Scottish Sanitary Survey Project

Sanitary Survey Report

Cidhe Eolaigearraidh

UB 427

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Cefas

FOOD STANDARDS AGENCY SCOTLAND

Buidheann Inbhe-Bìdhe an Alba

Final Report Distribution – Cidhe Eolaigearraidh

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* Distribution of both draft and final reports to relevant agency personnel is undertaken by FSAS.

** Distribution of draft and final reports to harvesters in undertaken by the relevant local authority.

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1. General Description

Cidhe Eolaigearraidh is located at the north end of the island of Barra, the most southerly of the Outer Hebrides. It is located on a sandy beach next to a shallow channel between Barra and the island of Fuday. A sanitary survey was undertaken at this site in response to a standard application for classification of the area for Pacific and native oysters and for common mussels.

Figure 1.1 Location of Cidhe Eolaigearraidh

2. Fishery

The harvester identified that the fishery at Cidhe Eolaigearraidh will eventually consist of Pacific and native oysters and mussels grown in bags on trestles.

Table 2.1. Cidhe Eolaigearraidh shellfish farms

Production Area	Site	SIN	Species
Cidhe Eolaigearraidh	Sound of Barra	UB 427 830 13	P. oyster
Cidhe Eolaigearraidh	Sound of Barra	UB 427 831 12	N. oyster
Cidhe Eolaigearraidh	Sound of Barra	UB 427 832 08	Common mussel

At the time of the shoreline survey only one trestle with two bags of mussels was present on site, placed here by the harvester in anticipation of the shoreline survey. As few shore mussels are present around the fishery site, these are gathered from Vatersay, an inhabited island south of Barra, and then transported to the site in bags and placed on the trestles. The harvester intends to keep some bags of mussels on trestles at the site to sell as and when demand warrants.

Since the date of the shoreline survey, Pacific oysters have been laid at the site. Growth trials with Pacific oysters were carried out by the grower at another location on Barra, with good growth reported. It is uncertain at present how suitable the Cidhe Eolaigearraidh site will be for trestle culture of either oyster species.

Prior to the sanitary survey, the production area boundaries and RMP had not been assigned. There is no Crown Estates lease associated with this site. The trestle present at the time of shoreline survey was located at NF 71469 08026. Figure 2.1 shows its location.

Figure 2.1 Cidhe Eolaigearraidh Fishery

3. Human Population

The figure below shows information obtained from the General Register Office for Scotland on the population within the census output in the vicinity of Cidhe Eolaigearraidh.

Figure 3.1 Population of Cidhe Eolaigearraidh

The population for the single census output area bordering immediately on Cidhe Eolaigearraidh is:

60RJ000006 147

There is a single settlement called Eolaigearraidh and several other individual scattered dwellings along the coastline of Cidhe Eolaigearriadh. The majority of the population for this census area is concentrated in and around Eolaigearraidh, and along the eastern shoreline, therefore any associated faecal pollution from human sources is likely to affect this area.

4. Sewage Discharges

Scottish Water identified one community sewage discharge for the area around Cidhe Eolaigearraidh. It is listed in Table 4.1. No sanitary or microbiological data was available for this discharge.

Table 4.1 Discharges identified by Scottish Water

NGR	Discharge Name	Discharge Type	Level of Treatment	Consented flow (DWF) m3/d	Consented /design PE	Q&S III Planned improvements?
NF 7041 0759	Eoligarry (Eolaigearraidh)	Continuous	Septic tank	6	20	No

One discharge consent was supplied by SEPA and it is listed in Table 4.2. This is the same discharge listed in Table 4.1. The discharge consent indicates that the septic tank discharges into the stream at Cille Bharra, which then discharges to the sea next to the public toilets at the pier.

Table 4.2 SEPA discharge consents

Ref no	NGR of discharge	Discharge type	Discharges to	Consented flow (DWF) m^3/day	Consented/ Design PE
WPC-N-61207	NF 7041 0759	Sewage (Public)	Stream at Cille Bharra	6	20

One additional sewage outfall was recorded during the shoreline survey. Its location has been included in the mapped discharges in Figure 4.1, and details are listed in Table 4.3.

Table 4.3 Discharges observed during shoreline survey

No.	Date	NGR	Description
1	03/09/2008	NF 71339 07523	Septic outfall for pier toilets.

The Eolaigearraidh public toilets have a septic tank overflow which discharges to the shore just over 500m to the south of the trestle. This is primarily used by tourists, and has a facility for emptying portable toilets such as those used in caravans.

In addition, there are about 30 dwellings in the area, of which only a small fraction will be connected to the Scottish Water septic tank. The public septic tank only has a PE of 20, and a PE of 5 is normally assumed by SEPA for a single household, so this tank would have capacity to serve approximately 4 homes. As thirty homes were observed, the sewage waste from 26 homes, with an estimated PE of 130, is going somewhere. These numbers broadly correlate with the population census figures for the area, so it is likely that this estimation captures the entire population in the vicinity.

No discharges direct to the marine environment were found during the shoreline survey, so those dwellings not connected to the community septic tank will most likely have private septic tanks, which will have overflows either to soakaway or to nearby water courses. As there has historically been no requirement to register septic tanks within Scotland, there is no record of the age or location of these systems. Likewise, their operational condition is unknown. It is presumed that

water samples taken from the two main streams in to which septic flows could be discharged would reflect any sewage discharged at the time of sampling. Details regarding the streams are provided in Section 13.

The known discharges are located approximately 0.5km south of the oyster trestle and could impact water quality at the planned fishery. A jetty and a number of rocks lie between the discharge and the fishery and these may affect the movement of contamination from these discharges to the oyster trestle(s).

An inter-island ferry operates between Ardmore Ferry Terminal, located approximately 4 km south of the oyster farm on Barra, and the Eriskay, South Uist to the northeast. The ferry route passes approximately 2 km southeast of the fishery at Cidhe Eolaigearraidh. During the winter, the ferry makes 4 daily round trips on weekdays, 2 on weekends. During the summer, up to 5 round trips are made daily. As there are unlikely to be pumpout facilities at either terminal, it is not known where sewage waste from on-board toilet facilities is discharged.

Other septic tank soakaway systems in the area may contribute to pollution levels in and around the area of the fishery should they become blocked and malfunction. However, as the number and locations of these systems are not known this cannot be taken into account when developing the sampling plan.

Figure 4.1 Sewage discharges at Cidhe Eolaigearraidh

5. Geology and Soils

Geology and soil types were assessed following the method described in Appendix 3. A map of the resulting soil drainage classes is shown in Figure 5.1. Areas shaded red indicate poorly draining soils while areas shaded blue indicate more freely draining soils.

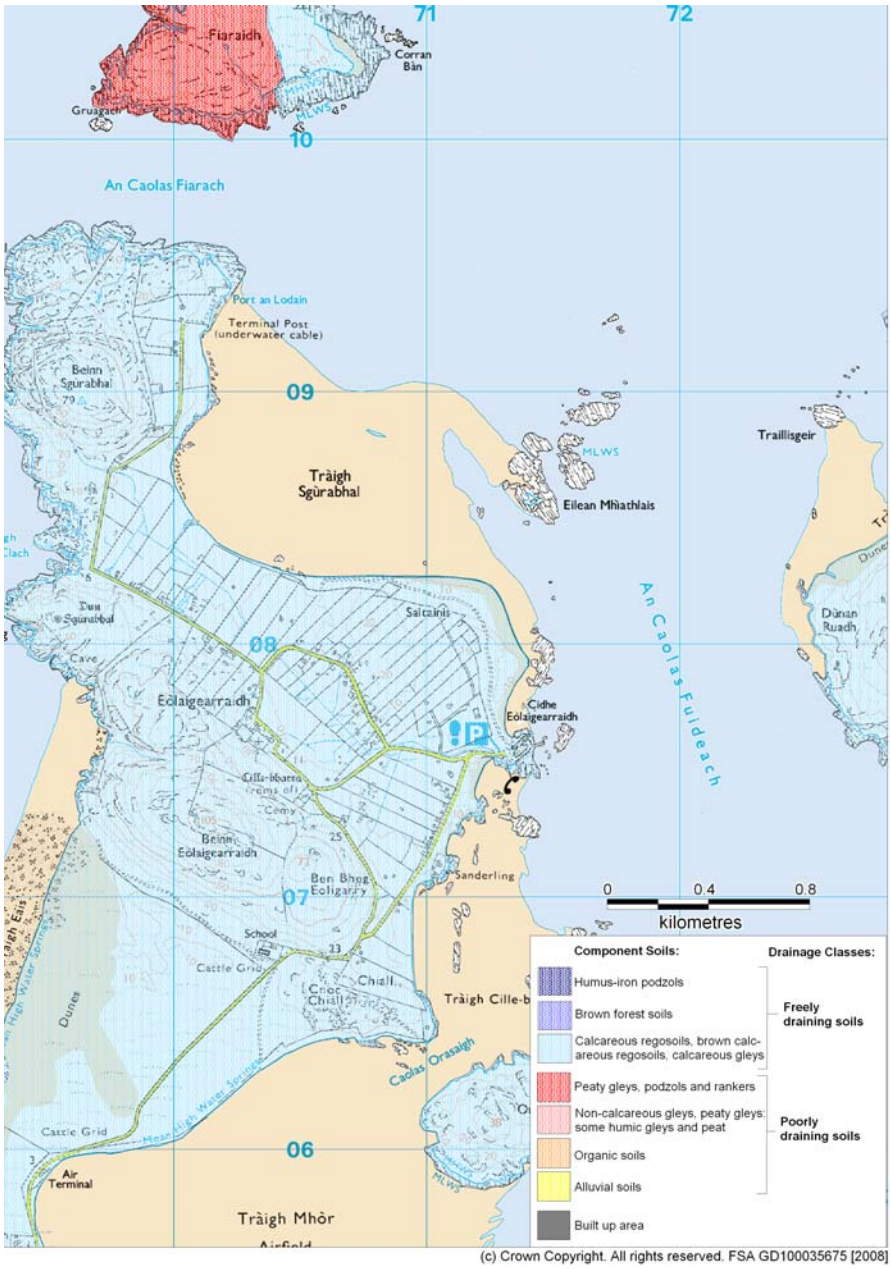

Figure 5.1 Component soils and drainage classes for Cidhe Eolaigearraidh.

There are two main types of component soils visible in this area. The most dominant soil type is composed of calcareous regosols, brown calcareous regosols and calcareous gleys, which are present all over the Island of Barra and also the Island of Fuday to the east. The second soil type is composed of peaty gleys, podzols and rankers and these occupy the western half of the island of Fiaraidh.

Virtually all of the area around Cidhe Eolaigearraidh is covered by freely draining soil. Soil permeability is important to the proper function of septic tank soakaway systems. Consequently, soakaway systems in the populated areas near the fishery are less likely to contribute to contaminated surface runoff.

