, no flow able to be measured.
29	15/12/2014	11:09	NM 81430 29570	181430	729571	Fig 11	KCFW7	Unplanned freshwater sample from unnamed watercourse.
30	15/12/2014	11:10	NM 81428 29570	181429	729570			Associated with waypoint 29. Watercourse width -1 m 66 cm; Depth - 9 cm; Flow - 0.298 m/s; SD - 0.015. Watercourse located on the north side of island at Slatrach Bay. Three cows, one horse and approximately eighty sheep in various fields along the hillside. Ten gulls on rocks next to sea.
31	15/12/2014	11:22	NM 81488 29553	181489	729553		KCFW8	Planned freshwater sample from unnamed watercourse.
32	15/12/2014	11:22	NM 81488 29553	181489	729553			Associated with waypoint 31. Freshwater sample taken from small watercourse. Width -1 m 2 cm; Depth - 15 cm; Flow - 0.518 m/s; SD - 0.064.
33	15/12/2014	11:30	NM 81558 29562	181559	729563			Very small watercourse less than 1 m in width so not sampled.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
34	15/12/2014	12:13	NM 81642 29639	181643	729639		KCSF2	Cockle sample taken from Slatrach Bay. Very difficult to find any cockles. Not much evidence of cockle shells either.
35	15/12/2014	12:15	NM 81643 29640	181643	729640	Fig 12		Calmac ferry passing by.
36	15/12/2014	12:18	NM 81653 29644	181654	729644		KCSW3	Seawater sample from Slatrach Bay.
37	15/12/2014	12:20	NM 81660 29646	181661	729647		KCFW9	Planned freshwater sample from watercourse named Leth Allt.
38	15/12/2014	12:20	NM 81661 29647	181661	729647			Associated with waypoint 37. Watercourse width - 2 m 70 cm; Depth - 16 cm; flow - 0.516 m/s; SD - 0.013.
39	15/12/2014	12:34	NM 81715 29784	181715	729785			Very small burn less than 1 m in width so not sampled.
40	15/12/2014	13:03	NM 82341 30133	182342	730133		KCFW10	Planned freshwater sample from small unnamed watercourse.
41	15/12/2014	13:03	NM 82341 30133	182342	730133			Associated with waypoint 40. Watercourse width - 97 cm; Depth - 8 cm; Flow - 0.272 m/s; SD - 0.008. Fourteen cows next to shore and not in field.
42	15/12/2014	13:55	NM 82362 30054	182362	730054		KCSW4	Planned seawater sample from Oitir Mhòr. No cockles found.
43	15/12/2014	14:00	NM 82344 29981	182344	729981		KCFW11	Planned freshwater sample from small unnamed watercourse.
44	15/12/2014	14:00	NM 82344 29981	182344	729981			Associated with waypoint 43. Watercourse width - 32 cm; Depth - 30 cm; Flow - 0.114 m/s; SD - 0.003.
45	15/12/2014	14:05	NM 82601 29899	182601	729899		KCSW5	Planned seawater sample from Oitir Mhòr. No cockles found.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
46	15/12/2014	14:19	NM 83042 30038	183042	730038		KCFW12	Planned freshwater sample from small unnamed watercourse.
47	15/12/2014	14:19	NM 83042 30038	183042	730038			Associated with waypoint 46. Watercourse width - 38 cm; Depth - 8 cm; Flow - 0.553 m/s; SD - 0.016.
48	15/12/2014	14:30	NM 83469 30259	183469	730259		KCFW13	Planned freshwater sample from unnamed watercourse.
49	15/12/2014	14:30	NM 83469 30259	183469	730259	Fig 13		Associated with waypoint 48. Watercourse width - 1 m 5 cm; depth - 32 cm; Flow - 0.181 m/s; SD - 0.035. Two highland cows on shore. One house next to river.

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

Sampling

Seawater and freshwater samples were collected at the sites marked in Figure 2. All planned freshwater and seawater samples were obtained. Three extra freshwater samples were also taken at waypoints 21, 27 and 29 and were named KCFW4, KCFW6 and KCFW7 respectively.

