Scottish Sanitary Survey Programme

Sanitary Survey Report
Seilebost
LH-249
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The hydrographic assessment and the shoreline survey and its associated report were undertaken by SRSL, Oban.

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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 Seilebost 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.crlcefas.org/gpg.asp). This production area was selected for survey at this time based on a risk-based ranking of the area amongst those in Scotland that have yet to receive sanitary surveys.

Seilebost production area is located on the west coast of the Outer Hebridean island of Harris, part of the local authority of Comhairle nan Eilean Siar.

The production area is located at Luskentyre Sands (Fadhail Losgaintir), an extensive area of intertidal sand flats.

The area hosts a wild common cockle fishery, which is exploited mainly in winter by up to six harvesters. The main bed area is within the inner part of the bay based on the most recent available stock assessment and the historical monitoring data.

The primary sources of faecal contamination to the fishery are:

- Discharges from septic tanks at Seilebost and Luskentyre
- Diffuse contamination carried via watercourses, particularly those at the head and along the south shore of the bay
- Diffuse contamination from livestock and wildlife sources

The largest identified sources were found along the south shore around Seilebost, where there are both community and private septic tank discharges and where more livestock were seen. Contaminants will be carried across the fishery on the incoming and outgoing tide. However, the specific pattern of movement across the sands will be complex and variable as channels and sand banks move over time.

Historical sampling locations have formed two distinct clusters within the inner part of the cockle bed. The southernmost of these lies nearer to identified sources of contamination along the south shore, and was found to have significantly higher results historically.

It is not possible to exclude the potential mixing zones of the two community discharges from the production area without affecting the extent of the main areas of cockles available to commercial harvest. The RMP and associated tolerance zone have been located to reflect the integrated impact, as represented by *E. coli*, of all of the main faecal pollution sources identified during this assessment but periodic monitoring may not reflect the total microbiological risk arising from the community discharges.

It is recommended that the boundaries be curtailed slightly eastward to exclude the outer sands nearer to the campsite, and also to reflect the area more likely to be fished. The RMP should be moved southward to NG 0808 9726 to better reflect contamination levels at the southern end of the cockle bed. Further details of the recommendations can be found in the sampling plan on the next page and in Section 16 of this report.

II. Sampling Plan

Production Area	Seilebost
Site Name	Seilebost
SIN	LH-249-129-04
Species	Common cockles
Type of Fishery	Wild
NGR of RMP	NG 0808 9726
East	108080
North	897260
Tolerance (m)	150
Depth (m)	not applicable
Method of Sampling	Hand (raked)
Frequency of Sampling	Monthly
Local Authority	Comhairle nan Eilean Siar
Authorised Sampler(s)	Paul Tyler
Local Authority Liaison Officer	Colm Fraser
Production Area Boundary	The area inshore of a line drawn between NG 0654 9831 and NG 0687 9893 and extending to MHWS

III. Report

1. General Description

Seilebost production area is located on the west coast of the Outer Hebridean island of Harris, part of the local authority of Comhairle nan Eilean Siar.

The production area is located in the bay of Luskentyre Sands (Fadhail Losgaintir), an extensive area of intertidal sand flats. The bay extends inland 4 km and is nearly 2 km at its widest. The production area terminates at the head of the bay at Loch Fincastle.

Two small settlements border the area; Luskentyre on the northern shore and Seilebost on the southern shore.

Figure 1.1 Location of Seilebost

2. Fishery

The fishery at Seilebost is a wild common cockle (*Cerastoderma edule*) fishery which has been classified for production since 2005. Details of the site are presented in Table 2.1.

Table 2.1 Area fishery

Production area	Site	SIN	Species	RMP	Boundary
Seilebost	Seilebost	LH-249-129-04	Common cockle	NG 0815 9772	Area inshore of a line drawn between NG 0650 9913 and NG 0605 9727 extending to MHWS

The current RMP is located in the inner half of the bay, south of the channel that carries flow from water courses discharging to the head of the bay.

The extent of the cockle bed had been identified in a survey of the Western Isles' cockle grounds in 2000 (Howell, et al., 2001). This is shown in Figure 2.1. The bed at that time was split into two distinct areas: one southeast of the point at Crago and the other northwest of this, on the outer part of the sands. However, as this is a wild population the location and extent of the bed may have changed over the past decade. This is reflected in the locations of shellfish samples taken since 2008, which are also plotted in Figure 2.1: the area covered by these extends beyond the bed identified in 2000. The shoreline survey reports "cockles were not found to be consistently abundant throughout the production area and some digging in various different areas of the mud/sand was necessary in order to find an area with plentiful cockles for sampling."

It is unknown how many harvesters are actively working this fishery although the shoreline survey report states a maximum of 6 people have been noted harvesting at any one time.

The shoreline survey report states that harvesting only really occurs during the winter months, when the area is classified A.

Regulations related to conservation of stock have been put in place that prohibit the fishing of cockles with vehicles (Scottish Government, 2006) and also prohibit the harvesting of cockles less than 30 mm in size throughout the Western Isles, including Harris (Scottish Government, 2009).

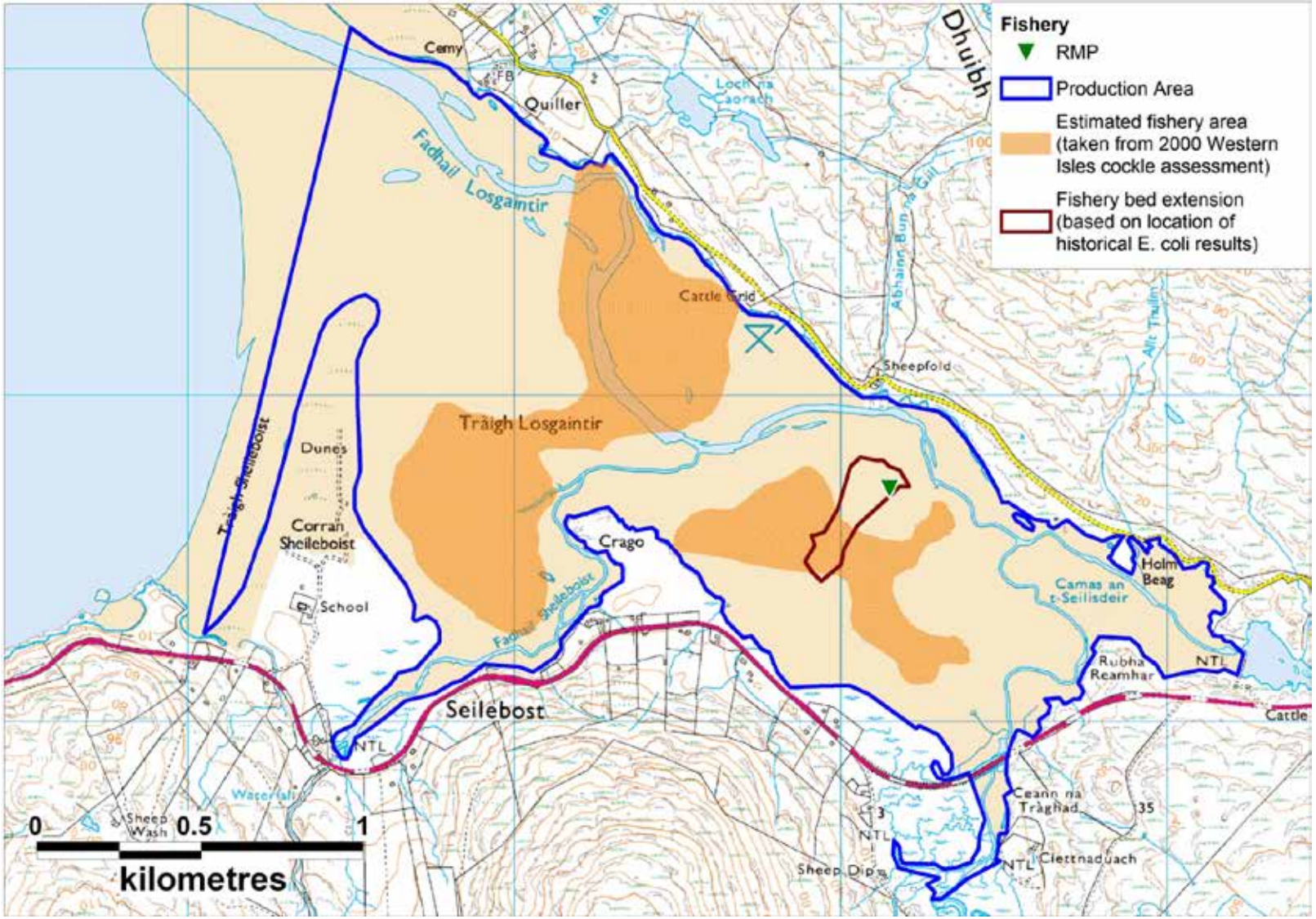

Figure 2.1 Seilebost Fishery

3. Human Population

Information was obtained from the General Register Office for Scotland on the population within the census output areas in the vicinity of Seilebost. The last census was undertaken in 2011. The census output areas surrounding Seilebost are shown in Figure 3.1, thematically mapped by the 2011 population densities. The figure shows that the overall population density for the census output areas surrounding Seilebost is low.

The small settlements of Seilebost and Losgaintir are located within the vicinity of Seilebost fishery. Seilebost located on the southern shoreline consists of approximately a dozen houses along the road running adjacent to the shoreline. Seilebost primary school, which appears on the OS map on a spit of land west of Seilebost, closed in June 2013. Losgaintir on the northern shoreline is slightly larger with approximately thirty five dwellings observed during the shoreline survey. Census output area S00072805, which surrounds Seilebost and includes Taransay (which is not populated), covers 67 km^2 and has a total population of 85. The adjacent census output area S00072803 covers 24 km^2 and has a total population of 62. It is likely that the dwellings surrounding Seilebost are accountable for majority of the population in S00072805 and therefore the overall population density shown in Figure 3.1 is not representative in this case. During the shoreline survey, two tents and two caravans were observed on the northern shoreline. No other tourist accommodation was observed.

There is a large campsite at Horgabost that provides space for touring caravans and tents, and has public toilets.

During the shoreline survey no piers were observed and a single sailing boat was seen out to sea. Two anchorages were identified on the Admiralty Chart for the area (UKHO, 2011). These are located opposite Seilebost located on the eastern coastline of Taransay.

Overall, impacts from human sources to the water quality of the shellfish bed are likely to be low due to the low population density of the area, with any effects predominating in the north where the greater concentration of dwellings are located.

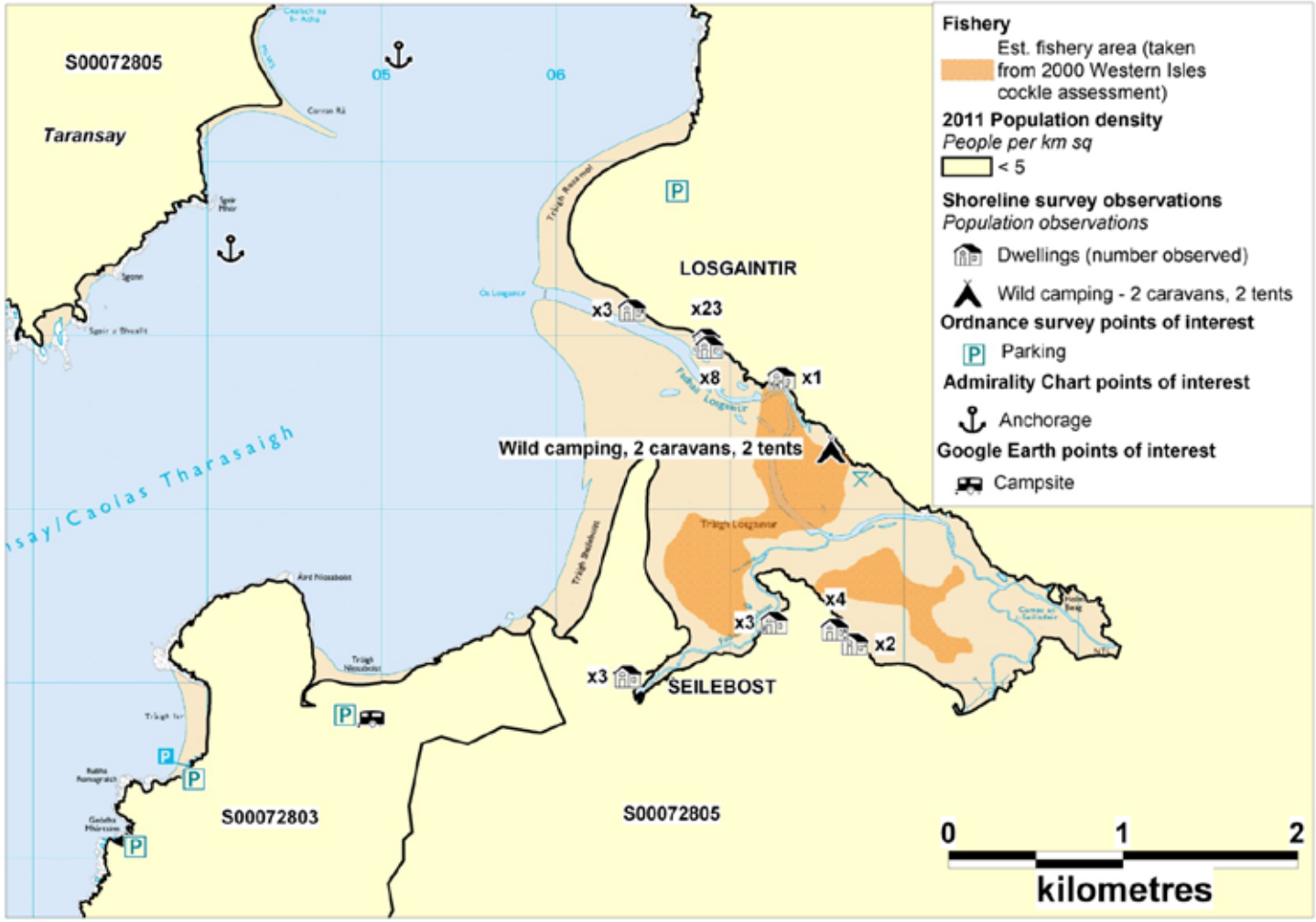

Figure 3.1 Population map for the area in the vicinity of Seilebost

4. Sewage Discharges

Information on sewage discharges within a 5 km area around point NG 07283 97918 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, freshwater body or sea), any available dispersion or dilution modelling studies, and whether improvements were in work or planned.

Scottish Water and SEPA datasets were compared to each other. Where differences or omissions were observed, clarification was sought from the data providers.

Scottish Water Discharges

Scottish Water provided information on two septic tanks (Table 4.1), Seilebost North WWTW and Seilebost South WWTW, which both discharge to the intertidal area of Luskentyre sands, and therefore directly into the production area, as shown in Figure 4.1. Scottish Water did not provide the discharge licence or population equivalent for Seilebost North and Seilebost South. When cross referenced with data provided by SEPA (Table 4.2), these two STs appeared to correspond with those named Seilebost 1 and Seilebost 2 in the SEPA dataset.

No CSOs or EOs were identified as being present in the area.