The potential for runoff contaminated with *E. coli* from human and/or animal waste is likely to be relatively low on the land surrounding Cidhe Eolaigearraidh.

6. Land Cover

No Land Cover Map 2000 data was available for this area, and no similar substitute data sources could be identified, so no detailed land cover maps could be produced for this area.

Agricultural census data provided by the Scottish Government Rural and Environment Research and Analysis Directorate (RERAD) indicated that in 2008 for the parish of Barra there were a total of 545 farm holdings reporting a total farmed land area of 4122 hectares. Of this, 2076 hectares were used for crops or improved grassland, 2018 hectares were rough grazing, 10 hectares were woodland and 18 hectares were other land, such as hard standing or farm yards. This compares to a total parish land area of 8907 hectares, indicating that nearly half of the land area on the island is farmed or grazed.

The shoreline survey identified that the land adjacent to the area the site was low lying pasture, some of which was used for the production of hay, some of which was being grazed by cattle and sheep at the time. Land in the vicinity of Cidhe Eolaigearraigh has been divided into crofts. The area was settled, but at a low density. Towards the west coast, the land rises up to about 100m in places, and these low hills are covered by rough grassland.

The faecal coliform contribution would be expected to be highest from developed areas (approx $1.2 – 2.8x10^{9}$ cfu km^{-2} hr^{-1}), with intermediate contributions from the improved grassland (approximately $8.3x10^{8}$ cfu km^{-2} hr^{-1}) and lowest from the other land cover types (approximately $2.5x10^{8}$ cfu km^{-2} hr^{-1}) (Kay *et al*. 2008). The contributions from all land cover types would be expected to increase significantly after marked rainfall events, this being expected to be highest, at more than 100-fold, for the improved grassland.

The improved grassland present within the crofts along the eastern shoreline is likely to present the most significant contributor of faecally contaminated runoff to the fishery and this is likely to increase after significant rainfall.

7. Farm Animals

Agricultural census data was provided by RERAD for the parish of Barra. This parish covers the islands of Barra and Vatersay, as well as a number of smaller, mostly unpopulated islands to the south and east. Recorded livestock populations for the parish in 2007 and 2008 are listed in Table 7.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data.

Table 7.1 Livestock census data for Barra parish, 2007-2008

	2007		2008	
	Holdings	Numbers	Holdings	Numbers
Total pigs	*	*	*	*
Total poultry	15	213	16	244
Total cattle	61	755	59	719
Total sheep	146	10475	144	9926
Horses used in Agriculture	*	*	*	*
Horses and Ponies	*	*	*	*

* Data withheld on confidentiality basis.

The Western Isles Crofters Commission (2007) identified that in 2005, there were an estimated 713 cattle and 10209 sheep on the Isle of Barra. This correlates roughly with the more recent data provided by RERAD. Cattle and sheep population numbers for 2008 represented a slight decline over those recorded in 2007 and reported by the crofter's commission for 2005. For 2008, the average number of cattle per holding on the island as a whole was 12, and the average number of sheep per holding was 72.

The only source of information specific to the area near the shellfishery was the shoreline survey (see Appendix), which only relates to the time of the site visit on 3rd – 4th September 2008.

Much of the area surrounding the bay is pasture, some of which is grazed by livestock and some of which is used for the production of hay for winter feed. Specifically, 28 sheep and 16 cattle were observed associated with the crofts behind the shoreline. Compared to the averages per holding for the island, the number of animals observed was lower than might be expected to be present in the area over time. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 7.1.

There is no information available concerning the seasonality of livestock populations on Barra, however overall numbers of livestock on the island would be expected to be higher during the summer and autumn months following the birth of calves and lambs in spring. Generally livestock on Barra are grazed on the higher areas further from the shore during the summer, and in lower areas nearer the shore during the winter, so livestock impacts to the production area may actually be higher during the winter months when they are closer to the shore.

Figure 7.1 Livestock observations at Cidhe Eolaigearraidh

8. Wildlife

General information related to potential risks to water quality by wildlife is given in Appendix 4. A number of wildlife species present or likely to be present at Cidhe Eolaigearraidh could potentially affect water quality around the fishery.

Seals

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.

The Sea Mammal Research Unit has recorded a decreasing number of harbour seals on the Islands of Uist and Barra over the past sixteen years (Table 8.1). The number of Grey seals counted has also declined since 1996. However, there are still a significant number of seals resident around the island.

Table 8.1 Seal counts around Barra

Location	Species	Aug 1992	Aug 1996	Aug 2000	Aug 2003	Aug 2006
South Uist & Barra	**Harbour seals**	1243	921	801	718	605
South Uist & Barra	**Grey seals**	398	1301	1174	805	535

The population of both species is relatively large in relation to the size of the area surveyed. It is not certain exactly where the seals prefer to haul out, but this may be anywhere with good access to a reasonable depth of water at all states of the tide, such as the rocks in the middle of the bay in which the trestles are located. Though none were seen during the course of the shoreline survey, it is likely that seals may be present in the area from time to time. Their impact to the fishery is not predictable on the basis of data currently available.

Whales/Dolphins

Whales and dolphins are relatively common off the west coast of Scotland and sightings are recorded by the Hebridean Whale and Dolphin trust. These are reported to the trust by ferry skippers, whale watch boats and other observers and are listed in Appendix 4.

No whales or dolphins (cetaceans) were observed during the course of the shoreline survey though dolphins and porpoises may occasionally be present in the area.

As the entire area between Cidhe Eolaigearraidh and the Island of Fuday is very shallow (Maximum depth is 5 m) it is very unlikely that the area would be visited by larger cetaceans. The presence any cetacean species is likely to be fleeting and unpredictable and so will not be taken into account with regard to establishing a sampling plan.

Birds

Though a number of bird species are found in the Western Isles, seabirds and waterfowl are most likely to occur around or near the fisheries in significant numbers.

Seabird populations were investigated all over Britain as part of the SeaBird 2000 census (Mitchell *et al*, 2004). Total counts of all species recorded within 5 km of the trestles during a seabased survey of the area on 5th June 2000 are presented in Table 8.2. The majority of counts were of occupied nesting sites, so actual numbers of seabirds present and breeding in the area will be higher.

Table 8.2 Seabird counts within 5km of the site (5/6/2000)

Common name	Species	Count	Method
Herring Gull	*Larus argentatus*	213	Occupied territory/nests
Northern Fulmar	*Fulmaris glacialis*	123	Occupied sites
Lesser Black-backed Gull	*Larus fuscus*	94	Occupied territory/nests
Great Cormorant	*Phalacrocorax carbo*	60	Occupied nests
Great Black-backed Gull	*Larus marinus*	40	Occupied territory/nests
Common Tern	*Sterna hirundo*	26	Occupied territory/Individuals on land
European Shag	*Phalacrocorax aristotelis*	6	Occupied nests
Common Gull	*Larus canus*	2	Occupied territory

Most of these nesting sites were on the small islands just offshore from the shellfishery. Nesting occurs in early summer and after this some species will disperse. However gulls, which form the majority in terms of numbers, are likely to be present in the area throughout the year.

Waterfowl (ducks and geese) are likely to be present in the area at various times from autumn through winter. Few of these birds would be expected to be present during the summer months. Overwintering geese would tend to be found on farm fields and open grassland, such as that bordering the fishery at Cidhe Eolaigearraidh.

Wading birds would be concentrated on intertidal areas, such as the area on which the trestles are located. An aggregation of 28 oystercatchers was seen around the mouth of the stream which discharges to the north of the trestle during the shoreline survey.

The impacts of these birds to the fishery is likely to be seasonally significant, with shorebirds and nesting seabirds having a higher impact during summer and migratory geese, should they be present, having a higher impact in autumn and winter. Gulls may sit on trestles and shellfish bags when they are exposed, leading to locally significant levels of contamination where they have defecated.

These impacts are spatially difficult to predict and will not materially affect the sampling plan.

Deer

It is not certain whether deer are present in significant numbers on Barra, as the DCS does not undertake counts there. Red deer are present on South Uist, so it is possible that this species may also be found on Barra. They prefer wooded habitats, of which there is very little on Barra. None were seen during the shoreline survey.

It is possible that some of the indicator organisms detected in the stream feeding into the bay at Cidhe Eolaigearraidh may be of deer origin, however it is expected that their contribution would be minor if at all present.

Otters

A survey of otters on Barra (International Otter Survival Fund, 2000) estimated that there were between 16 and 23 otters on the island, equivalent to 0.3-0.5 animals per km of coastline. Their presence in a particular area was linked to the presence of freshwater pools in which they must wash their fur frequently to maintain its insulating properties. Small marine fish predominated the diet, indicating that they were foraging in the sea. Therefore, although otters are likely to be present in the area, there are more suitable habitats with deeper water and better access to freshwater pools so their numbers will probably be low and their impact to the fishery negligible.

Eolaigearraidh is designated as an SSSI due to its dunes and machair, and an SPA due to its corncrake population, which although it is of national importance only consisted of an average of 28 calling males between 1993 and 1997 and this so will be of negligible impact to the fishery.

Summary

Species potentially impacting on Cidhe Eolaigearraidh include seals and waterbirds. However, the impacts of these on the fishery will be unpredictable, and deposition of faeces by wildlife is likely to be widely distributed around the area and will not be considered in determination of sampling plans.

9. Meteorological data

The nearest weather station is located at Barra, Isle of Barra, approximately 2 km southwest of the production area. Rainfall data was supplied for the period 01/01/03 to 31/12/2005 (total daily rainfall in mm). Insufficient rainfall data was available for 2006 and 2007 so these years were excluded from the analysis. It is likely that the rainfall experienced at Barra is very similar to that experienced at the production area due to their close proximity.

The nearest major weather station where wind is measured is located at Tiree, approximately 67 km to the south east of the production area. Wind direction was recorded at 3 hourly intervals for the majority of the period 1/1/1996 to 31/12/2007. Both Tiree and Barra are low-lying islands which are fully exposed to the Atlantic to their west, so it is likely that the wind patterns are broadly similar, but due to their distance from each other are liable to differ on a day to day basis. Although wind data is gathered at Barra Airport for purposes of aviation, it is not kept and so no historical records are available.

Rainfall at Barra

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 wastewater treatment plant overflows (e.g. Mallin *et al*, 2001; Lee & Morgan, 2003).

As the rainfall records from Barra are complete for the period 2003 - 2005, total annual rainfall and mean monthly rainfall can be calculated, and are presented in Figures 9.1 and 9.2.