Common cockle samples were obtained from a small embayment south of Ardantrive Bay at waypoint 14 and at Slatrach Bay at waypoint 34. The survey team found it difficult to obtain the requested number of cockles for testing at Slatrach bay and only 15 cockles were collected instead of the recommended minimum number of 30. At the bay at Oitir Mhor only two cockles were found after extensive searching by the team. This may be because of the state of the tide which was quite high for the week that this area was surveyed. No samples were sent for testing from this site (waypoint 45).

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 freshwater samples, seawater samples and shellfish samples were received by GSS within 24 hours of collection. The sample temperature on arrival at GSS was 2.1°C for the samples received on the 09/12/2014 and 4.9°C for the samples received on the 16/12/2014.

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

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

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (cfu/100ml)	Salinity (ppt)
1	08/12/2014	KCFW1	NM 82801 28554	Freshwater	810	-
2	08/12/2014	KCFW2	NM 82829 28562	Freshwater	410	-
3	08/12/2014	KCFW3	NM 83505 29474	Freshwater	80	-
4	08/12/2014	KCFW4	NM 85092 29771	Freshwater	<1000	-
5	08/12/2014	KCFW5	NM 84974 29657	Freshwater	40	-
6	08/12/2014	KCFW6	NM 84213 29122	Freshwater	500000	-
7	15/12/2014	KCFW7	NM 81430 29570	Freshwater	<10	-
8	15/12/2014	KCFW8	NM 81488 29553	Freshwater	10	-
9	15/12/2014	KCFW9	NM 81660 29646	Freshwater	80	-
10	15/12/2014	KCFW10	NM 82341 30133	Freshwater	30	-
11	15/12/2014	KCFW11	NM 94711 10697	Freshwater	<10	-
12	15/12/2014	KCFW12	NM 94600 10729	Freshwater	<10	-

No.	Date	Sample	Grid Ref	Type	E. coli (cfu/100ml)	Salinity (ppt)
13	15/12/2014	KCFW13	NM 94600 10729	Freshwater	<10	-
14	08/12/2014	KCSW1	NM 84033 29913	Seawater	43	33.24
15	08/12/2014	KCSW2	NM 84401 30260	Seawater	45	33.24
16	15/12/2014	KCSW3	NM 81653 29644	Seawater	13	26.92
17	15/12/2014	KCSW4	NM 94708 10708	Seawater	13	24.57
18	15/12/2014	KCSW5	NM 94709 10696	Seawater	5	20.05

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	Sample depth (m)	E. coli (MPN/100g)
1	08/12/2014	KCSF1	NM 84034 29914	Cockles	surface	130
2	15/12/2014	KCSF2	NM 81642 29639	Cockles	surface	140

Salinity Profiles

No CTD profiles were taken as cockles were collected from the shore.

Photographs – Kerrera Cockles

Fig 3. Ferry landing with compost toilet next to shore. Associated with waypoint 5.