Table 4.1 Scottish Water Sewage Discharges

Discharge Name	Discharge Licence	NGR of discharge	Level of Treatment	DWF m^3/d	PE	Shoreline survey observation
SEILEBOST NORTH WWTW	- (See Table 4.2 Seilebost 1)	NG 0789 9911	Septic Tank	-	- (See Table 4.2 Seilebost 1)	-
SEILEBOST SOUTH WWTW	- (See Table 4.2 Seilebost 2)	NG 0726 9734	Septic Tank	-	- (See Table 4.2 Seilebost 2)	See Table 4.3. No.3

DWF=Dry Weather Flow, PE=Population Equivalent, - = No data provided

Consented Discharges (SEPA)

SEPA provided information on a total of 42 consented discharges in the requested area. Those considered most relevant in terms of potential contribution to faecal contamination at the fishery are listed in Table 4.2 and shown in Figure 4.1. A total of 27 consented discharges were considered to be potentially impacting on the production area. Incomplete information was received regarding the nature of some of the discharges, and where data is missing

No discharge type was given for 11 of the consents in Table 4.2. These were queried with SEPA but no response had been received by the date of publication of this report. Therefore as population equivalents were given for 11 of those consents, they were assumed to relate to primary discharges from private septic tanks. The discharge type of two discharges remains unidentified, but they are likely to be private primary discharges from domestic septic tanks, with low PE.

No consent was received for the public toilets at Horgabost Campsite, circled in red in Figure 4.1. Any discharge from this facility is likely to be a significant seasonal sewage input to the outer part of the bay.

The majority of the other consents were for private septic tanks that discharge into waters outside the production area or to inland water bodies and are not considered to be impacting the production area. Other consents related to one impoundment, one bridging culvert and three sheep dips.

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Table 4.2 Consented discharges in vicinity of production area

No.	Licence No.	NGR*	Site Name	Discharge Type	Discharges to	PE
1	WPC/N/70204	NG 0726 9736	Seilebost 2	Sewage (Public) Primary	Unknown tributary	20
2	WPC/N/70205	NG 0791 9711	Seilebost 1	Sewage (Public) Primary	Sound of Taransay	30
3	CAR/R/1026440	NG 0639 9702	6 Seilebost, Isle of Harris	Sewage (Private) Primary	Unnamed tributary of Abhainn Sheileboist	6
4	CAR/R/1048346	NG 0769 9725	17 Seilebost, Isle Of Harris	Sewage (Private) Primary	Unknown tributary of Fadhail Sheileboist	5
5	CAR/R/1048626	NG 0614 9721	3 Seilebost, Isle of Harris	Sewage (Private) Primary	Soakaway	5
6	CAR/R/1050565	NG 0667 9955	8 Luskentyre, Isle of Harris	#	-	6
7	CAR/R/1053689	NG 0690 9899	10 Luskentyre, Isle of Harris	#	-	5
8	CAR/R/1053690	NG 0692 9897	Seaview, Luskentyre, Isle of Harris	#	-	5
9	CAR/R/1055806	NG 0598 9716	1 Seilebost, Isle of Harris	Sewage (Private) Primary	Soakaway	5
10	CAR/R/1056511	NG 0748 9859	7 Luskentyre, Isle of Harris	#	-	5
11	CAR/R/1056611	NG 0813 9680	20 Seilebost, Isle of Harris	Sewage (Private) Primary	-	5
12	CAR/R/1056622	NG 0811 9675	The Cottage, 20 Seilbost, Harris	#	-	5
13	CAR/R/1057278	NG 0669 9686	10 Seilebost, Isle of Harris	#	-	5
14	CAR/R/1059730	NG 0680 9927	6 Luskentyre, Isle of Harris	Sewage (Private) Primary	Soakaway	5
15	CAR/R/1059735	NG 0700 9913	4A Luskentyre, Harris	#	-	5
16	CAR/R/1059843	NG 0708 9902	Rosamol, 3 Luskentyre, Isle of Harris	Sewage (Private) Primary	Unnamed watercourse	5
17	CAR/R/1059926	NG 0696 9903	4 Luskentyre, Isle of Harris	Sewage (Private) Primary	-	5
18	CAR/R/1059998	NG 0601 9723	Fiscavaig, 1A Seilebost, Isle of Harris	Sewage (Private) Primary	Soakaway	6
19	CAR/R/1065603	NG 0500 9571 $	1 Horgabost	#	-	5
20	CAR/R/1066383	NG 0684 9914	Atlantic Cottage, Luskentyre	#	-	5
21	CAR/R/1066392	NG 0684 9922	5 Luskentyre, Isle of Harris	Sewage (Private) Primary	Soakaway	5
22	CAR/R/1066407	NG 0732 9877	Shore Cottage, Luskentyre, Isle of Lewis	Sewage (Private) Primary	Soakaway	5
23	CAR/R/1076621	NG 0701 9928	5 Luskentyre, Isle of Harris	#	-	5

24	CAR/R/1078394	NG 0724 9895	Barabhas, 2 Luskentyre, Isle of Harris	Sewage (Private) Primary	Soakaway	6
25	CAR/R/1087242	NG 0986 9697	Luskentyre Rd A859 Temp Site Office	Sewage (Private) Secondary	Soakaway	5
26	CAR/R/1096522	NG 0493 9600 $	Beannachd, 2 Horgabost, Isle of Harris	Sewage (Private) Primary	Soakaway	7
27	CAR/R/1097651	NG 0725 9893	2B Luskentyre, Isle of Harris	#	-	5

- =No data provided, * =NGRs rounded to nearest 10 m, # =assumed Sewage Primary due to PE having been provided by SEPA, $ = lies outside boundary of map in Figure 4.1.

Shoreline Survey Discharge Observations

Sewage-related observations recorded during the shoreline survey are shown below in Table 4.3.

Table 4.3 Discharge-associated observations made during the shoreline survey

No.	Date	NGR	*E. coli* cfu/100ml (Sample No.)	Description
1	23/07/2013	NG 0688 9893	N/A	Concrete structure in front of house behind river, probable septic tank.
2	24/07/2013	NG 0790 9710	3800 (LSSW2)	Public discharge onto shore, smell of sewage. Discharge appears to be piped underground and covered over with stones until it reaches the beach.
3	24/07/2013	NG 0725 9735	630000 (LSFW9)	Watercourse running from under road onto shore. Strong smell of sewage.

Observation 1 relates to a concrete structure assumed to be a septic tank. No discharge was noted during the shoreline survey. This structure looks like it may be a septic tank with overflow pipe, and based on its location may relate to either consent CAR/R/1053689 or CAR/R/1053690.

Observation 2 relates to the Seilebost North septic tank discharge, which flowed via a pipe buried under rocks until it reached the shore. A seawater sample taken from near the end of the pipe returned a result of 3800 *E. coli* cfu/100ml, which was indicative of moderate faecal contamination.

Observation 3 relates to a small, unnamed watercourse culverted under the road, which discharges to the foreshore. The sample taken from this watercourse returned a result of 630000 *E. coli* cfu/100ml which indicated a high level of faecal contamination entering the production area from this watercourse. This is reinforced by the observed strong smell of sewage on the shore. This is presumed to come from the Seilebost South public septic tank (WPC/N/70204).

Summary

The Seilebost South septic tank discharges on the south west shoreline of the production area and has a PE of 20. A water sample taken from near the outfall of this location returned a relatively high value of 630000 *E. coli* cfu/100ml.

The outfall for the Seilebost North septic tank was found further east of Seilebost, and a seawater sample taken from near the end of the pipe returned a result of 3800 *E. coli* cfu/100 ml.

The majority of the other consents which discharge into the production area are private septic tanks and are clustered around Luskentyre (Losgaintir on the OS map) and spread along the road through Seilebost.

At least one significant unconsented discharge from the campsite at Horgabost is likely to be a significant source of sewage to the outer bay during the tourist season.

Subsequent to distribution of the draft report, the sampling officer

List of Acronyms

CSO	Combined Sewage Overflow
DWF	Dry weather flow
EO	Emergency Overflow
FE	Final Effluent
PE	Population Equivalent
PS	Pumping Station
ST	Septic Tank
WWPS	Wastewater Pumping Station
WWTW	Wastewater Treatment Work

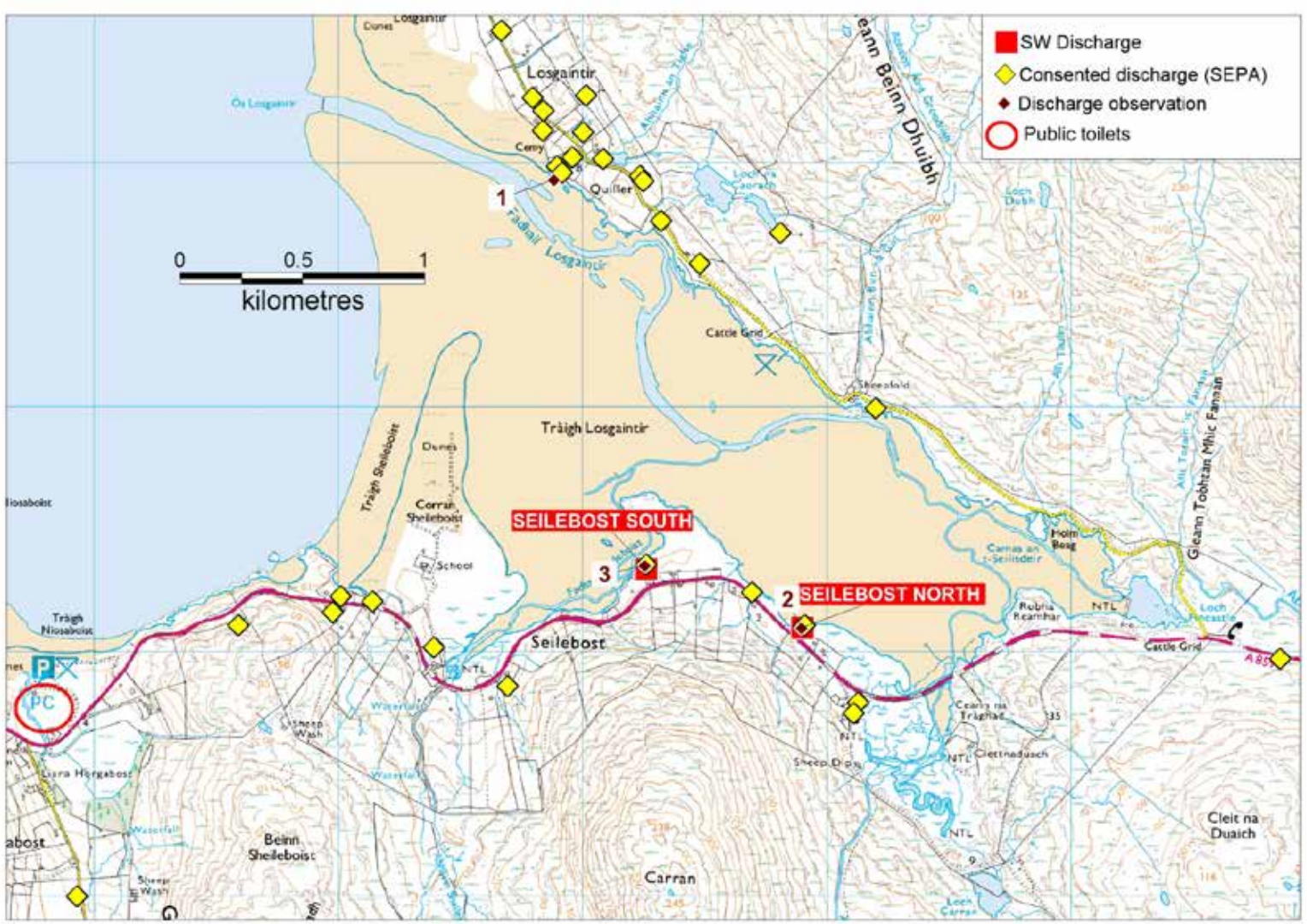

Figure 4.1 Map of discharges near the Seilebost production area

5. Agriculture

Information on the spatial distribution of animals on land adjacent to or near the fishery can provide an indication of the potential amount of organic pollution from livestock entering the shellfish production area. Agricultural census data to parish level was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the Harris parish. Reported livestock populations for the parish in 2012 are listed in Table 5.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data. Any entries which relate to less than five holdings, or where two or fewer holdings account for 85% or more of the information, are replaced with an asterisk.

Table 5.1 Livestock numbers in the Harris agricultural parish 2012

	Harris	
	502 km^2	
	Holdings	Numbers
Pigs	*	*
Poultry	44	597
Cattle	35	442
Sheep	233	30,621
Other horses and ponies	*	*

The livestock census numbers relate to a very large parish area (covering the whole Isle of Harris), therefore it is not possible to determine the spatial distribution of the livestock in relation to the Seilebost area or identify how many animals are likely to impact the catchment around the fishery. Therefore the figures are of little use in assessing the potential impact of livestock contamination to the fishery; however they do give an idea of the total numbers of livestock over the broader area. Sheep are the dominant livestock in the parish. Poultry and cattle are present in low numbers. The number of pigs and other horses and ponies were not reported due to the small number of holdings.

The South Harris Agricultural Show takes place every July at Leverburgh approximately 12 km southwest of Seilebost. A large number of livestock including cattle, sheep and poultry are shown each year. Due to the distance of the location from Seilebost, the show is not likely to have an impact on the extent of faecal contamination at the Seilebost fishery.

A source of spatially relevant information on livestock population in the area was the shoreline survey (see Appendix 5) which only relates to the time of the site visit on the 7th July 2013 (see Table 5.1). Observations made during the survey are dependent upon the viewpoint of the observer some animals may have been obscured by the terrain. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 5.1.

During the survey sheep were observed grazing along the shoreline adjacent to the fishery. In total approximately 86 sheep were observed grazing along the southern shoreline and 16 sheep were observed along the northern shoreline. A sheep fold was also present on the northern shoreline.

Numbers of sheep will be approximately double during late spring following the birth of lambs, and decrease again in the autumn when they are sent to market.

Any contributions of faecal contamination from livestock grazing in the area would be most likely to affect the areas of shellfish bed closest to the shoreline. The distribution of animals observed at the time of the shoreline survey implies that the impact would be greatest on the southern side of the bed: however, the distribution may change with time.