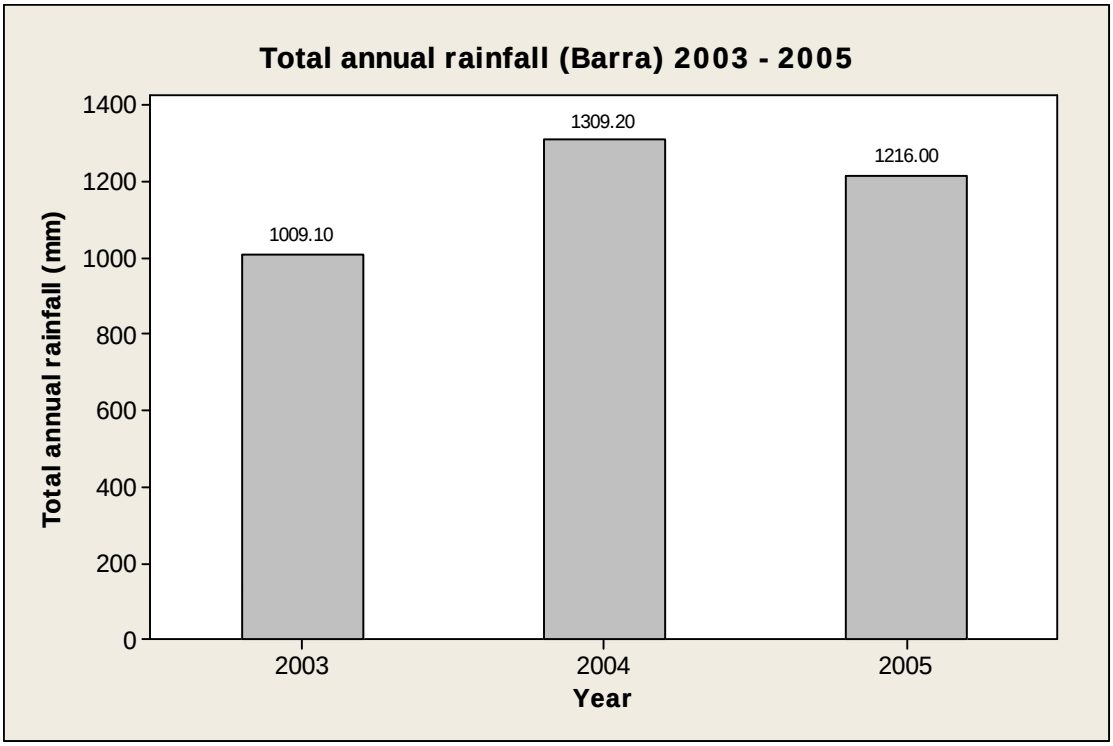

Figure 9.1 Total annual rainfall at Barra 2003 – 2005

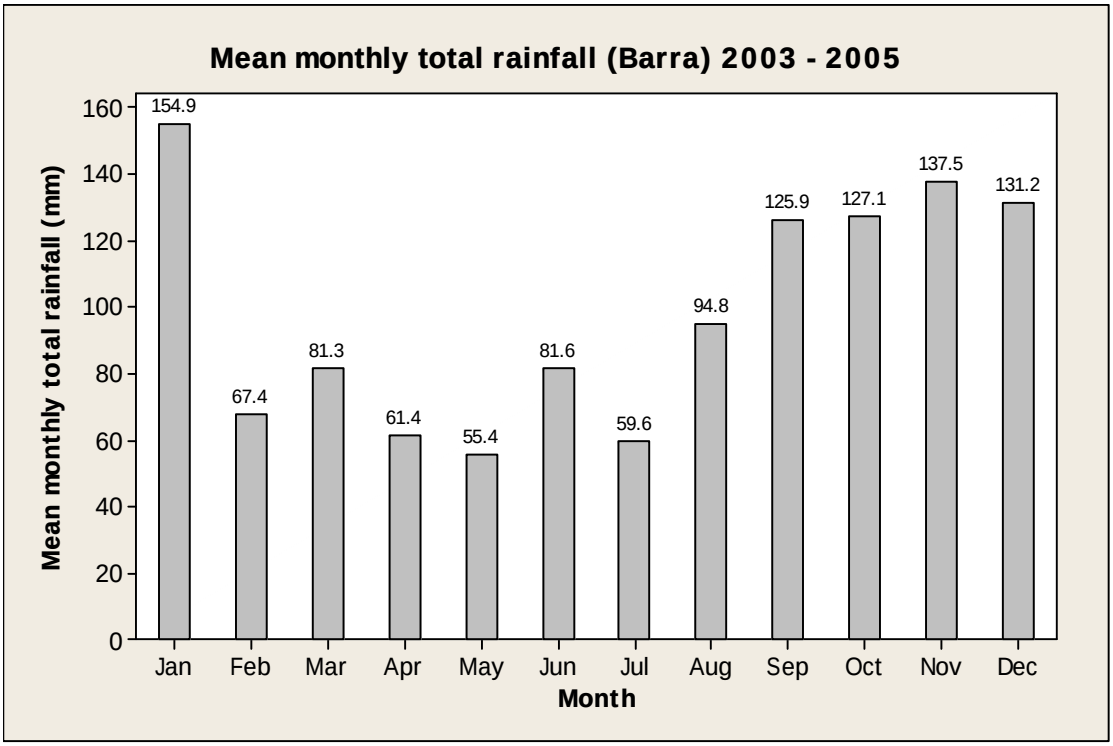

Figure 9.2 Mean total monthly rainfall at Barra 2003 – 2005

The wettest months were January and November, though rainfall levels were elevated from September through January, inclusive. For the period considered here (2003 – 2005), 25% of the days experienced no rainfall and 50% of days experienced rainfall of 1 mm or less. Significant increases in average rainfall occurred between May and June, July and August, and August and September.

It can therefore be expected that levels of rainfall dependent faecal contamination entering the production area from these sources will be higher during the autumn and winter months, but episodes of contamination following heavy rain may occur at any time of year. It is also probable that faecal matter will build up on pastures during the drier summer months when stock levels are at their highest, leading to more significant faecal contamination of runoff at the onset of the wetter weather in the autumn.

Wind at Tiree

Wind data collected at the Tiree weather station is summarised by season and presented in Figures 9.3 to 9.7.

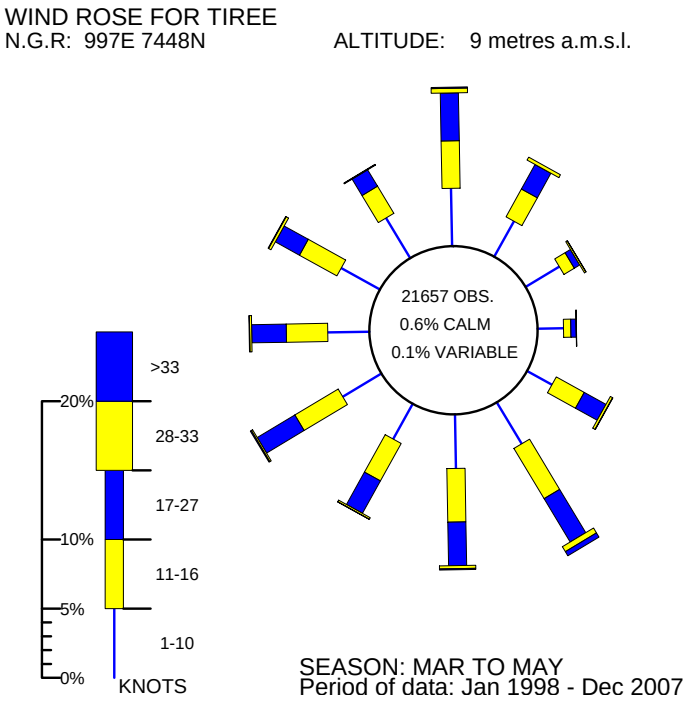

Figure 9.3 Wind rose for Tiree (March to May)

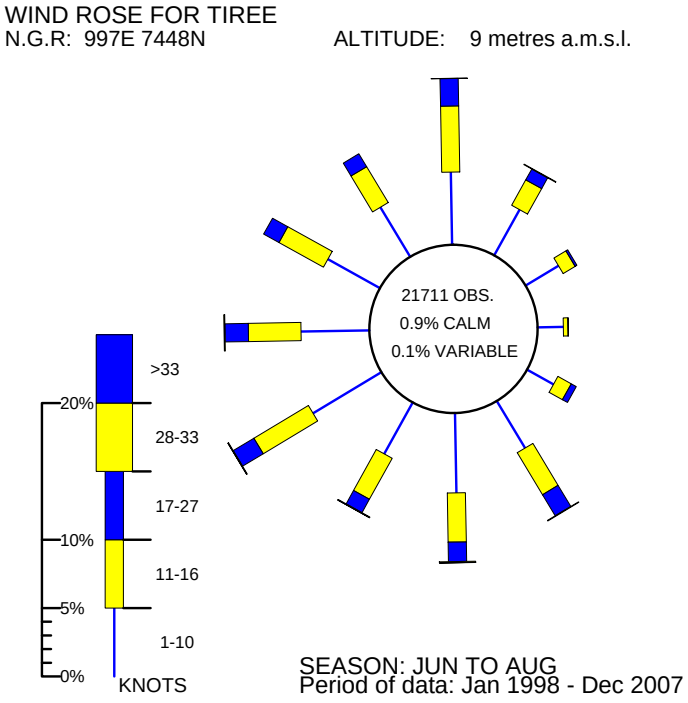

Figure 9.4 Wind rose for Tiree (June to August)

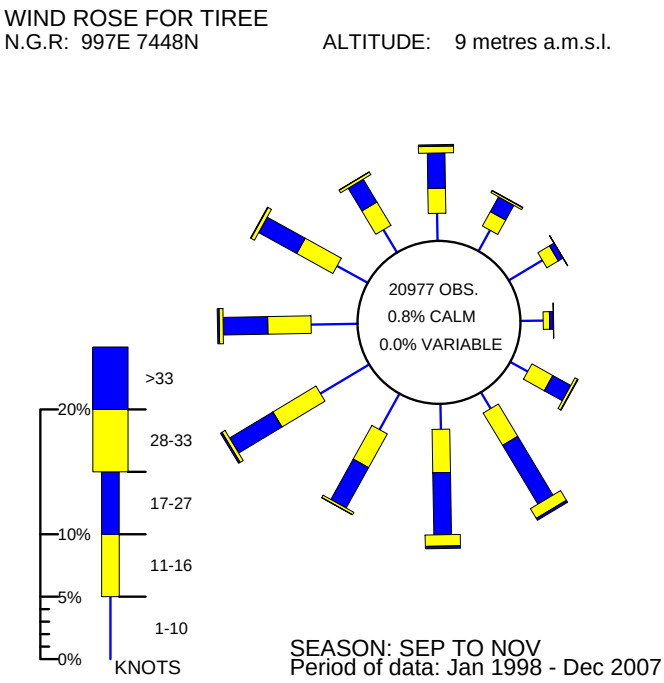

Figure 9.5 Wind rose for Tiree (September to November)