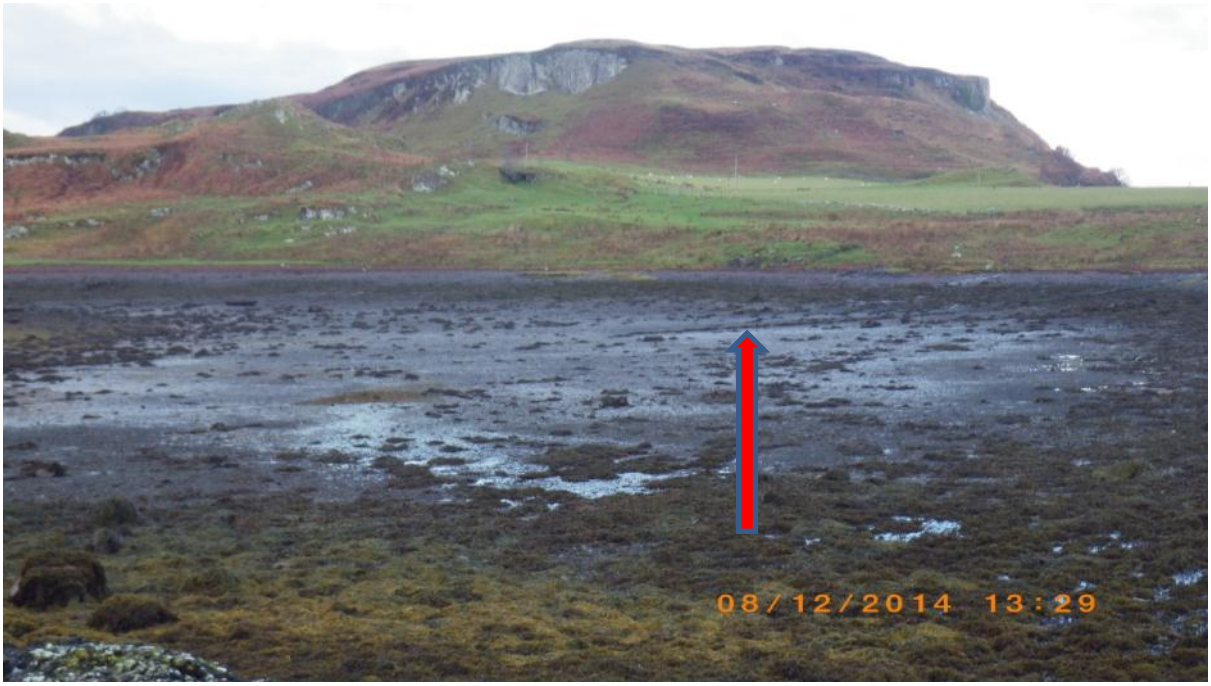


Fig 4. Bay where cockle samples were obtained associated with waypoints 14-16. Red arrow shows pipe on shore, no flow observed.

Fig 5. Debris on shore associated with waypoint 16.

Fig 6. View across the water from waypoint 18 looking towards the town of Oban. Associated with seawater sample KCSW2.

Fig 7. Marina at Ardantrive Bay associated with waypoint 19.

Fig 8. House at Mount Pleasant with pipe onto shore, no flow was observed, associated with waypoint 20.

Fig 9. Pipe discharging water onto shore, unplanned freshwater sample KCFW4 taken, associated with waypoint 21.

Fig 10. Houses at Dungallan Terrace with overflowing manhole. Insert shows raw sewage around manhole cover. Associated with waypoint 28 and location of contaminated freshwater sample KCFW6.

Fig 11. Unplanned freshwater sample taken from watercourse. Associated with waypoint 29 and location of freshwater sample KCFW7.

Fig 12. Calmac ferry route passing northeast of survey area. Associated with waypoint 35.

Fig 13. Highland cow grazing close to shore. Associated with waypoint 49.