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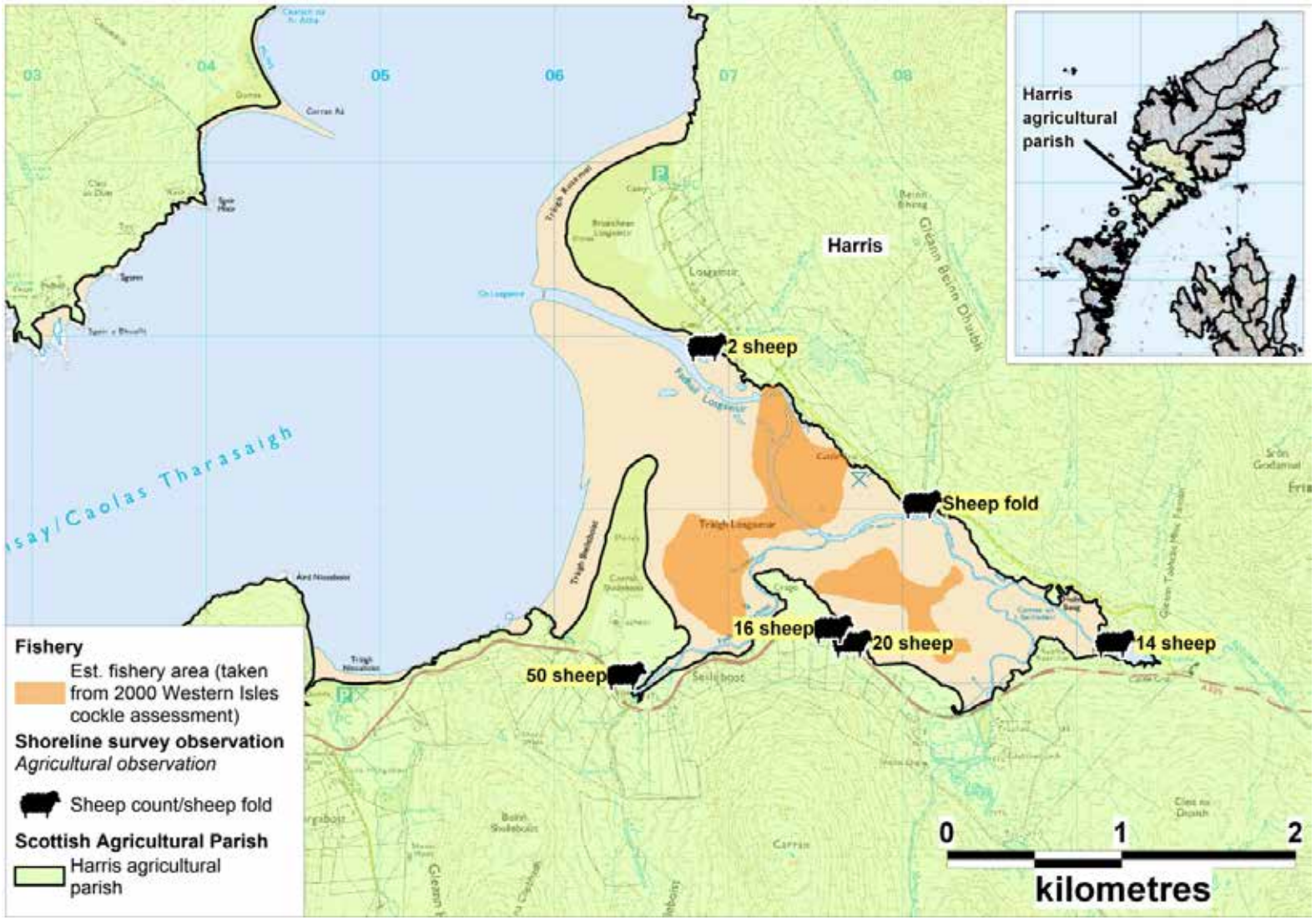


Figure 5.1 Agricultural parish boundary and livestock observations

6. Wildlife

Wildlife species present in and around the production area will contribute to background levels of faecal contamination at the fishery, and large concentrations of animals may constitute significant sources when they are present. Seals, cetaceans and some seabirds may deposit faeces directly into the sea, while 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 at the Seilebost common cockle fishery are considered below.

Pinnipeds

The Outer Hebrides forms an important colony of both Harbour and grey seals. In a report by SCOS (2012) it was noted that the harbour seal population in the Outer Hebrides was in decline, and had decreased by 35% since 1996, equating to 3% per annum. From a study by SMRU it is estimated that the colony close to Seilebost comprises of <100 individuals. Comparatively the grey seal population is experiencing a population boom, with 12857 pups born in 2010, a 6.14% increase on the 2009 population.

No seals were observed during the shoreline survey.

Cetaceans

The west coast of the Isle of Lewis is an area where marine cetaceans are often spotted. The Whale and Dolphin Trust report both large cetaceans including whales, as well as smaller dolphins and porpoise (Hebridean Whale and Dolphin Trust, 2013). They are unlikely to frequent the shallow area at Seilebost.

Birds

Seabird 2000 census data (Mitchell, et al., 2004) was queried for the area within a 5 km radius of the Seilebost production area and is summarised in Table 6.1 below and displayed in Figure 6.1. This census undertaken between 1998 and 2002 covered the 25 species of seabird that breed regularly in Britain and Ireland.

Table 6.1 Seabird counts within 5 km of the Seilebost

Common name	Species	Count*	Method
Arctic tern	*Sterna paradisaea*	22	Occupied nests

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

The only record for the survey area in the Seabird 2000 data was of a nesting colony of Arctic terns. This species is migratory and only comes to UK shores during the

summer. Any impact from faecal contamination contributed by this colony would be during the summer months.

During the shoreline survey, birds were the only species that was identified during the survey. Eight terns were noted close to the location of the known Arctic tern nesting site; species included Arctic, Common and Little terns. Gulls were the most regularly spotted species, with one single count of 40 birds. Other birds noted included oystercatchers, crows and a four ringed plover. It is likely that many different bird species will use the sand banks at Seilebost to rest and forage on and it is expected that their populations will vary from day to day.

Deer

Red Deer are known to have been introduced to the Outer Hebrides, and are now reported as being prevalent in all areas, particularly on higher grounds. On Lewis and Harris alone, 4000 Red deer are stated as being present (Visit Hebrides, 2013). No population data was found for Seilebost in particular. There are no areas of woodland nearby to Seilebost, but the area is backed by highland, which is expected to support red deer herds. It is expected that contamination impacts from deer will be low and variable .

Otters

The Eurasian otter (*Lutra lutra*) is known to be common on Lewis in the Outer Hebrides; however no reports of otters around Seilebost were available at the time of drafting. No otters were observed during the shoreline survey.

Overall

Contributions from wildlife to faecal contamination levels at the fishery are expected to be modest, with seabirds contributing most directly at the location of the cockle bed. A breeding colony of terns, as well as gulls and wading birds are present at or very near the cockle bed and droppings deposited at low tide will be resuspended and available for uptake by the cockles as the tide comes in. Seasonal variation in the numbers and types of bird present is expected, though little specific data on this variation was found.

Given the location of the nesting site, other seabird observations, and the small size of the area, it is expected that any effects may eb seen across the whole cockle bed. Impacts of other wildlife species are expected to be low and unpredictable in location and time.

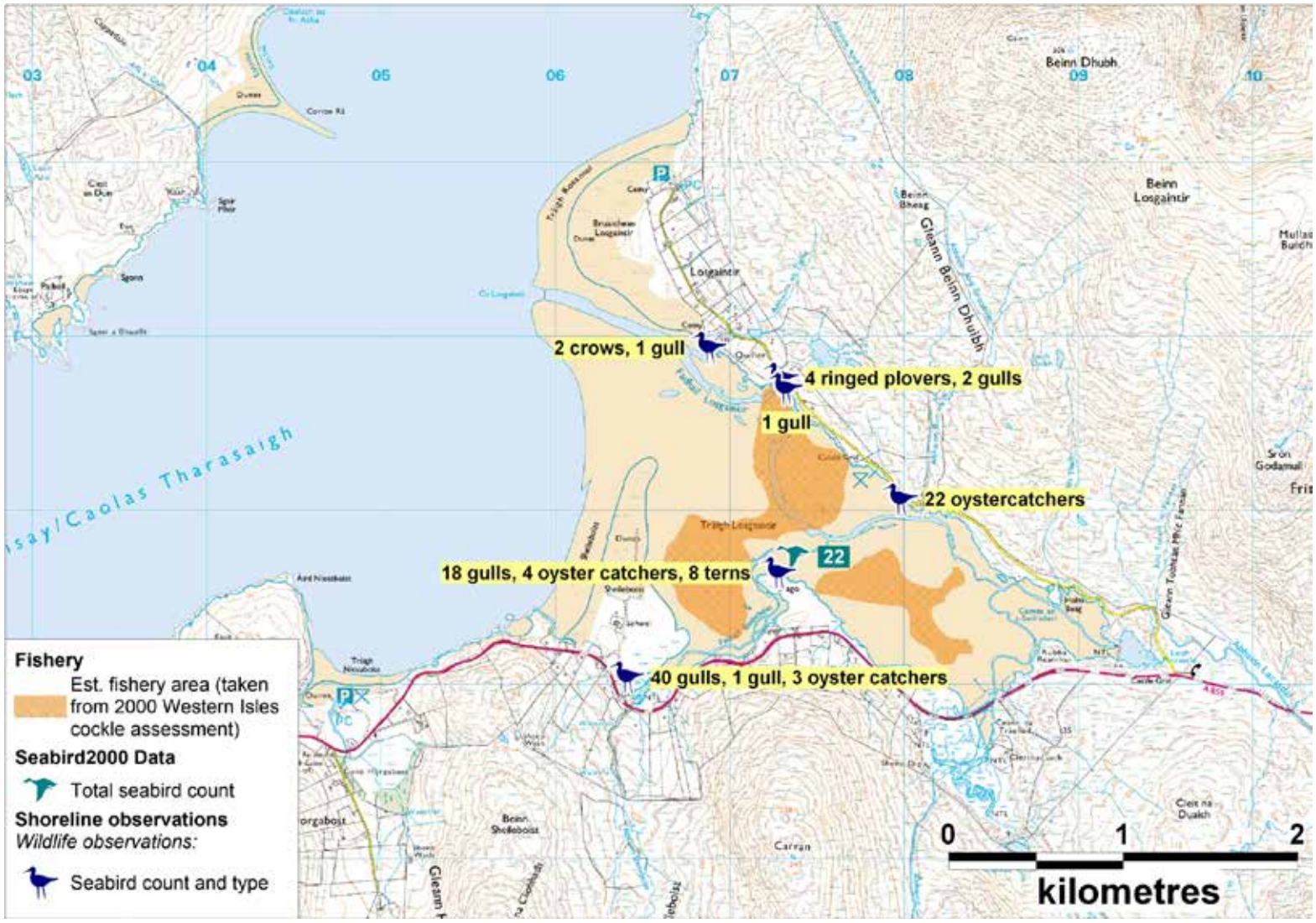


Figure 6.1 Map of wildlife around Seilebost

7. Land Cover

The Land Cover Map 2007 data for the area is shown in Figure 7.1 below:

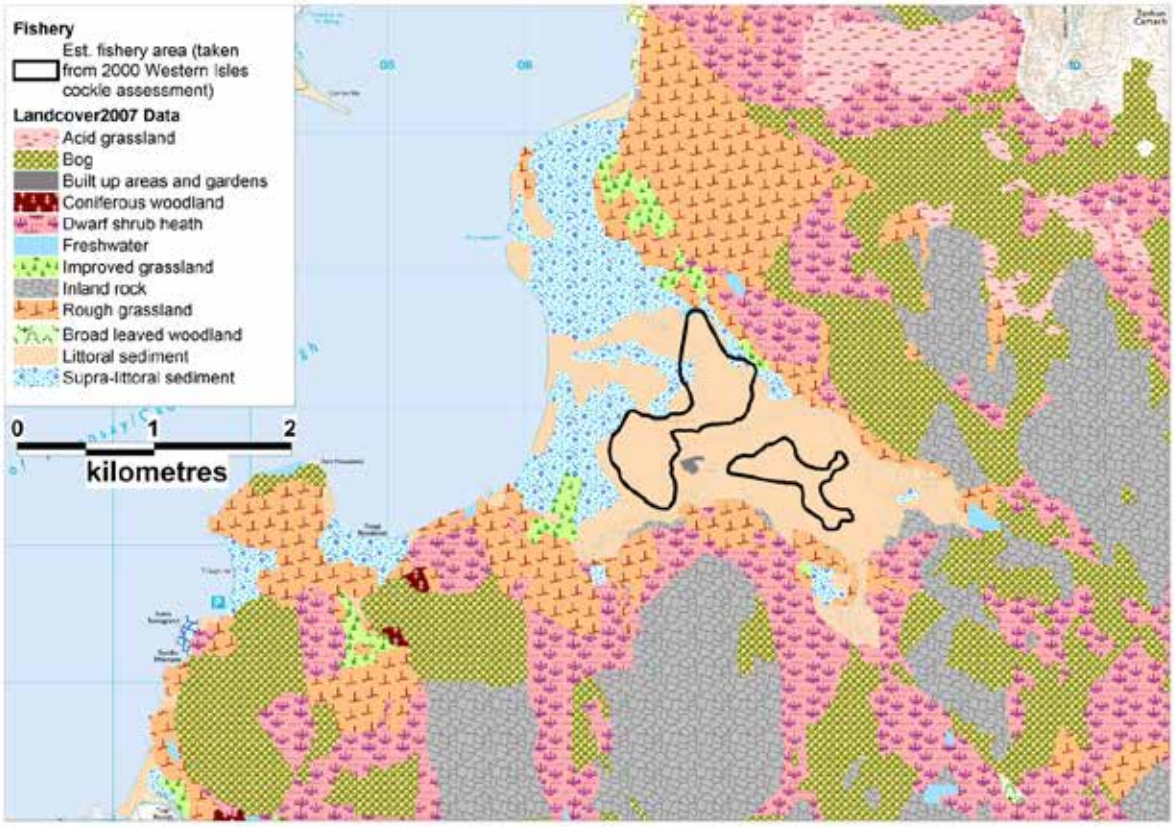


Figure 7.1 LCM2007 land cover data for the area around Seilebost

Rough grassland, dwarf shrub heath, bog, inland rock and improved grassland are the predominant land cover types on the shoreline adjacent to the Seilebost fishery. The areas of improved grassland are situated on the northwestern and southwestern shorelines.

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

The highest potential contribution of contaminated run-off to the Seilebost fishery is from the areas of improved grassland located along the north-western and south-western shorelines at the western extent of the shellfish bed. The potential contribution of contaminated run-off to the shellfish farm would be highest in this area.

8. Watercourses

There are no gauging stations on watercourses entering into Seilebost.

Information on flows and microbial content was only available from the shoreline survey conducted on the 23rd and 24th July 2013. The weather was noted to the warm and dry in the 48 hrs prior to the survey, and on both survey days, except for one heavy shower on the first survey day. The watercourses listed in Table 8.1 are noted to be the most significant freshwater inputs to the Seilebost area.

At the time of the shoreline survey flows for two named watercourses on the northern side of the shore could not be assessed; Abhainn Bun na Gill had no flowing water and the flow of Allt Thuilm was disrupted by stones.

Table 8.1 Watercourses entering the Seilebost survey area

No.	NGR	Description	Width (m)	Depth (m)	Flow (m^3/d)	Loading (*E. coli* per day)
1	NG 0686 9898	Abhainn an Tighe	0.26	1.60	1000	$4.8x10^9$
2	NG 0730 9876	Unnamed watercourse	0.55	0.02	0.7	$1.6x10^6$
3	NG 0793 9815	Land drainage	-	-	0.5	$3.1x10^6$
4	NG 0922 9723	Abhainn Lacasdal (via Loch Fincastle)	1.00	0.15	4500	$9.1x10^8$
5	NG 0772 9723	Piped burn	0.50	0.02	0.5	$5.2x10^8$
6	NG 0725 9735	Unnamed Watercourse	0.70	0.03	1.3	$8.2x10^9$
7	NG 0645 9688	Abhainn Sheileboist	2.20	0.10	2500	$2.5x10^8$
8	NG 0852 9692	Abhainn Gil an Tailleir	3.00	0.83	9300	$3.3x10^{10}$

-No Data available

There are a large number of watercourses entering into the sands at Seilebost. The largest flows are from Abhainn Lacasdal at the head and Abhainn Sheileboist and Abhainn Gil an Tailleir on the shouth shore. The highest estimated loading was from Abhainn Gil an Tailleir at 3.3×10^{10} *E. coli* per day. Other significant freshwater inputs included Abhainn an Tighe (4.8×10^9 *E. coli* per day) to the northwest of the cockle bed and an unnamed watercourse (number 7; 8.2×10^9 *E. coli* per day) which enters near to the Crago. This unnamed watercourse may actually have been the outfall from the Seilebost South septic tank, as the water sample returned a very high E. coli result (630000 cfu/100 ml).