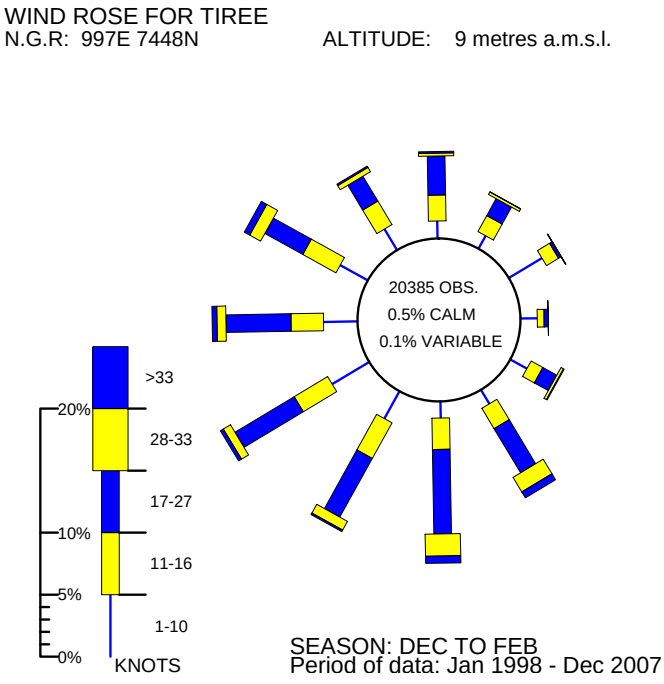

Figure 9.6 Wind rose for Tiree (December to February)

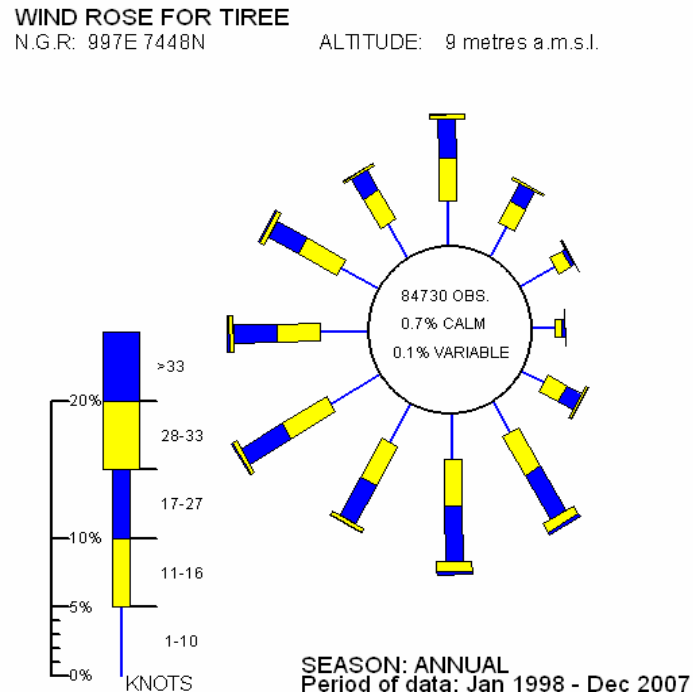

Figure 9.7 Wind rose for Tiree (All year)

The prevailing wind direction at Tiree is from the south and west, but wind direction often changes markedly from day to day with the passage of weather systems. Winds are lightest in the summer and strongest in the winter.

Winds typically drive surface water currents 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. A strong wind combined with a spring tide may result in higher than usual tides, which could carry accumulated faecal matter from livestock at and above the normal high water mark into the production area.

Cidhe Eolaigearraidh is a small bay on the east coast of Barra, partially sheltered from easterly winds by the island of Fuday. It is most exposed to north easterly and south easterly winds. The bay is small, shallow and dries on low spring tides, so tidal exchange of water is likely to be more important overall than wind driven flows. An onshore wind will however result in increased wave action, which may resuspend any organic matter settled in the substrate potentially leading to an increase in contamination levels.

On a larger scale, winds may alter the circulation of water within the surrounding seas in such a way to assist the transport of contamination from further afield. However, the only point source of contamination in the local area is the stream located 0.5 km south of the shellfishery. Between this source and the oyster trestle, a jetty and series of rocks would complicate wind driven surface currents, making prediction of impact to the shellfishery difficult.

10. Current and historical classification status

Cidhe Eolaigearraidh has not yet been classified.

11. Historical *E. coli* data

No records of historical *E. coli* classification samples for this production area were found on the FSAS database of monitoring results to the end of 2007.

The Traigh Mhor cockle beds, approximately 2.5 km to the south of the trestles have been routinely sampled for classification purposes for a number of years. Although the species samples was different from the species to be cultured at Cidhe Eolangairraidh, and the distance between the two means that different sources of contamination may be important, an analysis of historical monitoring results from here may give some tentative insight into the seasonal and environmental influences on levels of contamination in the general area.

An analysis of these results, carried out as part of a sanitary survey of Traigh Mhor, identified that there had been an apparent increase in contamination levels since 2005, and that a significant seasonal effect was found with *E. coli* results in the summer tending to be higher than those in the spring. No relationships were found between *E. coli* results and water temperature, rainfall, salinity, tidal amplitude or wind direction.

Therefore, tentatively extrapolating from the Traigh Mhor cockle results, a seasonal variation in results at Cidhe Eolangairraidh may be expected, with other environmental variables perhaps being of less importance.

12. Designated Shellfish Growing Waters Data

Cidhe Eolaigearraidh does not lie within a designated shellfish growing water.

13. River Flow

The following streams were measured and sampled during the shoreline survey. These represent the only significant freshwater inputs into the production area.

Table 13.1 Stream loadings for Cidhe Eolaigearraidh

No	Grid Ref	Description	Width (m)	Depth (m)	Flow (m/s)	Flow (m^3/day)	*E.coli* (cfu/ 100ml)	Loading (*E.coli* per day)
1	NF 71274 07546	Stream	0.74	0.18	0.802	9230	<100	*
2	NF 70080 08472	Stream	1.05	0.04	0.309	1121	800	9.0×10^{09}

* loading not calculated

Only two significant streams discharge to the area. Although the Eolaigearraidh septic tank continuously discharges to stream 1, levels of contamination in this stream were low at the time of survey. This septic tank is only designed to serve a small proportion of the households present in the area. Stream 2 may receive inputs from private septic tanks. Both streams will probably receive inputs from livestock, but at the time of survey sheep and cattle were present only in the catchment area of stream 2. Daily fluctuations in household water use can mean that smaller community and private septic tanks may only discharge during times of high use, such as early morning and late afternoon. It is unlikely that they would discharge continuously and so the sampling undertaken during the shoreline survey may not have captured all likely contaminant flows. Water samples in this case were taken at 06:17 (stream 1) and 06:37(stream 2), theoretically just before or at the early end of peak morning water usage.

It should be noted that levels of contamination measured in the streams relate to the day of shoreline survey only. Conditions such as time of day, livestock presence, recent application of manure to arable land, or higher levels of recent rainfall may materially change the levels of contamination in these streams.

Stream 1 discharges to the sea approximately 0.5 km south of the oyster trestle while Stream 2 discharges approximately 1.5 km to the northwest of the trestle. Both streams are likely to affect water quality at the fishery, depending upon the state of tide and meteorological conditions at the time of sampling.

While different contamination levels were observed in the two streams at the time of survey, the likely sources to both area similar and so similar levels of contamination may be present in either stream at any given time. As there is so little sampling data available, it is not possible to draw longer-term conclusions regarding the relative contamination levels in these streams.

Figure 13.1 Location of significant streams near Cidhe Eolaigearraidh

14. Bathymetry and Hydrodynamics

Figure 14.1 OS map of northern Barra

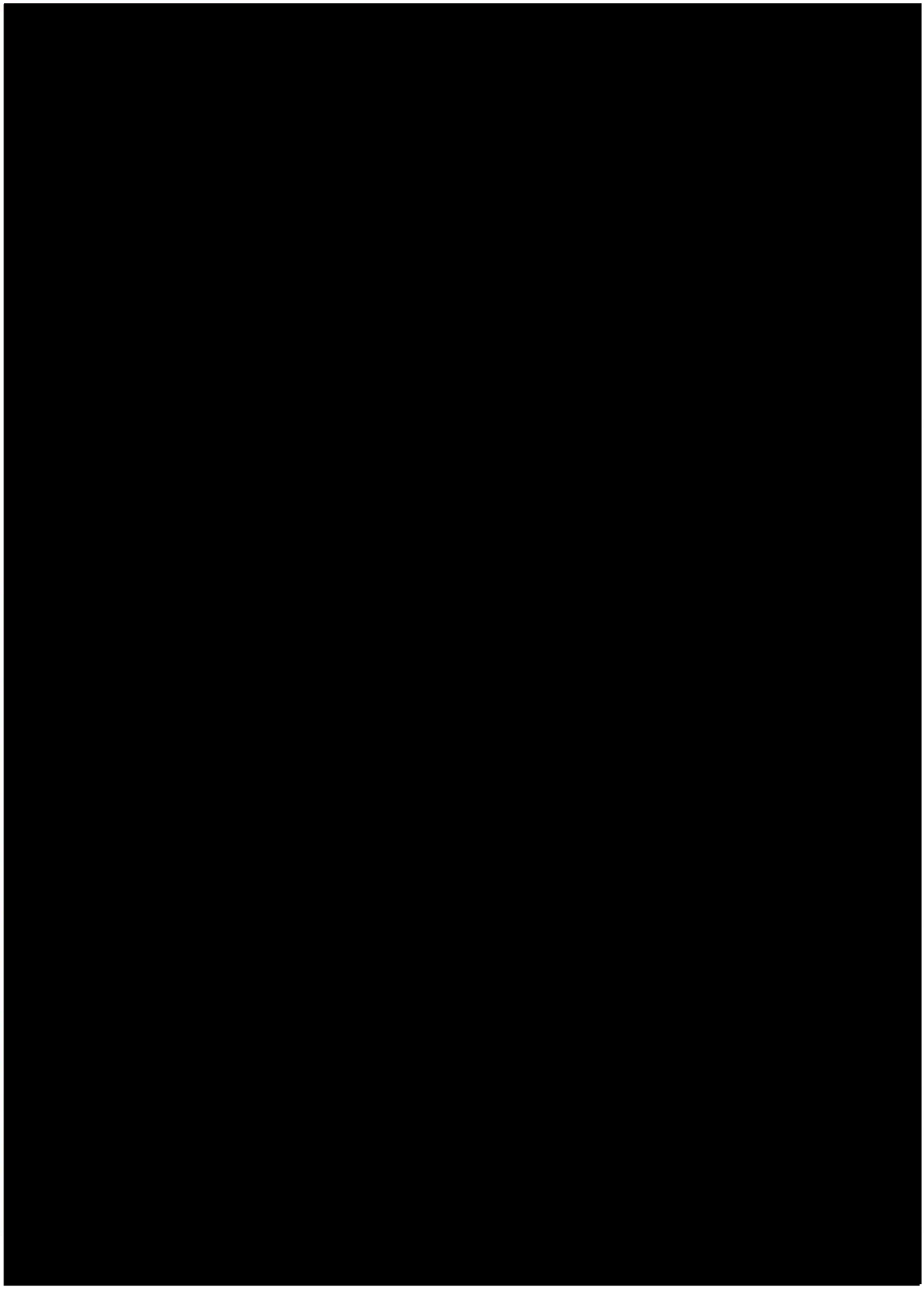

Figure 14.2 Bathymetry of northern Barra

Figure 14.2 shows that the fishery is located on a drying area next to a shallow channel between the islands of Barra and Fuday, where depth does not exceed

5m. The shallow Sound of Barra lies to the north, which provides a connection between the Minch and the Atlantic Ocean.