5. SEPA Discharge Consents

Licence No.	NGR	Discharge Type	Discharges to	Op	PE
CAR/L/1003316	NM 86052 32694	Sewage (Private) Primary	Ganavan Bay	=	100
CAR/R/1009285	NM 84511 30847	Sewage (Private) Primary	Ardantrive Bay	=	6
CAR/R/1010988	NM 87540 29880	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1013629	NM 85399 32030	Sewage (Private) Primary	Firth of Lorn	=	5
CAR/R/1014140	NM 85380 32040	Sewage (Private) Primary	Firth of Lorn	=	5
CAR/R/1014557	NM 85370 32080	Sewage (Private) Primary	Camas Ban	=	5
CAR/R/1014806	NM 85335 31871	Sewage (Private) Primary	Firth of Lorn	=	5
CAR/R/1015011	NM 88140 29580	Sewage (Private) Primary	Land	=	12
CAR/R/1015462	NM 85840 28304	Sewage (Private) Primary	U/T of Scroba Burn	=	5
CAR/R/1016245	NM 85412 31935	Sewage (Private) Primary	Soakaway	=	8
CAR/R/1016811	NM 85340 31760	Sewage (Private) Primary	Land	=	18
CAR/R/1020698	NM 84326 28053	Sewage (Private) Secondary	Soakaway	=	14
CAR/R/1022555	NM 88690 29790	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1022604	NM 84666 29214	Sewage (Private) Primary	Soakaway	=	10
CAR/R/1022606	NM 87532 29912	Sewage (Private) Primary	Soakaway	=	6
CAR/R/1022607	NM 84750 29250	Sewage (Private) Primary	U/T of Sound of Kerrera	=	5
CAR/R/1024633	NM 87487 30028	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1028139	NM 86220 32270	Sewage (Private) Primary	Soakaway	=	7
CAR/R/1028813	NM 87480 29930	Sewage (Private) Primary	Soakaway	=	7
CAR/R/1030773	NM 87940 30721	Sewage (Private) Primary	Alltan Tartach	=	5
CAR/R/1034129	NM 84540 30890	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1035111	NM 88987 29975	Sewage (Private) Secondary	U/T of Dig Bharrain	=	6
CAR/R/1037061	NM 84680 29110	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1037182	NM 88090 29500	Sewage (Private) Primary	Soakaway	=	16
CAR/R/1037183	NM 86099 32313	Sewage (Private) Primary	U/T of Firth of Lorn	=	5
CAR/R/1037184	NM 88126 29559	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1037276	NM 87381 30073	Sewage (Private) Primary	Soakaway	=	6
CAR/R/1037395	NM 87397 30055	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1037465	NM 85370 32060	Sewage (Private) Primary	Firth of Lorn	=	5
CAR/R/1037561	NM 86109 31095	Sewage (Private) Primary	Soakaway	=	8
CAR/R/1037716	NM 87910 29920	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1037726	NM 85380 28990	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1037975	NM 85740 32540	Sewage (Private) Primary	Firth of Lorn	=	5
CAR/R/1037979	NM 86133 32261	Sewage (Private) Primary	Soakaway		5
CAR/R/1037980	NM 86111 32296	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1037981	NM 86067 32305	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1038157	NM 85740 32540	Sewage (Private) Primary	Firth of Lorn	=	10
CAR/R/1038198	NM 86133 32261	Sewage (Private) Primary	Soakaway	=	10
CAR/R/1038203	NM 82433 28789	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1038218	NM 86100 32340	Sewage (Private) Primary	Soakaway	=	10
CAR/R/1038224	NM 86126 32389	Sewage (Private) Primary	Soakaway	=	10
CAR/R/1038246	NM 79581 27030	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1038293	NM 84043 29958	Sewage (Private) Primary	Sound of Kerrera	=	10
CAR/R/1038294	NM 84060 30070	Sewage (Private) Primary	Soakaway	=	5