At the time of the shoreline survey, the estimated loadings were low to moderate. However, due to the proximity to the shellfish bed, they will potentially have a significant impact on microbiological quality. Loadings would be expected to increase

after significant rainfall events. The impact of the watercourses entering the inner (eastern) part of the area will change over an ebbing tide as water becomes confined to the main channels. Contamination from the watercourses entering the outer (western) part of the area will be taken over the shellfish beds on the incoming tide but the extent (and dilution) will change as the tide depth increases. Due to the nature of the substrate, the sand banks at Seilebost are likely to shift with time and will result in freshwater channel formation also changing. This may result in differences in the impact that each watercourse will have on the cockle bed over time.

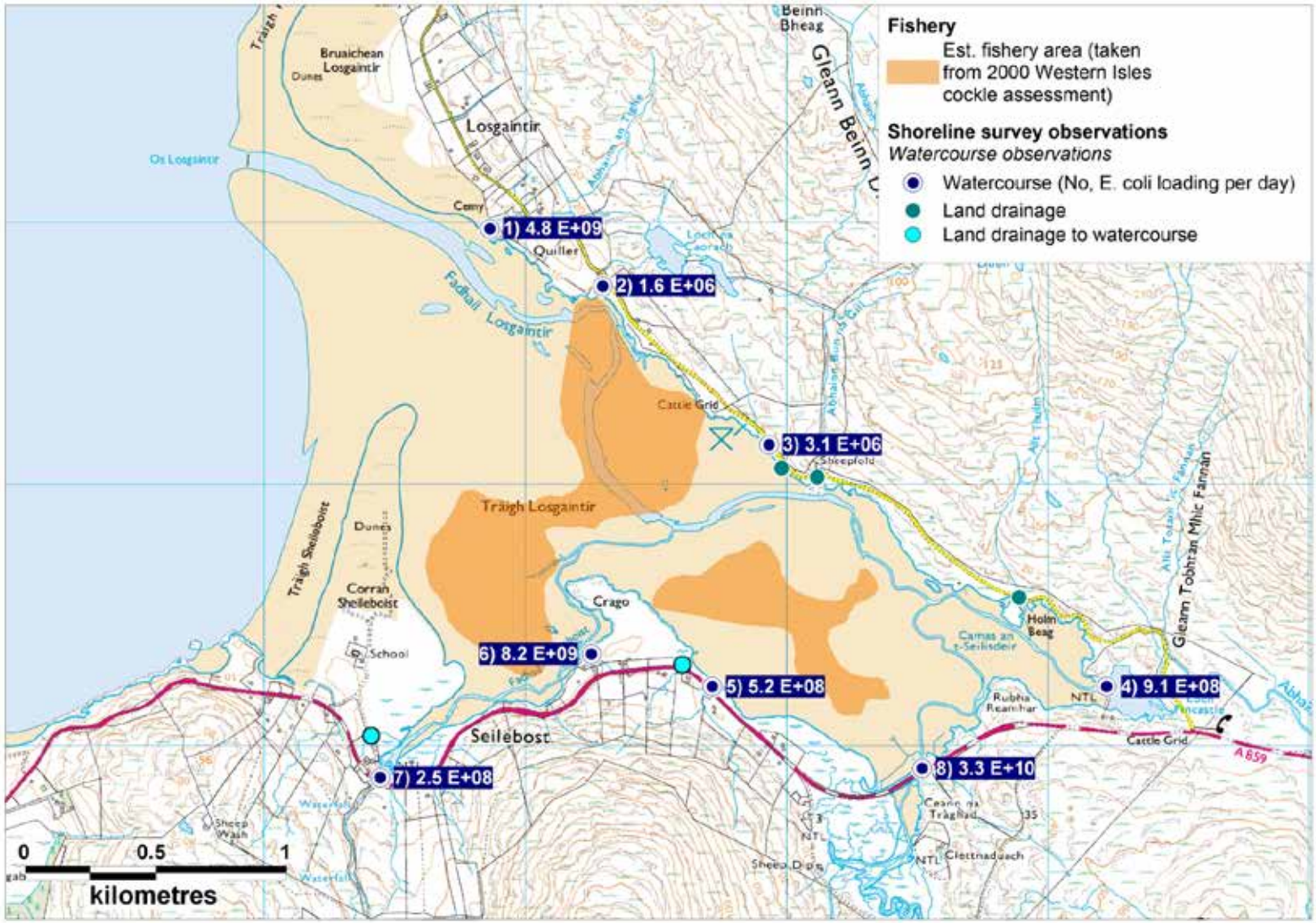


Figure 8.1 Map of watercourse loadings at Seilebost

9. Meteorological Data

The nearest weather station for which rainfall data was available is located at Harris Quidnich, situated approximately 10 km to the south of the fishery. Rainfall data was available for January 2007 – December 2012. The nearest wind station is Stornoway Airport, situated approximately 55 km north east of the fishery. 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 Seilebost.

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 (e.g. (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 *.

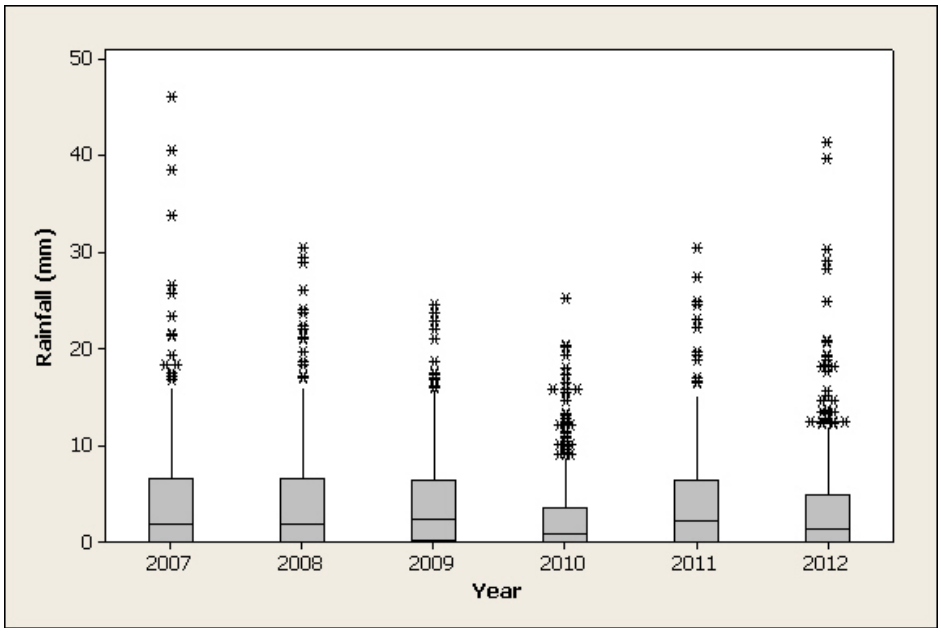


Figure 9.1 Box plot of daily rainfall values by year at Harris Quidnich (2007 – 2012)

Total rainfall varied markedly from year to year, with 2010 being the driest year (a total of 977 mm). The wettest year was 2007 (a total of 1633 mm). High daily rainfall values of more than 30 mm/d occurred in 2007, 2008, 2011 and 2012 and an extreme rainfall event of nearly 50 mm/d was seen in 2007.

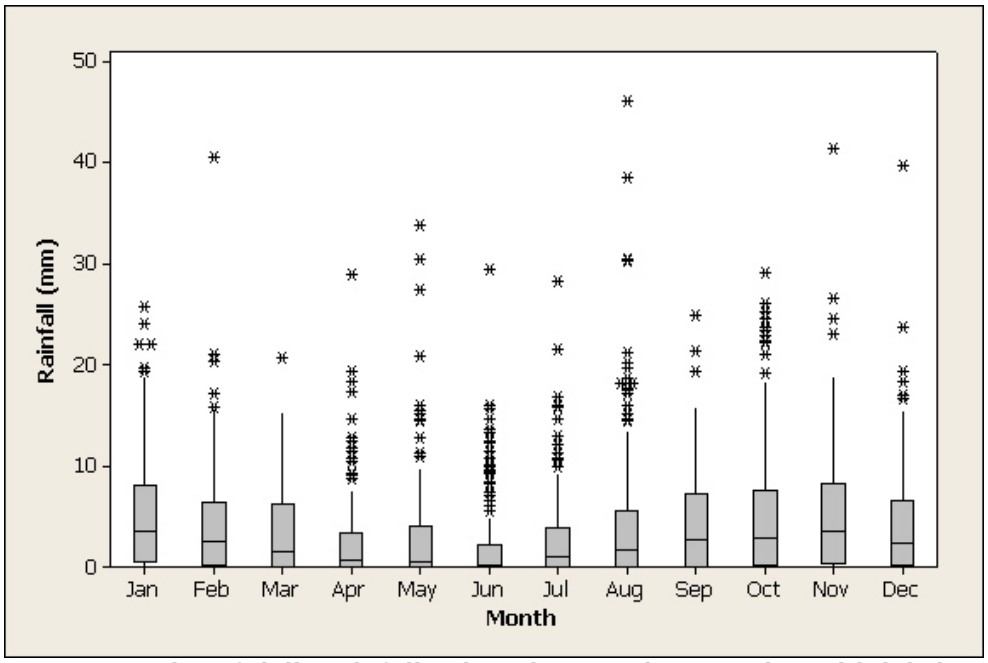


Figure 9.2 Box plot of daily rainfall values by month at Harris Quidnich (2007 – 2012)

Rainfall was lowest between April and July and highest from August to March. Rainfall values exceeding 30 mm/d were seen in February, May, August, November and December. The 2007 extreme event occurred in August.

For the period considered here (2007 – 2012) 43 % of days received daily rainfall of less than 1 mm and 12 % of days received rainfall of over 10 mm.

It is therefore expected that run-off due to rainfall will be higher during the autumn and winter months. However, extreme rainfall events leading to episodes of high runoff can occur in most months and when these occur during generally drier periods in summer and early autumn, 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 Stornoway Airport and summarised in seasonal wind roses in Figure 9.3 and annually in Figure 9.4.

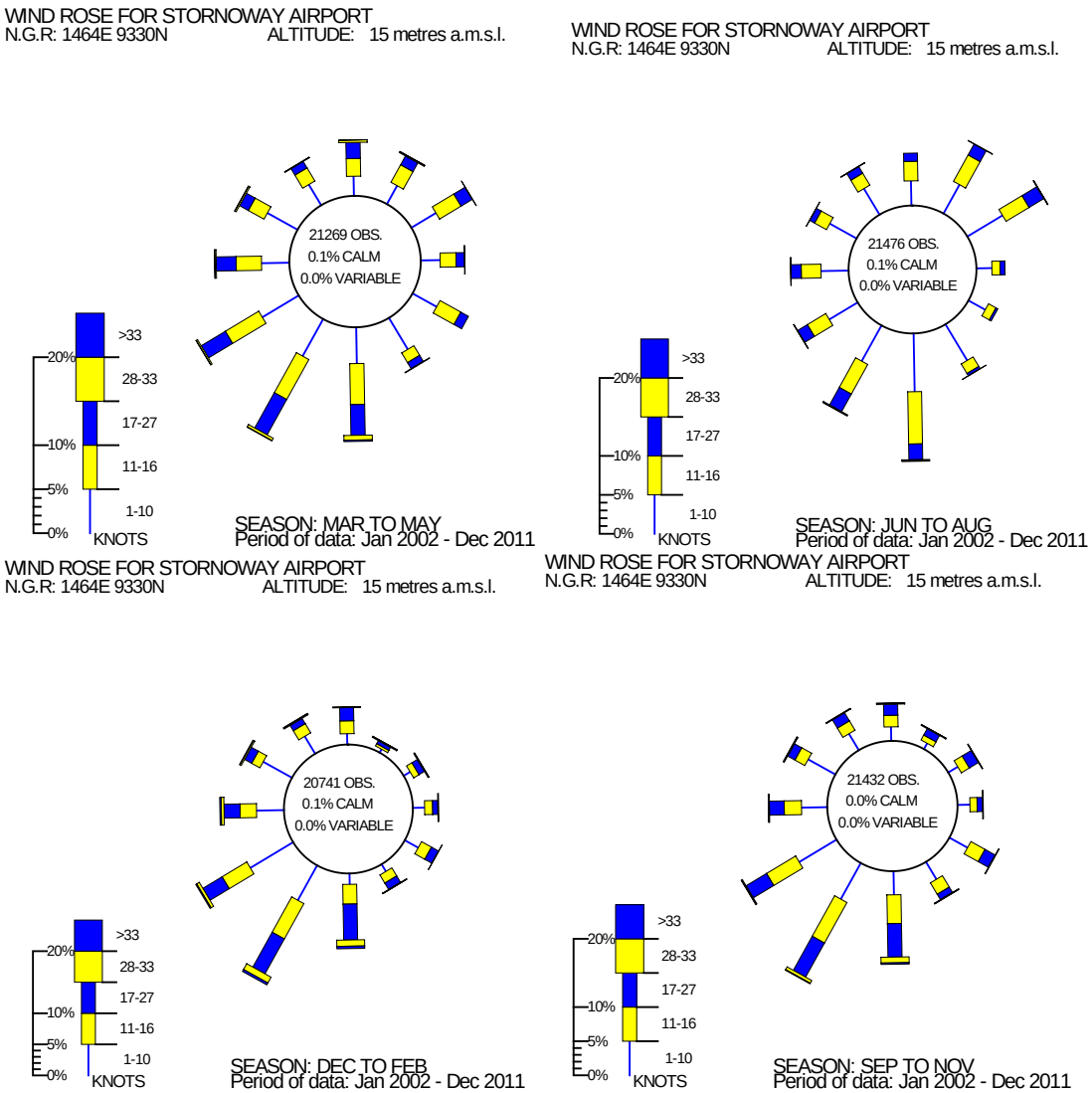


Figure reproduced under license from Meteorological Office. Crown Copyright 2012.

Figure 9.3 Seasonal wind roses for Stornoway Airport

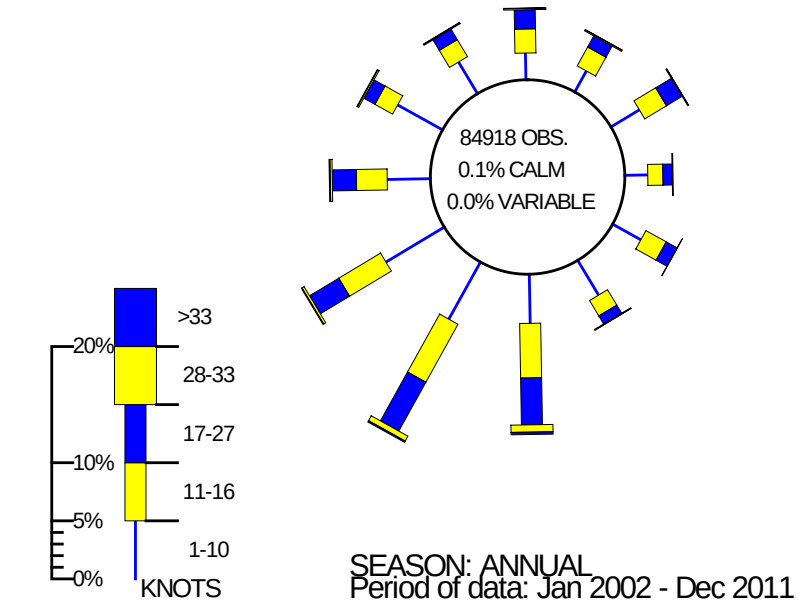


Figure 9.4 Annual wind rose for Stornoway Airport

Overall, winds were predominantly from the southwest. However, during summer, southerly winds predominated and there were also relatively strong winds from the north-west. 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 fishery area.