Tidal Curve and Description

The two tidal curves below are for North Bay, approximately 5 km to the south of the site. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 GMT on 2 September 2008 and the second is for seven days beginning 00.00 GMT on 16 September 208. This two-week period covers the dates of the shoreline survey (3-4 September). Together they show the predicted tidal heights over high/low water for a full neap/spring tidal cycle.

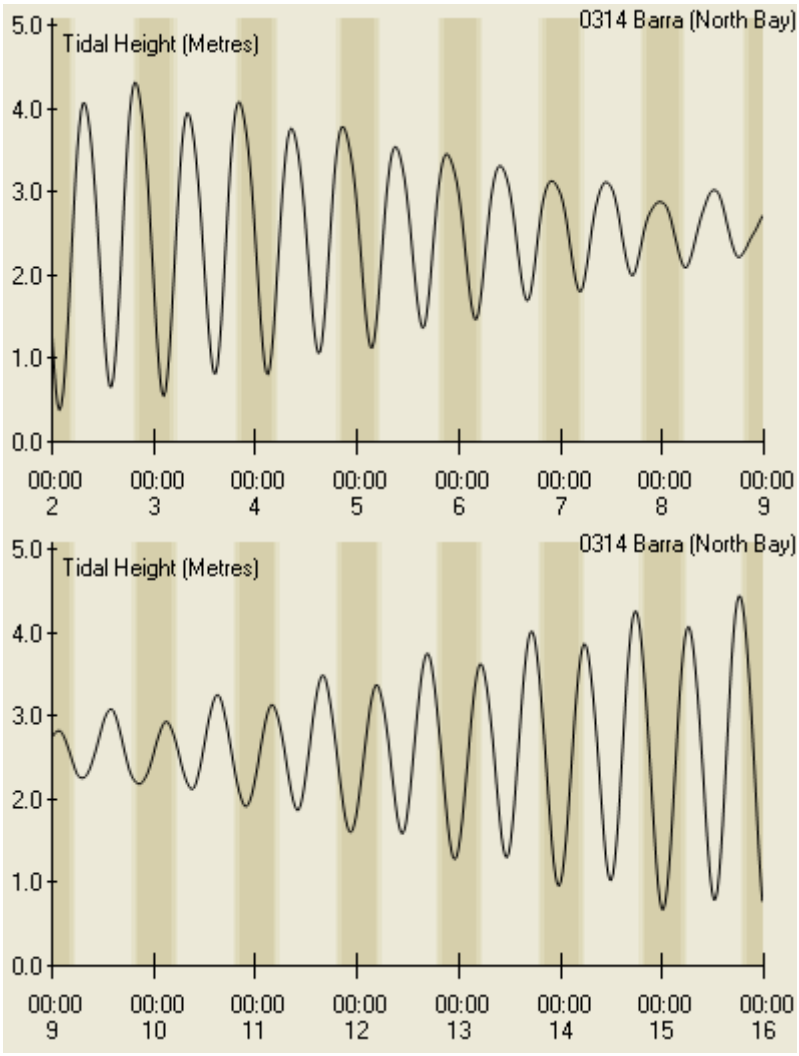

Figure 14.3 Tidal curves for North Bay

The following is the summary description for Barra (North Bay) from TotalTide: Barra (North Bay) is a Secondary Non-Harmonic port. The tide type is Semi-Diurnal.

HAT	4.8 m
MHWS	4.2 m
MHWN	3.2 m
MLWN	1.8 m
MLWS	0.6 m

Predicted heights are in metres above Chart Datum. The tidal range at spring tide is approximately 3.6 m and at neap tide 1.4 m.

Currents

Currents in coastal waters are driven by a combination of tide, wind and freshwater inputs. This section aims to make a simple assessment of water movements around the area.

Tidal diamonds located in the middle of the Minch and to the South of Barra did not provide sufficient information for a judgement to be made on either speed or direction of flows around the Eolaigearraidh site at various states of the tide.

Generally, tidal streams around the Outer Hebrides are north-bound on the flood tide and south-bound on the ebb tide. However, in the Sound of Barra, the flood tide flows in from both the NW and SE ends, meeting in the middle before flowing back out both ends again on the ebb (Clyde Cruising Club, 2007). The streams are reported to be weak and variable, meeting to the east of Traigh Mhor and south of Fuday, where the 10m curve is located on the bathymetry map in Figure 14.2. However, no information was found on measured flows here.

An aerial photograph (Figure 14.4) shows the shallow sand banks within the Sound between Fuday and North Barra.

Figure 14.4 Aerial photograph of North Barra (Source: GoogleEarth)

The strongest currents for this area are reportedly found within the Drover Channel north of the island of Fuday, just at the far upper right border of the photograph.

Tidal streams within the sound are reportedly weak. Flows in this area would be further complicated by the large number of rocks and sand bars present. From the photo, a channel of deeper water can be seen running roughly north and south just offshore of the rocks off Eoligarry (Eolaigearraidh), which may be indicative of tidal scouring. As the fishery lies slightly to the north of where the incoming tidal streams meet, currents in the area may tend to be southward flowing on a flood tide, and northward flowing on an ebb tide. Contaminants may be carried both away from shore and then northward along the shore on the falling tide and toward shore and southward along it on a rising tide. This is a highly simplistic prediction and actual flows in the area are expected to be more complex.

The Cidhe Eolaigearraidh fishery may be affected by sources of contamination in close proximity to it, such as the streams and septic tank discharges north and south of the trestle, but it is less likely to be affected by sources from further away, such as any discharges from the inter-island ferry.

As the tidal range is relatively large, and the water is shallow with large drying areas, tidal exchange is likely to be important here. Density (freshwater) driven flows are likely to be insignificant as the area is unenclosed, shallow, and has little in the way of freshwater inputs.

Strong winds will tend to create a surface current in the same direction as the wind. However this is complicated by the open aspect and unusual tidal flows within the area. Winds over the shallow waters in this area will increase wave action, which may re-suspend sediment and contaminants in the water.

Contamination from the stream discharging to the middle of the bay (Traigh Sgurabal) would be transported in the approximate direction of the trestles on the south flowing ebb tide. As this is flows across a large intertidal area, the exact direction in which the tide would transport contamination from this source is less predictable and more dependent on the height of the water at the time. A northward moving flow past the public toilet outfall and the stream just next to it into which the Eoligarry septic tank discharges is likely to carry contamination from these sources in the direction of the trestle.

15. Shoreline Survey Overview

The sanitary survey at Cidhe Eolangairraidh was carried out in response to an application to harvest mussels, Pacific oysters and native oysters from the production area.

The shoreline survey was conducted on the 3rd to 4th September 2008.

At the time of survey only one trestle with two bags of mussels was present on site. The harvester has undertaken growth trials with Pacific oysters at another location on Barra, and reported good growth. However, it is uncertain at present whether this site will be suitable for trestle culture.

Population on the shores of the area is low. Houses in the area do not have access to mains sewers, so all waste water goes to septic tank. None of these discharge direct to the production area as they are too far from the shore. The Eoligarry public toilets have a septic tank overflow which discharges to the shore just over 500m to the south of the trestle. This is primarily used by tourists, and has a facility for emptying portable toilets such as those used in caravans.

There will be an increase in population in the area during the summer months. One of the larger dwellings in the area operated as a Bed and Breakfast. Two static caravans were also counted which are likely to be used as holiday dwellings. It is possible that other dwellings serve as holiday homes, but it is believed that most are in year round occupation. One tent was seen by the public toilets.

The area surrounding the production area is pasture, some of which was being grazed, and some was used for the production of hay. 28 sheep and 16 cattle were observed associated with the crofts behind the shoreline. An aggregation of 28 oystercatchers was seen around the mouth of a stream which discharges to the bay.

Two small dinghies were seen tied up at a small concrete pier next to the public toilets. Aside from this no other boats were seen during the course of the survey. The Eriskay ferry appeared to pass within 4 km of the trestle. This sails 5 times daily in summer, and 4 times daily during the winter.

A total of three seawater samples were taken during the course of the survey. The samples taken near the trestles and near the septic overflow from the public toilets were uncontaminated (0 and 1 *E. coli* cfu/100 ml respectively) but the sample taken in the middle of the sandy bay to the north was heavily contaminated (600 *E. coli* cfu/100 ml). Only one mussel sample was taken from the trestles, and this was only lightly contaminated (110 *E. coli* mpn/100g).

Two streams were sampled during the course of the survey. The level of contamination in the stream to the south of the trestle was low (<100 *E. coli* cfu/100ml) but it was higher in the stream to the north of the trestle (800 *E. coli* cfu/100ml).

Figure 15.1 Summary of shoreline observations

16. Overall Assessment

Human sewage impacts

There are no major discharges in the area. There are about 30 dwellings, of which a small number are connected to a Scottish Water septic tank. This discharges continuously to a stream, which in turn discharges alongside the jetty at Cidhe Eolaigearraidh. The impact of this was low at the time of survey, as a water sample taken from this stream gave an *E. coli* result of <100 cfu/100ml. However, it is not known whether the septic tank discharge was flowing at the time. It is likely that those dwellings not connected to the community septic tank would have private septic tanks, which will have overflows to soakaway or to nearby streams. For the latter, any impacting contamination would be carried in freshwater flow to the sea and any contamination present at the time represented in the water sample taken during the shoreline survey. No private discharge pipes, other than that for the public toilets, were observed during the shoreline survey. However, properties were not closely inspected at the time.

The Eolaigearraidh public toilets have a septic tank overflow which discharges to the shore just alongside the jetty. This is primarily used by tourists, and has a facility for emptying portable toilets such as those used in caravans. The impact of this will probably be highly seasonal with greater use occurring during the summer months and school holidays.

Agricultural impacts

Much of the area surrounding the bay is pasture, some of which is grazed by livestock and some of which is used for the production of hay for winter feed. The only source of detailed information on livestock numbers and distribution was the shoreline survey, which only applies to the day of survey. This identified 28 sheep and 16 cattle associated with the crofts behind the shoreline. The livestock population in the vicinity is likely to be higher than that counted during the survey.