Licence No.	NGR	Discharge Type	Discharges to	Op	PE
CAR/R/1038302	NM 87650 30280	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1038417	NM 86150 32460	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039308	NM 85340 31870	Sewage (Private) Primary	Camas Ban	=	6
CAR/R/1039448	NM 86596 29768	Sewage (Private) Primary	U/T of Alltan Tartach	=	5
CAR/R/1039477	NM 87599 30607	Sewage (Private) Primary	Land	=	5
CAR/R/1039611	NM 85640 32390	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039613	NM 82782 28664	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039616	NM 82890 28670	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039618	NM 86430 31640	Sewage (Private) Primary	Soakaway	=	10
CAR/R/1039620	NM 85300 31610	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039624	NM 85300 31620	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039627	NM 85475 32067	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039630	NM 85590 32190	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039635	NM 81060 26868	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039637	NM 80885 26348	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039639	NM 81704 27322	Sewage (Private) Primary	Soakaway	=	10
CAR/R/1039677	NM 82360 28740	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039678	NM 82290 28680	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039679	NM 80170 28340	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1039680	NM 81890 29170	Sewage (Private) Primary	Soakaway	=	10
CAR/R/1039686	NM 80650 27060	Sewage (Private) Primary	Soakaway	=	20
CAR/R/1039984	NM 86619 29730	Sewage (Private) Primary	Alltan Tartach	=	6
CAR/R/1040504	NM 87610 29890	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1040753	NM 89050 29710	Sewage (Private) Primary	Soakaway	<=	20
CAR/R/1041588	NM 87948 30262	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1046285	NM 85880 28445	Sewage (Private) Primary	Soroba Burn	=	5
CAR/R/1057525	NM 85901 28444	Sewage (Private) Primary	Soroba Burn	=	5
CAR/R/1076356	NM 85820 28460	Sewage (Private) Primary	Soakaway	=	8
CAR/R/1076615	NM 85832 28372	Sewage (Private) Primary	Soakaway	=	10
CAR/R/1079227	NM 88960 30120	Sewage (Private) Primary	Soakaway	=	6
CAR/R/1081644	NM 84860 30860	Sewage (Private) Primary	Sound of Kerrera	=	6
CAR/R/1082582	NM 88680 29981	Sewage (Private) Secondary	Soakaway	=	15
CAR/R/1083790	NM 87309 30112	Sewage (Private) Secondary	Alltan Tartach	=	5
CAR/R/1085372	NM 86402 31330	Sewage (Private) Primary	UN/WC	=	5
CAR/R/1086857	NM 84464 27951	Sewage (Private) Primary	UN/WC	=	13
CAR/R/1086894	NM 82810 27430	Sewage (Private) Untreated	Sound of Kerrera	=	5
CAR/R/1093903	NM 82734 28666	Sewage (Private) Primary	U/T of Sound of Kerrera	=	8
CAR/R/1094673	NM 88674 29715	Sewage (Private) Secondary	U/T of Dig Bharrain	=	8
CAR/R/1095399	NM 85225 31364	Sewage (Private) Primary	Oban Bay	=	13
CAR/R/1095791	NM 81731 27368	Sewage (Private) Primary	Soakaway	=	10
CAR/R/1095871	NM 81130 26940	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1097470	NM 84822 29382	Sewage (Private) Primary	UN/WC	=	5
CAR/R/1099103	NM 87310 30430	Sewage (Private) Primary	Soakaway	=	10
CAR/R/1102753	NM 88916 29933	Sewage (Private) Secondary	U/T of Dig Bharrain	=	5
CAR/R/1106852	NM 88900 29620	Sewage (Private) Primary	Soakaway	=	8
CAR/R/1108005	NM 88130 29490	Sewage (Private) Secondary	UN/WC	=	5

Licence No.	NGR	Discharge Type	Discharges to	Op	PE
CAR/R/1113552	NM 85370 32080	Sewage (Private) Primary	Camas Ban	=	5
CAR/R/1113758	NM 88360 29450	Sewage (Private) Primary	Soakaway	=	10
CAR/R/1114293	NM 86644 29742	Sewage (Private) Secondary	Allt Tartach	=	15
CAR/R/1117804	NM 83190 27590	Sewage (Private) Secondary	Soakaway	=	10
CAR/S/1107891	NM 83080 27560	Sewage (Private) Tertiary	Soakaway	<=	25
CAR/L/1003475	NM 85185 30824	Sewage (Public) Secondary	Oban Bay	=	13597
CAR/L/1026157	NM 84810 29460	Sewage (Public) Combined Sewer Overflow (CSO)			0
CAR/L/1026157	NM 85623 30556	Sewage (Public) Combined Sewer Overflow (CSO)			0
CAR/L/1026157	NM 85795 29907	Sewage (Public) Combined Sewer Overflow (CSO)			0
CAR/L/1026157	NM 86818 29881	Sewage (Public) Combined Sewer Overflow (CSO)			0
CAR/L/1000889	NM 85920 32590	Sewage (Public) Emergency Overflow (EO)			0
CAR/L/1026157	NM 85920 32590	Sewage (Public) Emergency Overflow (EO)			0
CAR/L/1026157	NM 85508 29727	Sewage (Public) Combined Sewer Overflow (CSO)			0
CAR/L/1026157	NM 85793 30010	Sewage (Public) Combined Sewer Overflow (CSO)			0
CAR/L/1026157	NM 85871 30609	Sewage (Public) Combined Sewer Overflow (CSO)			0
CAR/L/1026157	NM 86044 29338	Sewage (Public) Combined Sewer Overflow (CSO)			0
CAR/L/1026157	NM 86413 28473	Sewage (Public) Combined Sewer Overflow (CSO)			0

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