10. Classification Information

Seilebost has been classified for production of common cockles (*Cerastoderma edule*) since 2005. The classification history since 2008 is listed in Table 10.1. In recent years, the area has tended to hold an A classification in winter and early spring and a B classification at other times.

Table 10.1 Sielebost classification history

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

11. Historical *E. coli* Data

11.1 Validation of historical data

Results for all samples assigned against the Seilebost site for the period 01/01/2008 to the 23/09/2013 were extracted from the FSAS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. The data was extracted from the database on 23/09/2013. All *E. coli* results were reported as most probable number (MPN) per 100 g of shellfish flesh and intravalvular fluid.

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

One sample in the dataset was recorded as rejected and was deleted from further analysis. The remaining 67 samples were received by the laboratory within the 48 hr window, with all except one having a box temperature of <8^{o}C (recorded as “Validated” on the database). All sampling locations lay within the production area boundaries.

Salinity was recorded for fewer than 10 samples and the effect of salinity on results will therefore not be analysed.

11.2 Summary of microbiological results

Table 11.1 Summary of historical sampling and results

Sampling Summary	
Production area	Seilebost
Site	Seilebost
Species	Common cockles
SIN	LH-249-129-04
Location	Various
Total no of samples	67
No. 2008	12
No. 2009	11
No. 2010	12
No. 2011	12
No. 2012	12
No. 2013	8
Minimum	<20
Maximum	5400
Median	110
Geometric mean	121
90 percentile	1700
95 percentile	2400
No. exceeding 230/100g	26 (39%)
No. exceeding 1000/100g	11 (16%)
No. exceeding 4600/100g	1 (2%)
No. exceeding 18000/100g	0

Sampling has been even across years. The magnitude of the results have varied markedly, ranging from <20 to 5400 *E. coli* MPN/100 g with 16% of results being >1000 *E. coli* MPN/100 g.

11.3 Overall geographical pattern of results

The geographical locations of all sample results assigned to Seilebost have been thematically mapped in Figure 11.1. The sampling locations split roughly into two clusters; one within 150 m of the RMP (NG 0815 9772), and the other to southwest of the RMP.

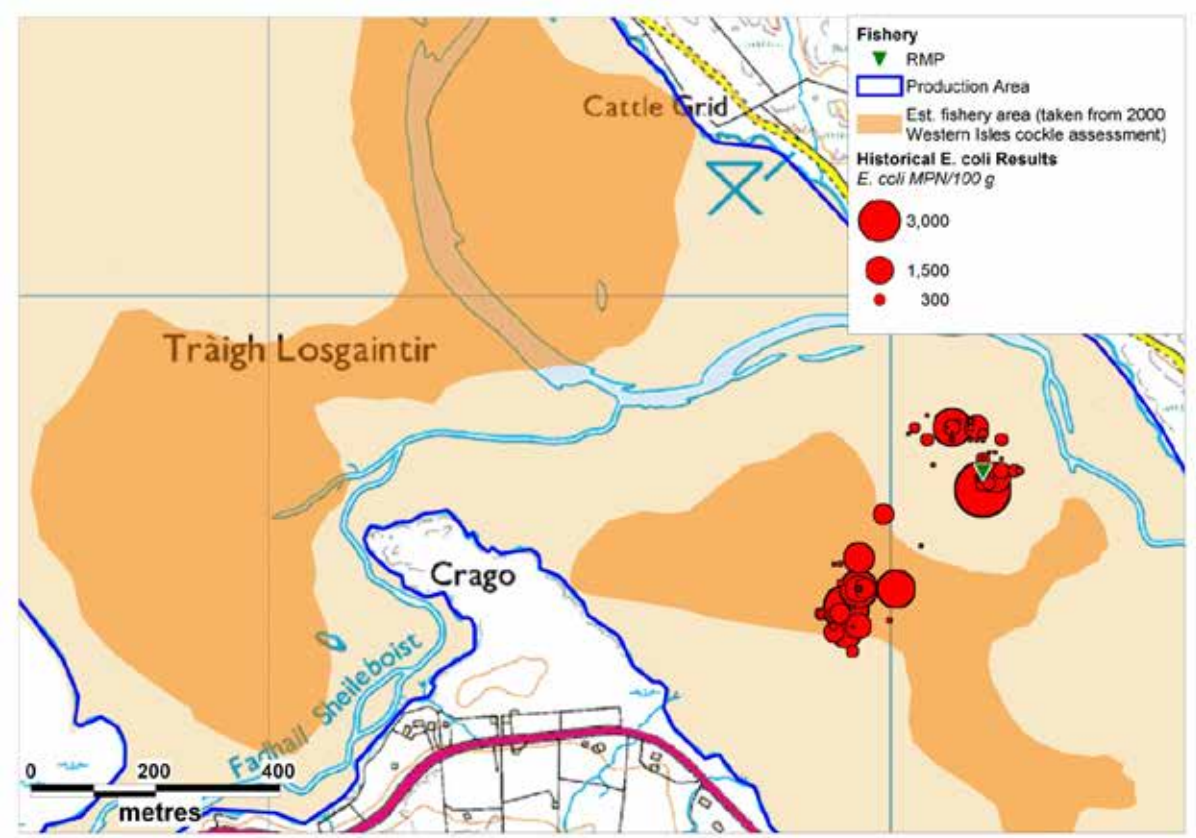


Figure 11.1 Map of reported sampling locations for common cockles at Seilebost

Samples with results of >1000 *E. coli* MPN / 100 g were taken from both areas. Seven of these came from the southern cluster and four came from the northern cluster. The highest sample result (5400 *E. coli* MPN / 100 g) from the northern cluster. A two sample t-test was conducted on log_{10}-transformed data in order to determine whether there was a statistically significant difference between the two areas. The geometric means of the results at the north and south clusters were 2.338 and 1.909, respectively.
A statistically significant difference was found between samples taken from the northern and southern sites (t value= -2.24, p= 0.029, df 55). Therefore, although the highest result was obtained from the northern cluster of sampling locations, the average level of contamination was higher at the southern cluster.

11.4 Overall temporal pattern of results

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

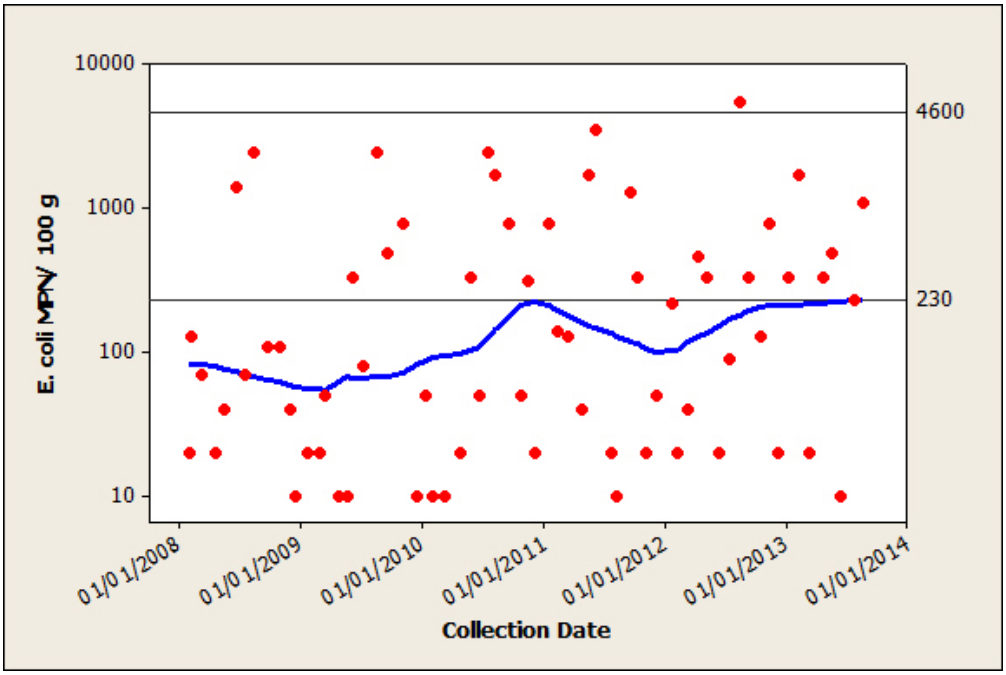


Figure 11.2 Scatterplot of *E. coli* results by collection date at Seilebost, fitted with a lowess line

The trend in contamination levels showed a slight increase over the period.

11.5 Seasonal pattern of results

Season dictates not only weather patterns and water temperature, but livestock numbers and movements, presence of wild animals and patterns in human distribution. All of these can affect levels of microbial contamination, causing seasonal patterns in results. A scatterplot of *E. coli* results by month, overlaid by a lowess line to highlight trends is displayed in Figure 11.3. Jittering was applied at 0.02 (x-axis) and 0.001 (y-axis) respectively.

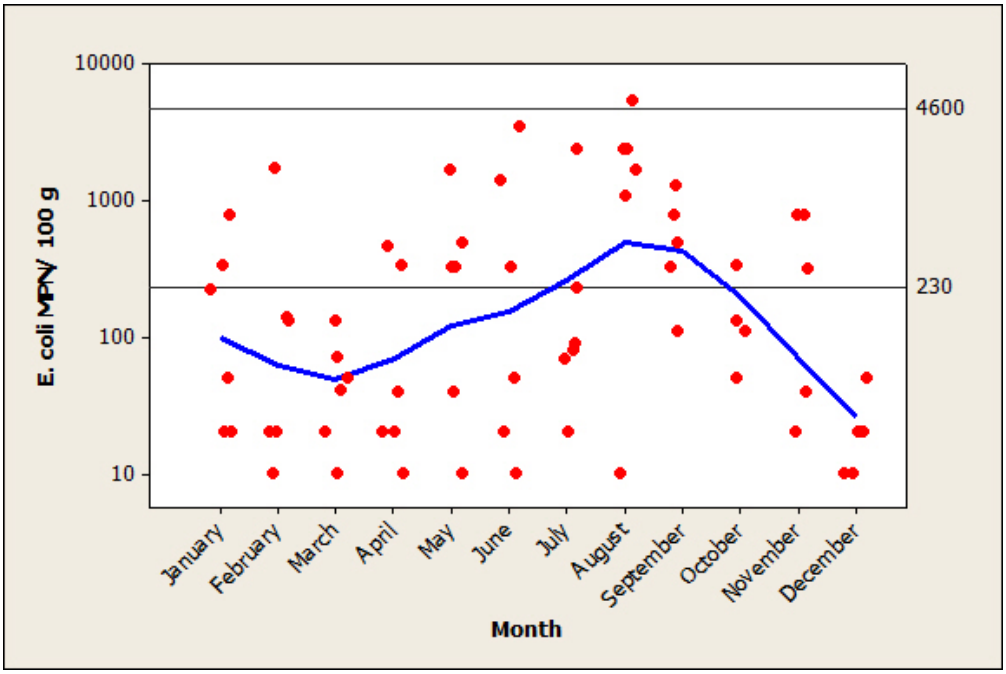


Figure 11.3 Scatterplot of *E. coli* results by month at Seilebost, fitted with a lowess line

Contamination levels show a strong seasonal increase, peaking in August before declining again.

For statistical evaluation, seasons were split into spring (March-May), summer (June-August), autumn (September-November) and winter (December-February). A boxplot of *E. coli* results by season is presented in Figure 11.4.

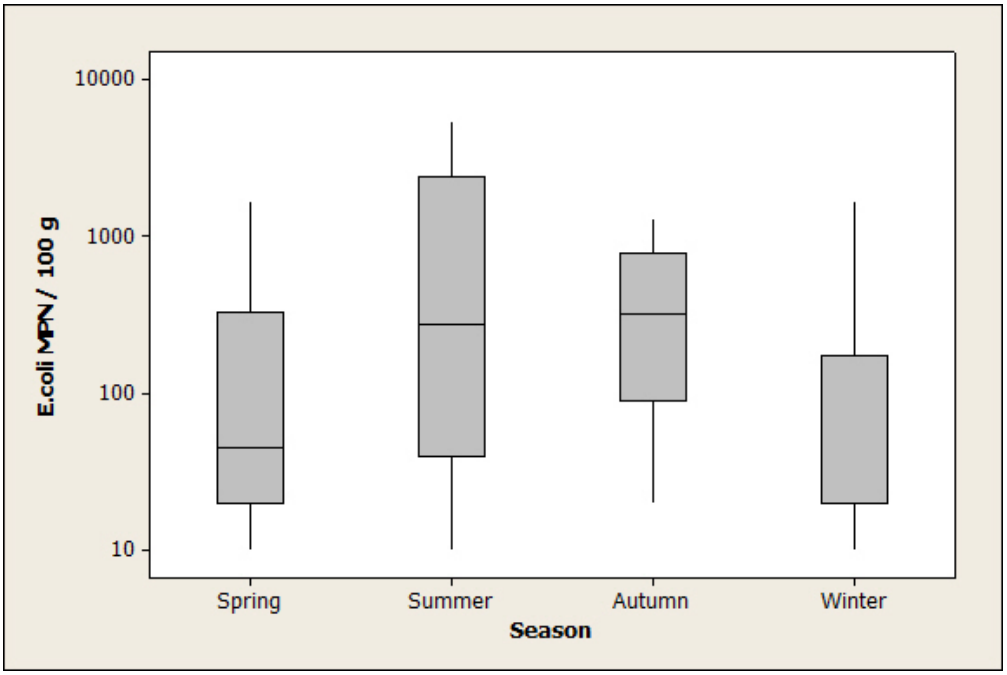


Figure 11.4 Boxplot of *E. coli* results by season at Seilebost

A significant difference was found between *E. coli* results by season (one-way ANOVA, p = 0.017, Appendix 4), with sample results in summer being higher than those taken in winter.

11.6 Analysis of results against environmental factors

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

11.6.1 Analysis of results by recent rainfall

The nearest weather station with available rainfall data was at Harris Quidnich approximately 10 km south of Seilebost. Rainfall data was purchased from the Meteorological Office for the period of 01/01/08 - 31/12/2012 (total daily rainfall in mm). Data was extracted from this for all sample results at Seilebost between 01/01/2008 – 31/12/2012.

Two-day rainfall

A scatterplot of *E. coli* results against total rainfall recorded on the two days prior to sampling is displayed in Figure 11.5. Jittering was applied to results at 0.02 (x-axis) and 0.001 (y-axis) respectively.

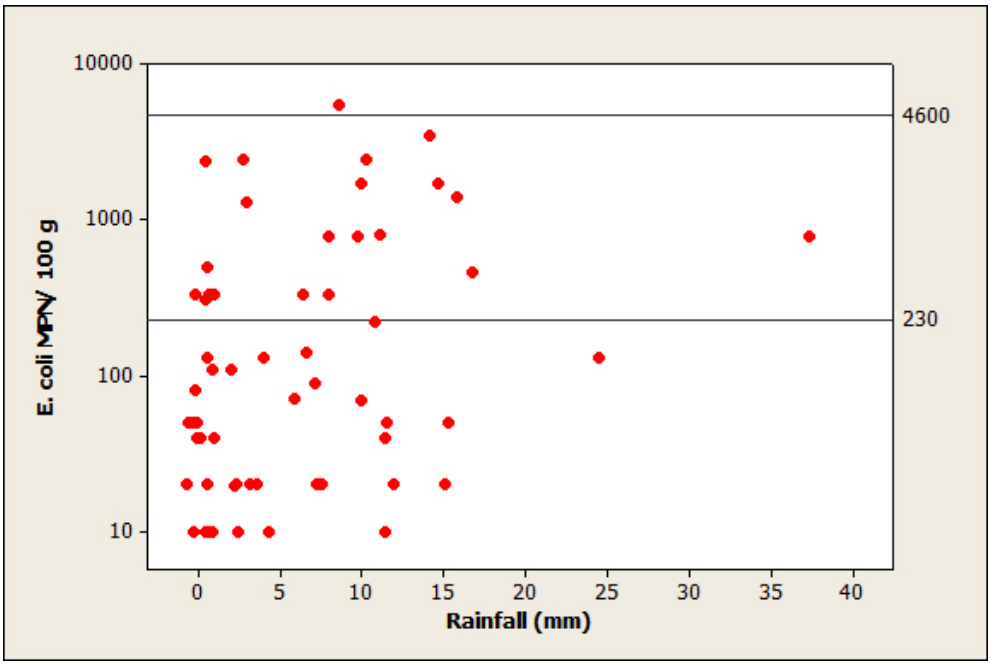


Figure 11.5 Scatterplot of *E. coli* results against rainfall in the previous two days at Seilebost

A significant correlation was found between *E. coli* results and rainfall in the previous two days (Spearman's rank correlation r = 0.323, p = 0.013).