Overall numbers of livestock on the island will be higher during the summer and autumn months following the birth of calves and lambs in spring. Generally, livestock on Barra are grazed on the higher areas further from the shore during the summer and in lower areas nearer the shore during the winter, so livestock impacts to the site may actually be higher during the winter months when they are closer to the shore. Contamination of livestock origin will mainly be carried to the site via the two streams draining the area. Distribution of livestock is likely to vary, with both streams equally likely to be contaminated with livestock faeces at least some of the time.

Wildlife impacts

Species potentially impacting on Cidhe Eolaigearraidh include seals and waterbirds. However, the impacts of these on the fishery will be unpredictable, and deposition of faeces by wildlife is likely to be widely distributed around the area.

Seasonal variation

Tourism will result in an increase in population in the area during the summer months. One of the larger dwellings in the area operated as a Bed and Breakfast. Some of the dwellings (e.g. two static caravans) may be holiday homes. Use of the public toilets at the jetty is likely to be significantly higher during the summer months. Livestock numbers will be higher in the summer, but they will generally be kept closer to the shore on lower lying pasture during the winter time. The weather is colder, wetter and windier in the autumn and winter months.

An analysis of historical *E. coli* monitoring data from the nearby Traigh Mor cockle beds identified a significant seasonal effect, with *E. coli* results in the summer higher than those in the spring. It is possible that a similar pattern might be observed at Cidhe Eolaigearraidh.

Rivers and streams

Freshwater input to the area is low, consisting of only two significant streams. One of these streams (stream 1) discharges next to the jetty. Although the Eoligarry septic tank continuously discharges to this stream, levels of contamination as measured during the shoreline survey were low (<100 *E. coli* cfu/100ml). The other stream (stream 2) discharges to approximately the middle of the bay named Traigh Sgurabal. This stream may receive inputs from private septic tanks and from livestock in its catchment area, and was more contaminated than stream 1 when sampled during the shoreline survey (800 *E. coli* cfu/100ml). However, this is only representative of contamination levels at the time of collection and it is likely that these may vary. Stream 2 lies further from the fishery than Stream 1, so it would be expected that discharge from here will be diluted to some extent before reaching the trestle at Cidhe Eolaigearraidh.

Meteorology, hydrology, and movement of contaminants

Currents in the area will be driven primarily by tide and to a lesser extent by wind. As the tidal range is relatively large, and the water is shallow with large intertidal areas, tidal exchange is likely to be very important here. Tidal flows in the vicinity of the fishery will generally flow southeast on the rising tide and northwest on the falling tide, however these flows may be complicated by the fact that the tide flows into both ends of the Sound of Barra on the flood and come together in the middle, somewhere southeast of the trestle at Cidhe Eolaigearraidh. This is likely to cause some unusual circulation patterns in and around this meeting zone making prediction difficult.

A northward moving flow past the public toilet outfall and stream 1 (into which the Eoligarry septic tank discharges) is likely to carry contamination from these sources in the direction of the trestles. Contamination from stream 2 would be transported in the approximate direction of the trestles on a southerly flow, but as this is farther away, and flows across a large drying area, the exact direction which the tide would transport contamination from this source is less predictable and more dependent on the height of the water at the time.

Given the relatively exposed nature of the area, wind driven flows are likely to significantly affect the pattern of circulation in the area at times. The site is most exposed to the north, so winds from this direction are likely to affect circulation in the area the most. Strong winds will create a surface current in the same direction, as the wind. Wind driven currents will create a return current, but it is difficult to predict the path of this around the islands. Onshore winds will increase wave action, which may resuspend contaminants from the substrate into the water. Density (freshwater) driven flows are likely to be of little or no importance as the area is unenclosed, shallow, and has little in the way of freshwater inputs.

An analysis of historical *E. coli* monitoring data from the nearby Traigh Mor cockle beds identified that there was no relationship between *E. coli* results and water temperature, rainfall, salinity, tide size or wind direction. It is uncertain whether a similar lack of meteorological influence will be found when monitoring starts at Cidhe Eolaigearraidh given the distance between the two and the different species involved.

Temporal and geographical patterns of sampling results

Given that the site has no monitoring history, and at the time of shoreline survey the operation was still at the pilot stage with only a small quantity of one of the species to be classified, there is no temporal or geographical sampling information available with which to advise the sampling plan.

Seawater samples taken during the shoreline survey near the trestles and near the septic overflow from the public toilets were uncontaminated (0 and 1 *E. coli* cfu/100 ml respectively). A seawater sample taken in the middle of the sandy bay to the north was heavily contaminated (600 *E. coli* cfu/100 ml), possibly due to a nearby stream and/or the presence of a flock of oystercatchers. A mussel sample was taken from the trestles was only lightly contaminated (110 *E. coli* mpn/100g). Results of sampling undertaken as part of the shoreline survey are specific to the conditions on the date of sampling, and care should be exercised in drawing broader conclusions from this data.

17. Recommendations

It is recommended that the boundaries for this site be restricted sufficiently to prevent expansion to potentially more contaminated areas, but not so restricted as to prevent expansion of the fishery in its present area. The recommended production area is the area bounded by lines drawn between NF 7107 0827 to NF 7173 0827 and between NF 7173 0827 to NF 7173 0782 and between NF 7173 0782 to NF 7133 0782 extending to MHWS. This allows for sufficient space for future expansion of the fishery, but prevents it from expanding to within 300 m of the public toilet discharge and stream 1, the closest point sources.

The mussels are currently brought in from Vatersay Island and the sanitary condition of the area from which they are gathered is not known. As these are only collected in small amounts for local sale, classification is not required and so it is not recommended that Cidhe Eolaigearraidh be classified for common mussels.

As the fishery is currently limited in area to a few square meters, no geographical considerations aside from its actual location can realistically be taken into account when setting the RMP. Therefore, it is recommended that the RMP for Pacific oysters be set at NF 7147 0803 where the trestle is located. It is further recommended that the harvester not relocate bags of mussels to this site, as if they are transported from an area with higher levels of faecal contamination they could cross contaminate the oysters being grown here.

No RMP is recommended at this time for native oysters as none were present during the survey. Should these be brought in at some point in the future, they should be given the same RMP location as the Pacific oysters. Both species should be monitored independently as Pacific oysters and native oysters have been shown to concentrate contaminants at different rates. All stock should be in place on the site for a minimum of two weeks prior to sampling to allow for contaminant levels to become representative of local conditions. In order to avoid cross contamination, adequate separation should be maintained between any new stock and existing stock on site until the new stock has been down for at least two weeks.

As it was not possible to adequately assess spatial variation in shellfish *E. coli* concentrations, if the current shellfish farm is expanded in area, a bacteriological survey should be conducted at that time to determine whether the RMP should be moved. This would involve analysing three sets of samples, each collected a fortnight or more apart, from the northern and southern extents of the trestles to see whether any variation in contamination levels is apparent.

Only stock of a harvestable size should be sampled. No sampling depth is applicable and a sampling tolerance of 10 m is recommended.

As this is a new production area, and there are likely to be seasonal fluctuations in *E. coli* results, the sampling frequency should be monthly.

Figure 17.1 Recommended production area boundaries and RMP for Cidhe Eolaigearraidh

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Sampling Plan for Cidhe Eolaigearraidh

PRODUC-TION AREA	SITE NAME	SIN	SP.	TYPE OF FISH-ERY	NGR OF RMP	EAST	NORTH	TOLER-ANCE (M)	DEPTH (M)	METHOD OF SAMPLING	FREQ OF SAMPLING	LOCAL AUTHORITY	AUTHORISED SAMPLER(S)	LOCAL AUTHORITY LIAISON OFFICER
Cidhe Eolaigearraidh	Sound of Barra	UB 427 830	Pacific oysters	Trestles	NF 7147 0803	07147	80803	10 m	N/A	Hand	Monthly	Comhairle nan Eilean Siar	Samantha Muir	Samantha Muir

Comparative Table of Boundaries and RMPs – Cidhe Eolaigearraidh

Production Area	Species	SIN	Existing Boundary	Existing RMP	New Boundary	New RMP	Comments
Cidhe Eolaigearraidh	Pacific oyster	UB 427 830 13	N/A	N/A	Area bounded by lines drawn between NF 7107 0827 to NF 7173 0827 and between NF 7173 0827 to NF 7173 0782 and between NF 7173 0782 to NF 7133 0782 extending to MHWS	NF 7147 0803	New production area and RMP. As only 1 trestle in place, when operation expands a bacteriological survey to be conducted and RMP re-evaluated on basis of results.
	Native oyster	UB 427 831 12	N/A	N/A	Same as above	To be assigned when stock is present on site	No native oysters present at time of survey - RMP to be same as that for Pacific oysters when stock is present
	Common mussel	UB 427 832 08	N/A	N/A	None	None	Not recommended for classification.

Geology and Soils Assessment

Component soils and their associations were identified using uncoloured soil maps (scale 1:50,000) obtained from the Macaulay Institute. The relevant soils associations and component soils were then investigated to establish basic characteristics. From the maps seven main soil types were identified: 1) humus-iron podzols, 2) brown forest soils, 3) calcareous regosols, brown calcareous regosols, calcareous gleys, 4) peaty gleys, podzols, rankers, 5) non-calcareous gleys, peaty gleys: some humic gleys, peat, 6) organic soils and 7) alluvial soils.

Humus-iron podzols are generally infertile and physically limiting soils for productive use. In terms of drainage, depending on the related soil association they generally have a low surface % runoff, of between 14.5 – 48.4%, indicating that they are generally freely draining.

Brown forest soils are characteristically well drained with their occurrence being restricted to warmer drier climates, and under natural conditions they often form beneath broadleaf woodland. With a very low surface % runoff of between 2 – 29.2%, brown forest soils can be categorised as freely draining (Macaulay Institute, 2007).

Calcareous regosols, brown regosols and calcareous gleys are all characteristically freely draining soils containing free calcium carbonate within their profiles. These soil types have a very low surface % runoff at 14.5%.

Peaty gleys, peaty podzols and peaty rankers contribute to a large percentage of the soil composition of Scotland. They are all characteristically acidic, nutrient deficient and poorly draining. They have a very high surface % runoff of between 48.4 – 60%.

Non-calcareous gleys, peaty gleys and humic gleys are generally developed under conditions of intermittent or permanent water logging. In Scotland, non-calcareous gleys within the Arkaig association are most common and have an average surface % runoff of 48.4%, indicating that they are generally poorly draining.

Organic soils often referred to as peat deposits and are composed of greater than 60% organic matter. Organic soils have a surface % runoff of 25.3% and although low, due to their water logged nature, results in them being poorly draining.

Alluvial soils are confined to principal river valleys and stream channels, with a wide soil textural range and variable drainage. However, the alluvial soils encountered within this region have an average surface % runoff of 44.3%, so it is likely that in this case they would be poorly draining.

These component soils were classed broadly into two groups based on whether they are freely or poorly draining. Drainage classes were created based on information obtained from the both the Macaulay Institute website

and personal communication with Dr. Alan Lilly. GIS map layers were created for each class with poorly draining classes shaded red, pink or orange and freely draining classes coloured blue or grey. These maps were then used to assess the spatial variation in soil permeability across a survey area and it's potential impact on runoff.

Glossary of Soil Terminology

Calcareous: Containing free calcium carbonate.

Gley: A sticky, bluish-grey subsurface layer of clay developed under intermittent or permanent water logging.

Podzol: Infertile, non-productive soils. Formed in cool, humid climates, generally freely draining.

Rankers: Soils developed over noncalcareous material, usually rock, also called 'topsoil'.

Regosol: coarse-textured, unconsolidated soil lacking distinct horizons. In Scotland, it is formed from either quartzose or shelly sands.

References

Macaulay Institute. http://www.macaulay.ac.uk/explorescotland. Accessed September 2007.

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 50-170kg. 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.

Table 1 Cetacean sightings in 2007 – Western Scotland.

Common name	**Scientific name**	**No. sighted***
Minke whale	*Balaenoptera acutorostrata*	28
Killer whale	*Orcinus orca*	183
Long finned pilot whale	*Globicephala melas*	14
Bottlenose dolphin	*Tursiops truncatus*	369
Risso's dolphin	*Grampus griseus*	145
Common dolphin	*Delphinus delphis*	6
Harbour porpoise	*Phocoena phocoena*	>500

*Numbers sighted are based on rough estimates based on reports received from various observers and whale watch groups. Source: Hebridean Whale and Dolphin Trust.

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 and 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 feed (Bedard and Gauthier, 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 Natural Heritage website). 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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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}		
Reedbed/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, D. et al (2008) Faecal indicator organism concentrations in sewage and treated effluents. *Water Research* 42, 442-454.

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: Adapted from Geldreich 1978 by Ashbolt et al in World Health Organisation (WHO) Guidelines, Standards and Health. 2001. Ed. by Fewtrell and Bartram. IWA Publishing, London.

Hydrographic Methods Document

1.0 Introduction

This document outlines the methodology used by Cefas to fulfil the requirements of the sanitary survey procedure with regard to hydrographic evaluation of shellfish production areas. It is written as far as possible to be understandable by someone who is not an expert in oceanography or computer modelling. This document collects together information common to all hydrographic assessments avoiding the repetition of information in each individual report.

The hydrography at most sites will be assessed on the basis of bathymetry and tidal flow software only and is not discussed in any detail in this document. Selected sites will be assessed in more detail using either: 1) a hydrodynamic model, or 2) an extended consideration of sources, available field studies and expert assessment. This document will focus on this more detailed hydrographic assessment and describes the common methodology applied to all sites.

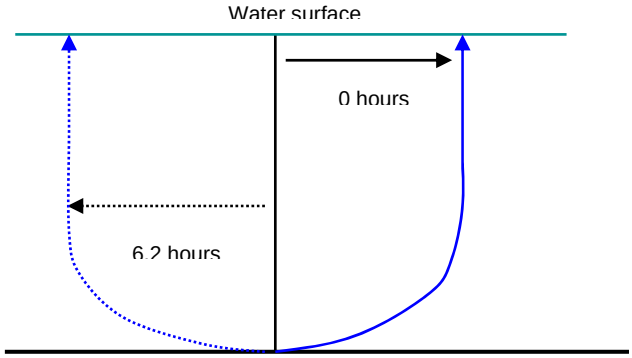
The regulations require an appreciation of the hydrography and currents within a region classified for shellfish production.

2.0 Background processes

This section gives an overview of the hydrographic processes relevant to sanitary surveys.

Movement in the estuarine and coastal waters is generally driven by one of three mechanisms: 1) Tides, 2) Winds, 3) Density differences. Unless tidal flows are weak they usually dominate over the short term (~12 hours) and move material over the length of the tidal excursion. The tidal residual flow acts over longer time scales to give a net direction of transport. Whilst tidal flows generally move material in more or less the same direction at all depths, wind and density driven flows often move material in different directions at the surface and at the bed. Typical vertical profiles are depicted in figure 1. However, it should be understood that in a given water body, movement will often be the sum of all three processes.

a)



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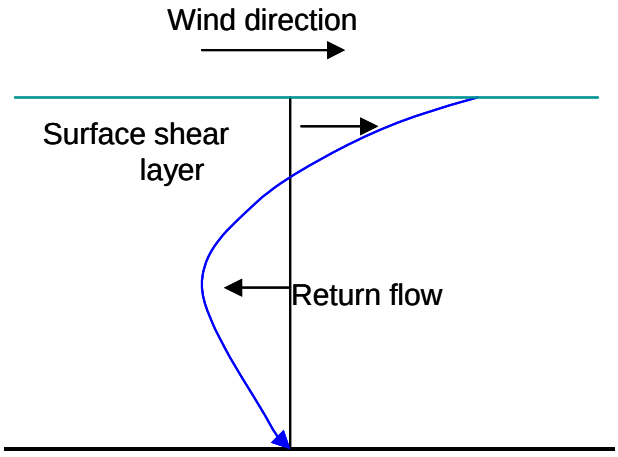

c)

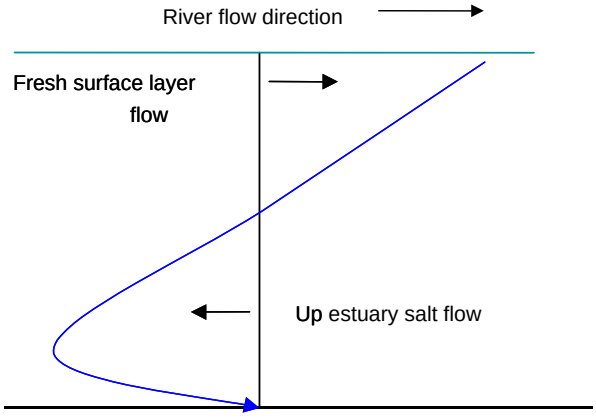

Figure 1. Typical vertical profiles for water currents. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction over a period of 6.2 hours. b) wind driven current profile, c) density driven current profile.

In sea lochs, mechanisms such as “wind rows” can transport sources of contamination at the edge of the loch to production areas further offshore. Wind rows are generated by winds directed along the main length of the loch. An illustration of the waters movements generated in this way is given in Figure 2. As can be seen the water circulates in a series of cell that draw material across the loch at right angles to the wind direction. This is a particularly common situation for lochs with high land on either side as these tend to act as a steering mechanism to align winds along the water body.

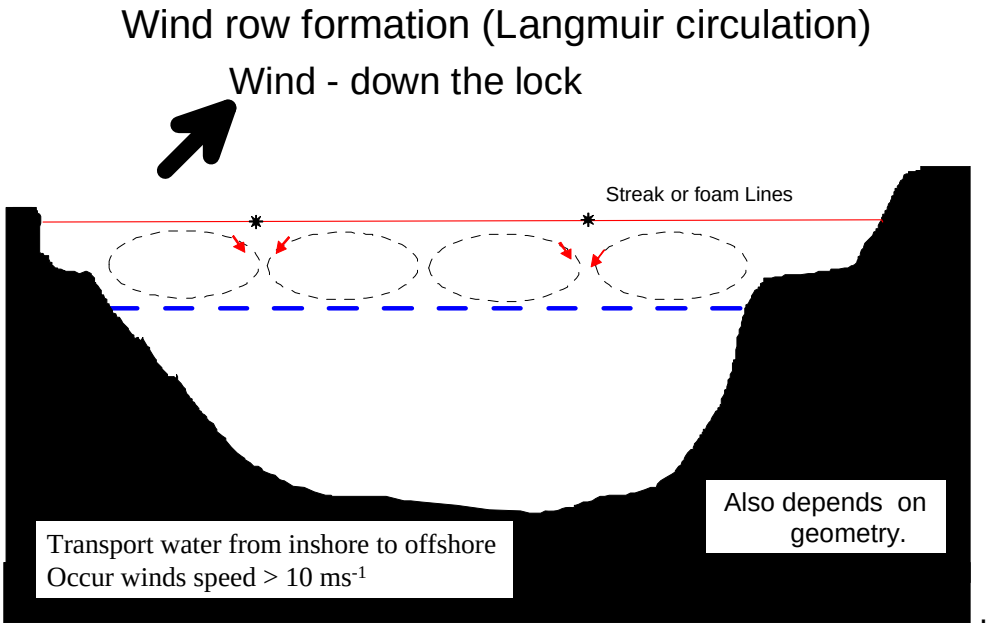

Figure 2: Schematic of wind driven ‘wind row’ currents. The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

Shoreline Survey Report

Survey Area: Cidhe Eolaigearraidh (UB 427)

Scottish Sanitary Survey Project

Shoreline Survey Report

Production Area:

Production Area	Site	SIN	Species
Cidhe Eolaigearraidh	Sound of Barra	UB 427 830 13	P. oyster
Cidhe Eolaigearraidh	Sound of Barra	UB 427 831 12	N. oyster
Cidhe Eolaigearraidh	Sound of Barra	UB 427 832 08	Common mussel

Harvester: Mr Gerard McDonald
Status: New application.
Date Surveyed: 3/9/08 and 4/9/08
Surveyed by: Samantha Muir, Alastair Cook
Existing RMP: None
Area Surveyed: See Figure 1.

Weather observations

3/9/08 – 7 km/h north easterly wind, 12 ºC, some showers.
4/9/08 – 4 km/h northerly wind, 13 ºC, dry.

Site Observations

Specific observations made on site are mapped in Figure 1 and listed in Table 1. Water and shellfish samples were collected at sites marked on Figures 2 and 3. Bacteriology results are given in Tables 2 and 3. Photographs are presented in Figures 4-9. The contiguous area to the south (Traigh Cille Barra) had been the subject of a restricted sanitary survey earlier in the year.

Fishery

At the time of survey only one trestle with two bags of mussels was present on site, placed here by the harvester in anticipation of the shoreline survey. The harvester has undertaken growth trials with Pacific oysters at another location on Barra, and reported good growth. However, it is uncertain at present whether this site will be suitable for shellfish culture as the substrate was not as fine as that typically encountered in oyster growing areas and the location appeared to be fairly exposed.

Sewage/Faecal Sources

Human – Population on the shores of the area is low. Houses in the area do not have access to mains sewers, so all waste water goes to septic tank. None of these discharge direct to the production area as they are too far from the shore and the permeable sandy soil in the area would lend itself to effective soakaways.

The Eoligarry public toilets have a septic tank overflow which discharges to the shore just over 500m to the south of the trestle. This is primarily used by

tourists, and has a facility for emptying portable toilets such as those used in caravans. One tent was seen here during the survey.