Seven-day rainfall

The effects of heavy rainfall may take differing amounts of time to be reflected in shellfish sample results in different system, the relationship between rainfall in the previous seven days and sample results was investigated in an identical manner to the above. A scatterplot of *E. coli* results against total rainfall recorded for the seven days prior to sampling at Seilebost is shown in Figure 11.6. Jittering was applied at 0.02 (x-axis) and 0.001 (y-axis) respectively.

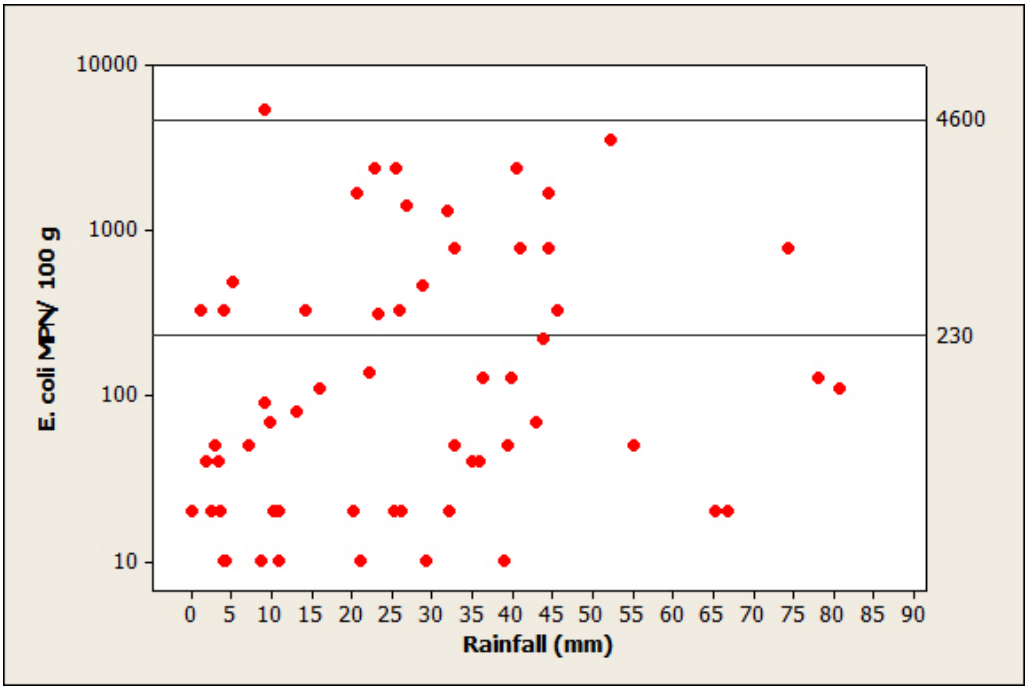


Figure 11.6 Scatterplot of *E. coli* results against rainfall in the previous seven days at Seilebost

A significant correlation was found between *E. coli* results and rainfall during the previous seven days(Spearman's rank correlation r = 0.278, p = 0.033).

11.6.2 Analysis of results by tidal cycle

Spring/neap tidal cycle

Spring tides are large tides that occur fortnightly and are influenced by the state of the lunar cycle. They reach above the mean high water mark and also increase circulation and particle transport distances from potential contamination sources on the shoreline. The largest Spring tides occur approximately two days after the full moon about 45^{o}, then decreases to the smallest neap tides at about 225^{o}, before increasing back to spring tides 0^{o}. Figure 11.7 presents a polar plot of *E. coli* results against the lunar cycle**.** It

should be noted local meteorological conditions (e.g. wind strength and direction) can also influence tide height, but is not taken into account in this section.

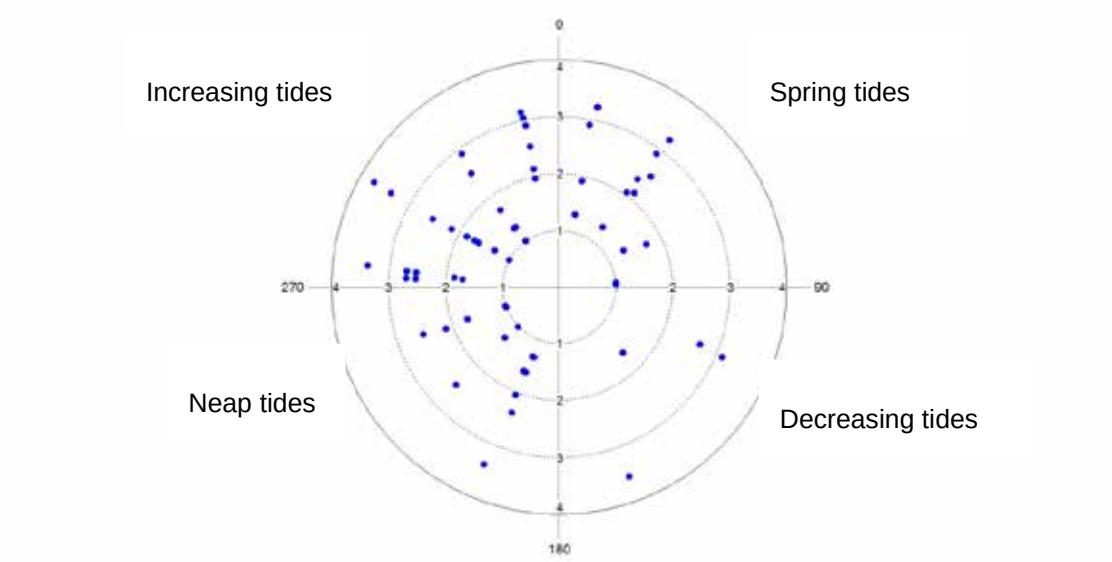


Figure 11.7 Polar plots of log_{10} *E. coli* results against the spring/neap tidal cycle at Seilebost

No significant correlation was found between log_{10} *E. coli* results and the spring/neap tidal cycle (circular-linear correlation r = 0.166, p = 0.17). The majority of samples were taken on increasing tides.

High/low tidal cycle

Tidal state (high/low tide) changes the direction and strength of water flow around production areas. Depending on the location of contamination sources, tidal state may cause marked changes in water quality near the vicinity of the farms. Shellfish species response time to *E. coli* levels can vary from within an hour to a few hours. Figure 11.8 presents a polar plot of *E. coli* results against the high/low tidal cycle. High water is at 0^o and low water at 180^o.

High and low water data from West Loch Tarbert was extracted from POLTIPS-3 in August 2013. This site was the closest to the production area (approximately 6 km to the northwest) and it is assumed that tidal state will be similar between sites.

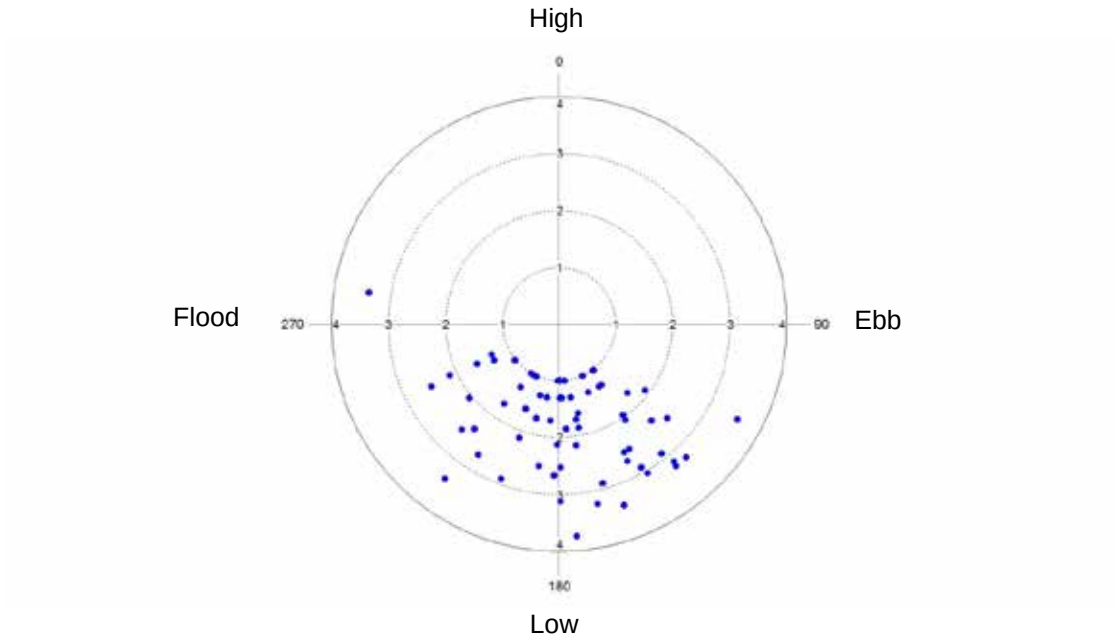


Figure 11.8 Polar plots of log_{10} *E. coli* results against the high/low tidal cycle at Seilebost

A significant correlation was found between log_{10} *E. coli* results and the high/low tidal cycle (circular-linear correlation r = 0.329, p = 0.001). As expected for the type of fishery, the majority of samples were taken around low tide. Higher results tended to be seen on the ebb side of low tide than on the flood side.

11.6.3 Analysis of results by water temperature

Water temperature can affect survival time of bacteria in seawater (Burkhardt, et al., 2000). It can also affect the feeding and elimination rates in shellfish and therefore may be an important predictor of *E. coli* levels in shellfish flesh. Water temperature is obviously closely related to season. Any correlation between temperatures and *E. coli* levels in shellfish flesh may therefore not be directly attributable to temperature, but to the other factors e.g. seasonal differences in livestock grazing patterns. Figure 11.9 presents *E. coli* results against water temperature. Water temperature was recorded for 34 out of the 67 samples. Jittering of results was applied at 0.02 (x-axis) and 0.001 (y-axis) respectively.

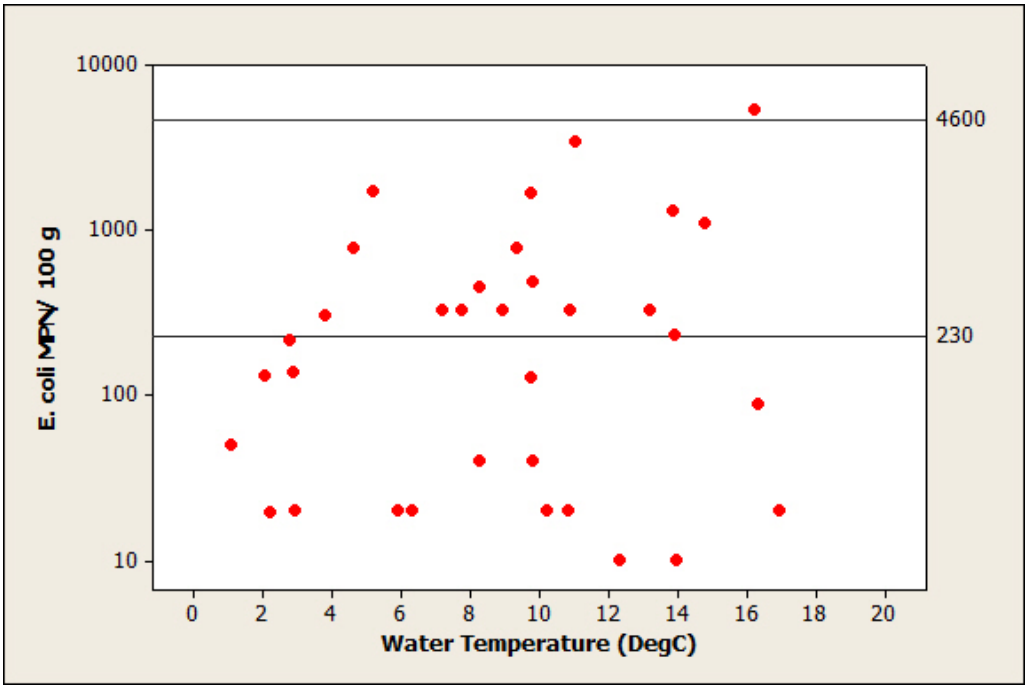


Figure 11.9 Scatterplot of *E. coli* results against water temperature at Seilebost

No significant correlation was found between *E. coli* results and water temperature (Spearman's rank correlation r = 0.126, p = 0.479). Samples were taken over a wide range of water temperatures between 1 and 17^{o}C.

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

In the results from Seilebost, 11 common cockle samples had results >1000 *E. coli* MPN/ 100 g and are listed below in Table 11.3.

Table 11.2 Historic *E. coli* sampling results over 1000 *E. coli* MPN/100g

Collection Date	*E. coli* (MPN/ 100g)	Location	2 day rainfall (mm)	7 day rainfall (mm)	Water Temp (^{o}C)	Salinity (ppt)	Tidal State (high/low)	Tidal state (spring/neap)
17/06/2008	1400	NG 0795 9753	16.5	26.7	-	27	Ebb	Increasing
12/08/2008	2400	NG 0795 9753	9.5	25.4	-	-	Low	Increasing
18/08/2009	2400	NG 0810 9779	3.2	40.6	-	18	Ebb	Increasing
19/07/2010	2400	NG 0801 9753	0.5	22.8	-	-	Flood	Neap
10/08/2010	1700	NG 0795 9758	10.6	20.6	-	-	Ebb	Spring
17/05/2011	1700	NG 0793 9746	15.2	44.6	10	23	Ebb	Spring
07/06/2011	3500	NG 0793 9750	14.8	52.2	11	-	Ebb	Decreasing
19/09/2011	1300	NG 0795 9747	2.6	31.9	14	-	Ebb	Decreasing
14/08/2012	5400	NG 0815 9769	9.0	9.0	16	-	Ebb	Increasing
11/02/2013	1700	NG 0817 9771	-	-	5	-	Ebb	Spring
20/08/2013	1100	NG 0814 9779	-	-	15	-	Ebb	Increasing

-No data available

Elevated results varied between 1100 and 5400 *E. coli* MPN/100 g. Samples yielding such results had been taken across the period assessed here. Five of the 11 samples were taken in August, whilst two were taken in June, and one sample in each July, May, September and February. Location varied, with seven of the samples taken in the cluster >250 m south of the RMP.

Rainfall was available for nine of the samples. Previous two day rainfall varied between 0.5 and 16.5 mm and previous seven day rainfall varied between 9.0 and 52.2 mm. Seawater temperature was available for six of the samples and varied between 5 and 16^{o}C, whilst salinity was available for three of samples and varied between 18 and 27 ppt, suggesting marked freshwater influence. Spring/neap tidal state variedbut most samples were taken on an ebb tide.