Livestock – Much of the area surrounding the bay is pasture, some of which is grazed by livestock and some of which is used for the production of hay for winter feed. Specifically, 28 sheep and 16 cattle were observed associated with the crofts behind the shoreline. Generally livestock on Barra are grazed on the higher areas further from the shore during the summer, and in lower areas nearer the shore during the winter time.

Two streams were sampled during the course of the survey. Both drained areas of pasture, and may have had septic discharges from the crofts to them. The level of contamination in the stream to the south of the trestle was low (<100 *E. coli* cfu/100ml) but it was higher in the stream to the north of the trestle (800 *E. coli* cfu/100ml).

A total of three seawater samples were taken during the course of the survey. The samples taken near the trestles and near the septic overflow from the public toilets were uncontaminated (0 and 1 *E. coli* cfu/100 ml respectively) but the sample taken in the middle of the sandy bay to the north was heavily contaminated (600 *E. coli* cfu/100 ml).

Only one mussel sample was taken from the trestles, and this was only lightly contaminated (110 *E. coli* mpn/100g). As no oysters were available, no samples were taken for norovirus testing.

Seasonal Population

One of the larger dwellings in the area operated as a Bed and Breakfast. Two static caravans were also counted which likely are used as holiday dwellings. It is possible that other dwellings serve as holiday homes, but it is believed that most are in year round occupation. One tent was seen by the public toilets.

Boats/Shipping

Two small dinghies were seen tied up at a small concrete pier next to the public toilets. Aside from this no other boats were seen during the course of the survey. The Eriskay ferry passes within 4 km of the trestle. This sails 5 times daily in summer, and 4 times daily during the winter.

Land Use

The area surrounding the production area is pasture, some of which was being grazed, and some was used for the production of hay.

Wildlife/Birds

An aggregation of 28 oystercatchers was seen around the mouth of the stream which discharges to the north of the trestle. Aside from these, and a few gulls, no other aggregations of wildlife were seen.

General observations

Recorded observations apply to the date of survey only. Animal numbers were recorded on the day from the observer's point of view. This does not necessarily equate to total numbers present as natural features may obscure individuals and small groups of animals from view.

Dimensions and flows of watercourses are estimated at the most convenient point of access and not necessarily at the point at which the watercourses enter the production area.

Figure 1. Map of Shoreline Observations

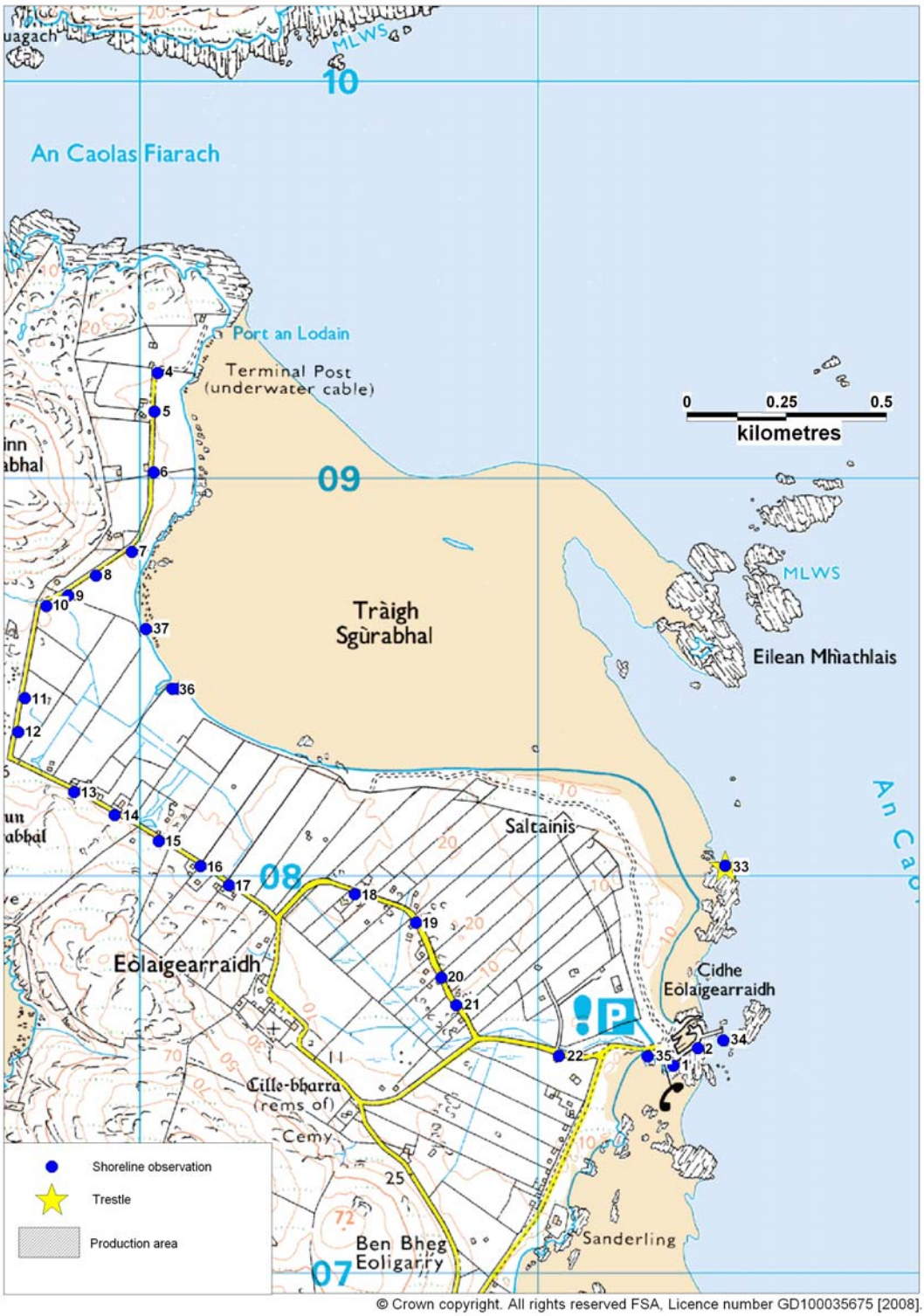

Table 1. Shoreline Observations

Name	Date and time	Position	Photgraph	Description
1	03-SEP-08 11:16:10AM	NF 71339 07523	Figures 4 & 5	1 tent & car. Septic outfall for pier toilets. Facility for emptying caravan chemical toilets.
2	03-SEP-08 11:17:35AM	NF 71401 07567		2 jetties, 2 small dinghies tied up.
3	03-SEP-08 11:43:41AM	NF 70095 08472		28 oystercatchers, stream (to be measured and sampled later)
4	03-SEP-08 12:00:25PM	NF 70043 09266		2 houses, another on end of peninsula
5	03-SEP-08 12:01:47PM	NF 70035 09169		House and 9 cattle
6	03-SEP-08 12:03:48PM	NF 70033 09015		House
7	03-SEP-08 12:06:30PM	NF 69978 08815		House
8	03-SEP-08 12:07:43PM	NF 69888 08755		Bed and Breakfast
9	03-SEP-08 12:08:41PM	NF 69818 08705		House
10	03-SEP-08 12:09:27PM	NF 69763 08679		Stream (to be measured and sampled later)
11	03-SEP-08 12:12:32PM	NF 69709 08448	Figure 6	Livestock pens
12	03-SEP-08 12:14:02PM	NF 69692 08363		6 cattle
13	03-SEP-08 12:16:52PM	NF 69833 08212		House and barn
14	03-SEP-08 12:19:12PM	NF 69935 08154		House
15	03-SEP-08 12:20:36PM	NF 70046 08088		House, 1 cow on hill behind
16	03-SEP-08 12:22:13PM	NF 70151 08025		28 sheep, 2 houses and barn
17	03-SEP-08 12:23:25PM	NF 70222 07977	Figure 7	Static caravan with septic tank awaiting instalment
18	03-SEP-08 12:28:12PM	NF 70538 07955		3 houses
19	03-SEP-08 12:30:10PM	NF 70692 07883		3 houses
20	03-SEP-08 12:31:57PM	NF 70756 07745		House and livestock pen
21	03-SEP-08 12:32:53PM	NF 70793 07675		2 houses and 1 static caravan
22	03-SEP-08 12:37:14PM	NF 71051 07547		5 houses and scrap yard
33	03-SEP-08 3:29:03PM	NF 71469 08026	Figure 8	Barra mussel sample 6. Seawater sample 1. Oyster trestle with 2 mussel bags on it.
34	04-SEP-08 6:14:33AM	NF 71464 07587		Seawater sample 2
35	04-SEP-08 6:17:36AM	NF 71274 07546		Stream 74cmx18cmx0.802m/s. Freshwater sample 3
36	04-SEP-08 6:36:54AM	NF 70080 08472		Stream 105cmx4cmx0.309m/s. Freshwater sample 4
37	04-SEP-08 6:42:28AM	NF 70013 08621		Seawater sample 5

Table 2. Water Sample *E. coli* Results

Name	Date and time	Position	Type	*E. coli* (cfu/100ml)	Salinity (ppt)
Barra 1	03-SEP-08 3:29:03PM	NF 71469 08026	Seawater	0	36.0
Barra 2	04-SEP-08 6:14:33AM	NF 71464 07587	Seawater	1	36.2
Barra 3	04-SEP-08 6:17:36AM	NF 71274 07546	Freshwater	<100	
Barra 4	04-SEP-08 6:36:54AM	NF 70080 08472	Freshwater	800	
Barra 5	04-SEP-08 6:42:28AM	NF 70013 08621	Seawater	600	33.1

Table 3. Shellfish Sample *E. coli* Result

Name	Date and time	Position	Species	*E. coli* (mpn/100g)
Barra 6	03-SEP-08 3:29:03PM	NF 71469 08026	Mussel	110

Figure 2. Water sample results map

Figure 3. Shellfish sample results map

Figure 4 Public toilet discharge pipe

Figure 5 Sign indicating facilities available at Eoligarry public toilets

Figure 6 Concrete livestock pen

Figure 7 Static caravan with septic tank awaiting installment

Figure 8. Trestle with two bags of mussels

Norovirus Testing Summary

Cidhe Eolaigearraidh
UB 427 830 13

Pacific oyster samples taken from the trestle at Cidhe Eolaigearraidh were submitted for Norovirus analysis quarterly beginning December 2008.

Results are tabulated below. No native oyster samples were submitted for norovirus analysis as there were none on site at the time of sampling.

Ref No.	Date	NGR	GI	GII
08/289	01/12/2008	NF 7138 0818	Not detected	Positive at limit of detection
09/086	11/05/2009	NF 7138 0818	Not detected	Not detected
10/033	18/01/2010	NF 7138 0818	Pos at LOD	Not detected