11.8 Summary and conclusions

Contamination levels at Seilebost have increased slightly since 2008. A strong seasonal trend is evident, with the majority of higher results taken in the summer months, and lowest results taken in winter months. Sampling location has varied between two clusters; a northern one within <150 m of the RMP and the other >250 m south of the RMP. Although the highest result was seen in the northern cluster, the average level of results at the southern cluster was significantly higher..

Statistically significant correlations were found between previous two day rainfall and seven day rainfall. No statistically significant correlation was found between seawater temperature and results.

A statistically significant correlation was found between results and the high/low tidal cycle Higher results tended to occur in samples taken on the ebbing tide.

12. Designated Waters Data

Seilebost fishery does not lie within a designated shellfish growing water and there are no designated bathing waters in the vicinity.

13. Bathymetry and Hydrodynamics

13.1 Introduction

13.1.1 The Study Area

Seilebost is situated on the west side of South Harris in the Western Isles. Seilebost is an area on the main body of Harris which is surrounded by an extensive intertidal sandy area called Tràigh Luskentyre. Tràigh Luskentyre extends deeply into the main body of Harris for approximately 4 km to the southeast and is characterised by intertidal sandflats. This area opens out to the Sound of Taransay to the west which itself connects to West Loch Tarbert in the north and the Atlantic ocean in the south. The seaward boundary of Tràigh Luskentyre is marked by the promontories of Luskentyre Banks in the north and Corran Seilebost in the south. Opposite Tràigh Luskentyre is the large island of Taransay. The peninsula of Aird Vanish is connected to Taransay. The study area is shown in Figure 13.1.

Coordinates for Seilebost (Tràigh Luskentyre):

57° 52.70’ N 006° 57.79’ W

NG 05887 98464

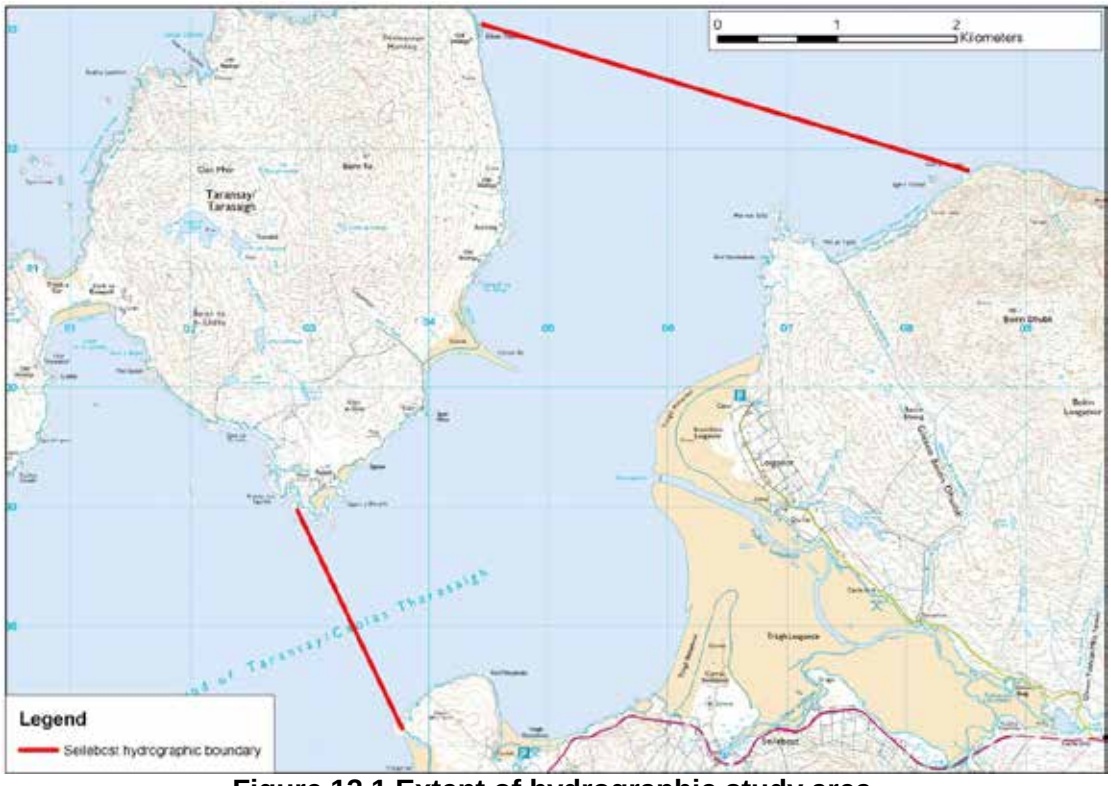


Figure 13.1 Extent of hydrographic study area

13.2 Bathymetry and Hydrodynamics

13.2.1 Bathymetry

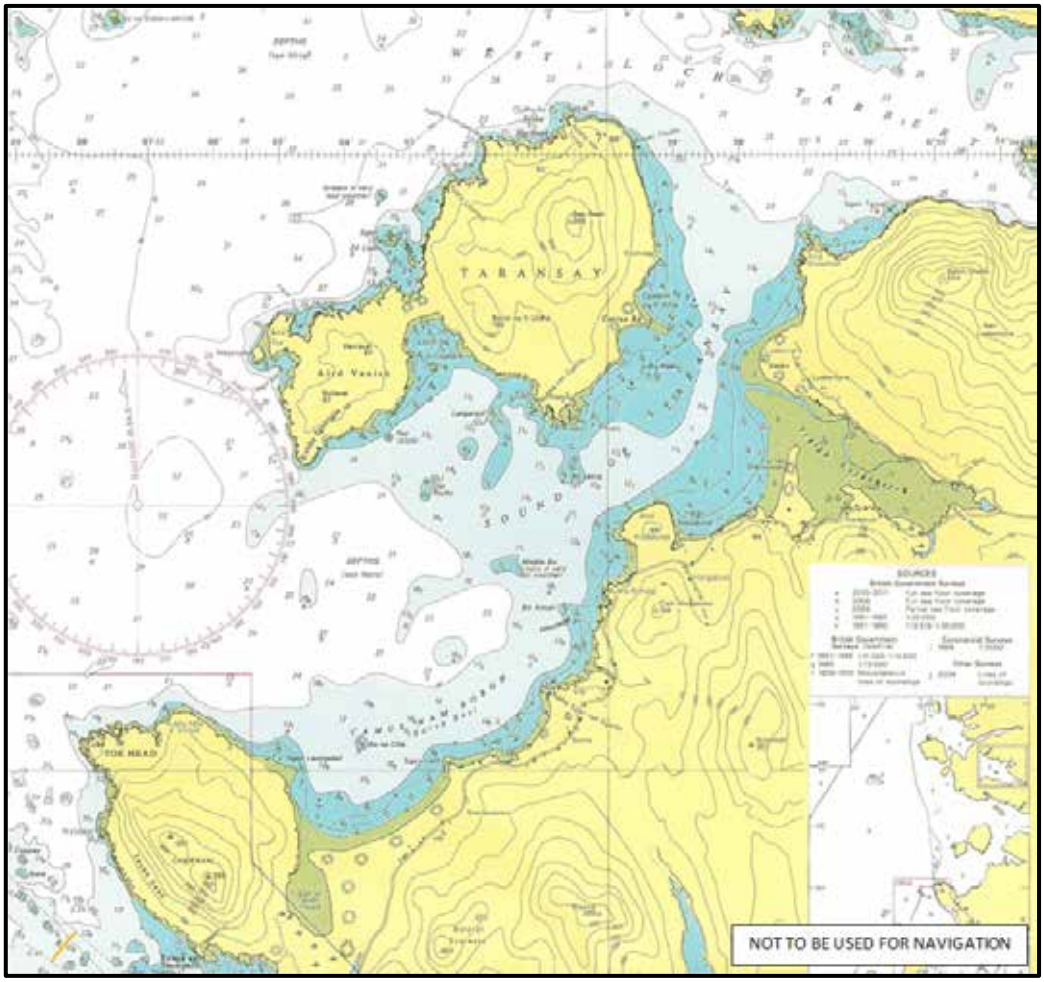


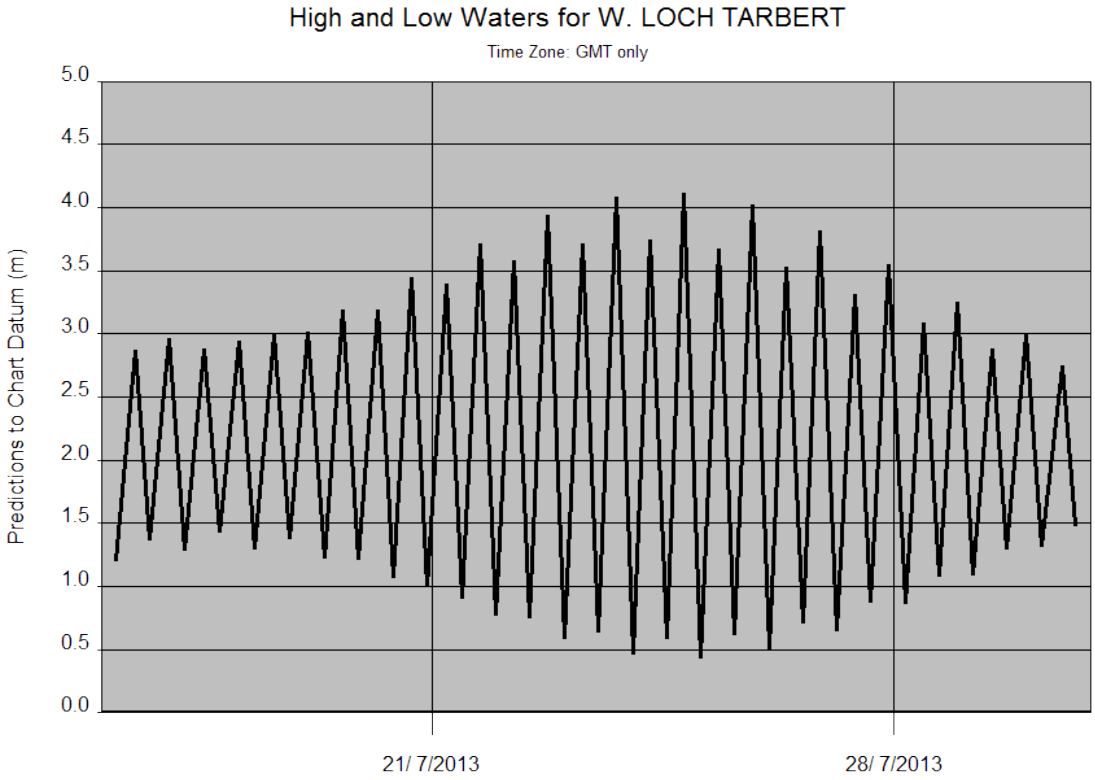
Figure 13.2 Admiralty chart (2841) extract for Seilebost.

Figure 13.2 shows the bathymetry of Tràigh Luskentyre and the Sound of Taransay near Seilebost. The Sound of Taransay runs approximately north to south with the southern part being open to the south west with a free run of water through it. The area is 5.6 km in length and with a width varying from a maximum of 4 km in the north to 1.5 km in the middle; the approximate area is 16 km^2. It has depths of less than 20 m throughout with much of it being less than 10 m. There are no constricting shallow sills and the bed slopes gently from the intertidal flats towards the relatively deep channel running through the area with typical depths of 10 – 14 m. The northern entrance to the area is rather more open than the southern entrance. In the southern entrance there are a number of isolated shallow banks and there is a sandy spit extending out from the east Taransay shore.

13.2.2 Tides

Seilebost has a typical semi-diurnal tidal characteristic. Data on tidal information is given from charted information. The nearest location for tidal predictions is West Loch Tarbert which is approximately 5 km north of Seilebost [http://easytide.ukho.gov.uk].

Standard tidal data for West Loch Tarbert are given below and the spring/neap cycle of tidal height around the time of the survey (23-24 July 2013) is shown in figure 13.3.



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

Figure 13.3 Two week tidal curve for West Loch Tarbert.

Tidal Heights for West Loch Tarbert (from Admiralty Chart 2841):

Mean High Water Springs = 3.7 m
Mean Low Water Springs = 0.7 m
Mean High Water Neaps = 2.8 m
Mean Low Water Neaps = 1.5 m

Tidal Ranges:

Mean Spring Range = 3.0 m
Mean Neap Range = 1.3 m

This gives a tidal volume of water during each tidal cycle of approximately:

Springs: 4.8×10^7 m^3
Neaps: 2.0×10^7 m^3

13.2.3 Tidal Streams and Currents

Data on tidal streams are very limited for this area, there being no tidal diamonds or charted information. The offshore currents are relatively weak, with peak flow at around 0.1 m/s or less (Harrald, et al., 2010). Thus the transport over the period of a tidal phase may be around 1 km. However, it is likely that the flow will be enhanced through the shallower water of the Sound of Taransay. Further, there is a generally northward residual flow offshore and so it might be expected that a similar weak northward residual flow is also occurring in the area.

There are no current meter data within the SEPA database that can be used to assess the flow in this area.

Dispersion is an important property of a water body with respect to redistribution of contaminants over time. There are no measurements or published data relating to dispersion in the Sound of Taransay. Without such data it is difficult to judge what the dispersive environment might be like, but the occurrence of small promontories, shallow banks and sand spits may enhance dispersion.

Dispersion of surface contaminants may be enhanced by wave energy within the study area. Sources of wave energy are from both short period waves that are created within the lee of Taransay and from swell conditions that have a much larger period originating in the North Atlantic. Longest fetch lengths occur in the south west direction and the biggest wind generated waves are produced from these wind directions.

The area of Tràigh Luskentyre is inundated during each tidal cycle, with the flood carrying dissolved and particulate matter towards the head of the estuary. The reverse transport will occur on the ebb and there is evidence from the morphology of the sands that the ebb transport of particulates is significant (May & Hansom, 2003). The complexity of morphology of the estuary, and the change in morphology with time, means that accurate transport rates and directions cannot be documented.

13.2.4 River/Freshwater Inflow

There are numerous freshwater pathways into Tràigh Luskentyre. Camas an t-Seilisdeir, which stems from several land-locked lochs, is the main input of water and is located towards the head of the intertidal area. Along the northern shore there are smaller rivers including Allt Thuilm, Abhainn Bun na Gill, Loch na Caorach and Abhainn an Tighe. On the southern shore, Abhainn Sheileboist and Abhainn Gil an Tailleir also contribute to the freshwater input.

There are many unnamed rivers on the OS map and their flow will vary seasonally.

Although no measurements exist, it is likely that the east side of the assessment area will have a greater fresh water influence than the west. It is also likely to have a greater degree of stratification, although given the shallow nature of the area; the most common situation would be for the water column to be well-mixed.

13.2.5 Meteorology

Wind data were taken from Stornoway approximately 55 km north east of Seilebost. and can be used to give a general picture of the seasonal wind conditions in the Western Isles. The data from Stornoway shows that, overall, westerly and southerly winds were stronger than northerly or easterly winds. There is a predominant south-westerly airflow year round for the area.

The closest area with adequate rainfall data is situated at Quidnich on the Isle of Harris which is approximately 10 km to the south of Seilebost. The data spanned from January 2007 to December 2012.

There were differing rainfall levels from year to year with the highest rainfall being recorded in 2008 and the lowest in 2010. Rainfall reached more than 30 mm/d throughout 2007, 2008, 2011 and 2012 and in 2007 an extreme level of rainfall of approximately 50 mm/d was recorded.

Rainfall values were, overall, higher during the autumn and winter months. The rainfall generally increases from July onwards and is highest in November and January. The months from April to June have the least rainfall. Levels of rainfall reach more than 30 mm/d in February, May, August, November and December.

43% of days from 2007 to 2012 had rainfall below 1 mm with over 10 mm of rainfall being recorded on 12% of the days. Consequently, it can be assumed that run-off because of rainfall with be high throughout both the autumn and winter months. However, whilst a general seasonal pattern in rainfall can be deduced from the historic data, periods of high rainfall can be recorded in most months.

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 assessment area.

13.3 Hydrographic Assessment

13.3.1 Surface Flow

The site and the meteorological data indicate that there is likely to be a rather moderate freshwater discharge into the surface waters of the loch, though the absolute value of discharge have the potentially to vary considerably between seasons.

Surface flows would be enhanced by winds blowing into the area from the prevailing south westerly directions, this would enhance mixing of the waters through the full depth and set up a long term residual flow to the north.

Any tidal flow is likely to run along the axis of the area (north-south) with maximum flow of around 0.1 m/s giving a cumulative transport during each phase of the tide estimated to be around 1 km.

Net transport of contaminants is related to the residual flow which is anticipated to be weak and to the north.

Transport within Tràigh Luskentyre will generally follow the flood (shoreward) and ebb (seaward) directions but the precise nature of the flows will be highly variable in both location and time.

13.3.2 Exchange Properties

Due to the close proximity to the Atlantic, the open aspect of the assessment area and the prevailing wind conditions, it is anticipated that the assessment area will have a relatively short flushing time of order a few days. It is expected that the study site will be a moderately-well flushed system throughout most of the year with surface contaminants being dispersed in the wind-enhanced residual flow.

There are no current meter data series available for the area and there is a complete lack of long term hydrographic data coverage for this area, particularly data sets with seasonal resolution. There is also rather little descriptive literature for the flow properties of the area. Therefore the confidence level of this assessment is LOW.

14. Shoreline Survey Overview

The shoreline survey at Seilebost was conducted on the 23rd and 24th July 2013. The weather was dry and warm in the 24 hrs prior to and on the days of survey, except for one heavy shower on the first day of survey. Little or no wind was recorded on both days, with a calm sea state.

The fishery consists of a wild common cockle fishery that is harvested by hand. Harvesting was stated by the sampling officer to mostly take place between December and March when the fishery is a class A. Four cockle samples were taken during the survey. Two returned results of 310 *E. coli* MPN / 100 g and two returned results of 3000 *E. coli* MPN / 100 g. The two highest results were from samples were taken to the east, whilst the two lower results were from samples taken towards the mouth of Seilebost, on the north and south sides respectively.

Private properties were located along the shoreline and included self catering holiday cottages, B&B's and a school was also noted on Corran Seilebost. A freshwater sample that was taken close to the Seilebost North ST discharge returned a result of 100000 *E. coli* cfu/100 ml, whilst a seawater sample taken just east also returned a result of 3800 *E. coli* / 100 ml. Another suspected septic tank was noted to the northwest of the shoreline. A strong smell of sewage and lots of algal growth were associated with a watercourse to the southwest. Three houses were noted nearby this watercourse. A freshwater sample of the watercourse returned a result of 630000 *E. coli* cfu/ 100 ml, whilst a seawater sample taken adjacent to the mouth of the watercourse returned a result of 42 *E. coli* cfu/ 100 ml. The other watercourses sampled during the survey had low to moderate levels of contamination <10 – 670 *E. coli* cfu /100 ml

A campsite is located along the northern shore of Loch Seilebost. The campsite seems to be a fairly small with only two tents and two mobile caravans observed from the shore during the survey. B&Bs and holiday cottages were observed but were sparse and were located mainly along the northernmost part of the survey route and along the southern shore.

No piers or anchorages were observed during the survey and only one sailing boat was seen out at sea.

The surrounding land is mostly used for sheep grazing, with animals fenced seen in areas and others free to roam the shoreline. No other livestock or farms were observed during the survey, though cattle grids were noted on the majority of roads.

Birds were the only type of wildlife observed during the shoreline survey: species included seagulls, herring gulls, oyster catchers, crows, ringed plover, arctic tern, common tern and little tern. Gulls were the most prevalent birds encountered.

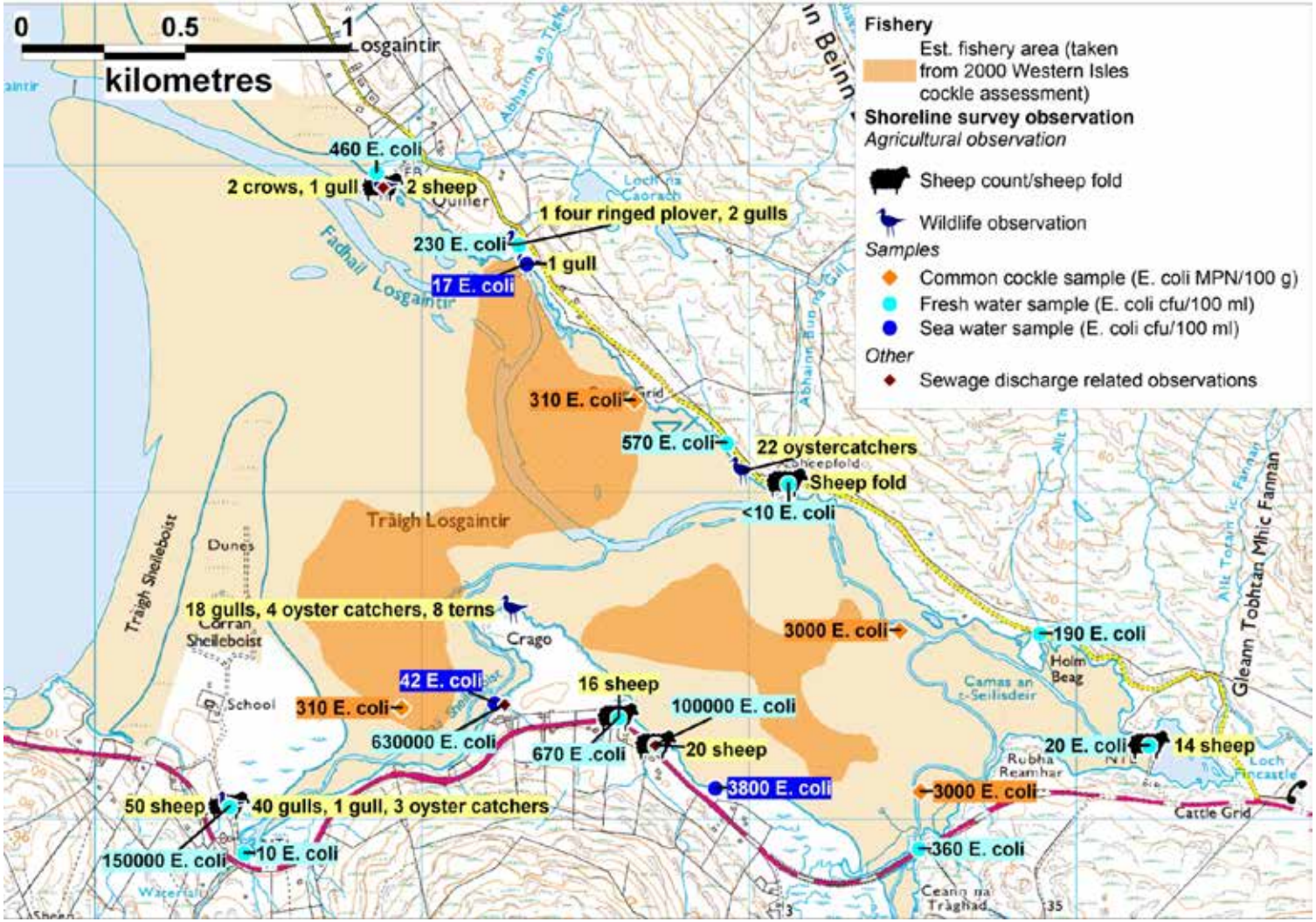


Figure 14.1 Principal shoreline survey observations at Seilebost

15. Overall Assessment

Human sewage impacts

Discharges of sewage were reported from two community septic tanks at Seilebost North and South, which are located east and west of the point at Crago, respectively. These are most likely to affect water quality along the southern shores nearest the outfalls. Therefore the Seilebost South tank would have a greater impact along the southern end of the outer (westernmost) cockle bed and the Seilebost North tank at the southern end of the inner cockle bed.

A cluster of private septic tanks at Luskentyre are most likely to have an impact on water quality along the north shore of the outer part of the bay and affect the northern edge of the outer cockle bed.

Although there did not appear to be much in the way of hotel and B&B accommodation in the area, there were campsites on the north shore southeast of Luskentyre and at Horgabost, west of Seilebost. The largest of these was at Horgabost, where there were also public toilets. Although no consent was received from SEPA for these, the toilets are likely to serve a relatively large population of visitors during the peak tourist months of July and August. It is not known whether the sewage from this source discharges to directly to sea or to soakaway. However, it is possible that this may be a significant source of faecal contamination to the outer sands during the summer months, where any impact would be most like to affect Traigh Sheileboist and the outer cockle bed near the entrance to the sands

Agricultural impacts

Agriculture in the area is predominantly rough grazing, with small amounts of improved grassland around the crofted areas of Luskentyre and Seilebost. Sheep were observed around the fishery, with the largest number of individual animals seen around the crofts at Seilebost and at the head of the estuary north of the Abhainn Lacasdal. Sheep are likely to contribute significantly to faecal contamination levels found in watercourses and along shore to which they have access.

Sheep produce approximately 10 times as much faecal indicator bacteria per day as humans and based on the numbers of sheep observed during the shoreline survey, the impact from sheep may be equivalent to a human population of approximately 850. If sheep are presumed to be present most regularly around their home crofts, then the impact from these animals would be higher at the southern side of the cockle bed where more animals were seen and there were more crofts present. There were approximately equal numbers east and west of Crago, and therefore both beds may be similarly affected.

Wildlife impacts

The predominant wildlife present around the fishery area are birds. Seabirds, such as gulls and terns, and wading birds are likely to be present in or around the cockle bed area and may directly deposit droppings there. A breeding colony of terns is present at Crago during the summer months, and impacts from these animals is most likely during summer. The colony is located between the two cockle beds, and as the number of animals is relatively small they are not expected to have a significant impact compared with other observed sources. Although the majority of wildlife observed during the shoreline survey were recorded around the outer sands, birds are relatively mobile and there is insufficient evidence to suggest that one part of the cockle bed will be significantly more impacted than another.

Seasonal variation

Seasonal variation in human population is expected due to the presence of campsites in the area. The largest variation is expected to be at the Horgabost campsite. Seasonal variation is also expected in the number of sheep present in the area, with the population at least doubling during summer when lambs are present. Little information was found on the numbers or seasonal variation in presence of other birds. The cockle bed is reported to be mainly harvested in winter, though there would be nothing to stop gathering during other times of year. Cockles were reported to be unevenly distributed during the shoreline survey, with some effort required to find sufficient numbers to sample.

Seasonal variation was seen in historical monitoring results, with higher results occurring in summer than in winter. Results appeared to peak in August, which coincides with the summer tourist season when the human population in the area is likely to be highest. It also coincides with the onset of rainier weather after relatively dry months in June and July.

Rivers and streams

A large number of watercourses feed into the fishery area. The largest of these are the Abhainn Lacasdal, at the head of the bay, and Abhainn Sheileboist and Abhainn Gil an Tailleir on the south shore. Estimated loadings were calculated based on spot sampling undertaken during the shoreline survey. These samples were taken during relatively dry weather during July and therefore may not be representative of conditions at other times, however they give some idea of the relative loadings between the watercourses. The highest loading came from the Abhainn Gil an Tailleir, which discharges to the south shore, nearest the southeast end of the inner cockle bed, and from Abhainn an Tighe, which discharges to the northwest of the outer cockle bed. Moderate loadings were found from the other measured watercourses. However, the majority of large watercourses discharged to the inner sands and therefore impact from freshwater-born

contamination is anticipated to be higher at the inner cockle bed and along the channels running along the north side of the sands.

Assessment of historical monitoring results against rainfall showed a statistically significant correlation between E. coli levels and rainfall recorded for 2 and 7 days prior to sampling. This suggests that rainfall is an important mechanism for transport of contaminants to the fishery. Much of this is likely to be carried via the watercourses identified above.

Movement of contaminants

The fishery area is an intertidal bay/estuary area and therefore water will move broadly eastward into the bay during the flood tide and westward out of the bay during the ebb. Movement within the bay is likely to be complex and changeable as the sand and sediment shift with time. Outside the bay in the sound of Taransay, there was no specific information on flows but these were likely to be higher than the 1km estimated outside the sound.

Therefore, sewage and other faecal contamination arising from along the shoreline is likely to be carried toward the head of the bay during the flood tide, and then back westward across the cockle bed on the ebb tide. No statistically significant correlation was found between results and the spring/neap tidal cycle. However, a significant correlation was found with the high/low tidal cycle. Although all samples were taken around low tide (due to the nature of the fishery), higher results tended to occur on the ebb side of low tide rather than the flood side.

Temporal and geographical patterns of sampling results

A general trend toward increasing *E. coli* results was seen in the historical monitoring data, with the mean approaching 230 *E. coli*/100 ml in 2013. Historical monitoring results were clustered around two locations within the inner part of the bay, one at the RMP and another further to the southwest. Although the highest result was recorded near the RMP, overall results tended to be higher at the southern location.

Results of shellfish sampling undertaken during the shoreline survey indicated contamination levels were approximately 10 times higher at the inner cockle bed than at the outer bed. Water samples taken along the southern shore around Seilebost returned higher results than those taken along the north shore.

Conclusions

Overall, despite the remoteness of the location the area is subject to significant seasonal faecal contamination, as seen in historical *E. coli* monitoring results as well as results from shoreline survey sampling. Human and livestock sources appear to be more significant along the south shore, where there are two community septic tanks, as well as

crofts with sheep and a large campsite further to the west. Although there are significant sources to the south of both the outer and inner cockle beds, concurrent sampling undertaken during the shoreline survey indicated higher contamination levels at the inner bed.

Monitoring results from the inner bed suggest higher contamination levels on the south side of the bed than the north side, and significant seasonal variation is seen with higher results in summer.

16. Recommendations

It is not possible to exclude the potential mixing zones of the two community discharges from the production area without affecting the extent of the main areas of cockles available to commercial harvest. The RMP and associated tolerance zone have been located to reflect the integrated impact, as represented by *E. coli*, of all of the main faecal pollution sources identified during this assessment but periodic monitoring may not reflect the total microbiological risk arising from the community discharges.

Production area

Given the reported locations of the bed and the location of the campsite at Horgabost, it is recommended that the western boundary of the production area be curtailed slightly to exclude the area west of the dunes at the entrance to Traigh Losgaintir. The recommended production area is the area inshore of a line drawn between NG 0654 9831 and NG 0687 9893 and extending to MHWS.

RMP

In light of the higher results seen on the southern side of the inner cockle bed and the location of sources along the south shore, it is recommended that the RMP be moved to NG 0808 9726 to reflect the sources along the southern shore.

Tolerance

A sampling tolerance of 150 m is recommended to ensure adequate cockles are available for sampling purposes.

Frequency

Due to the seasonal variation observed in results, it is recommended that monthly monitoring be maintained.

Depth of sampling

Not applicable

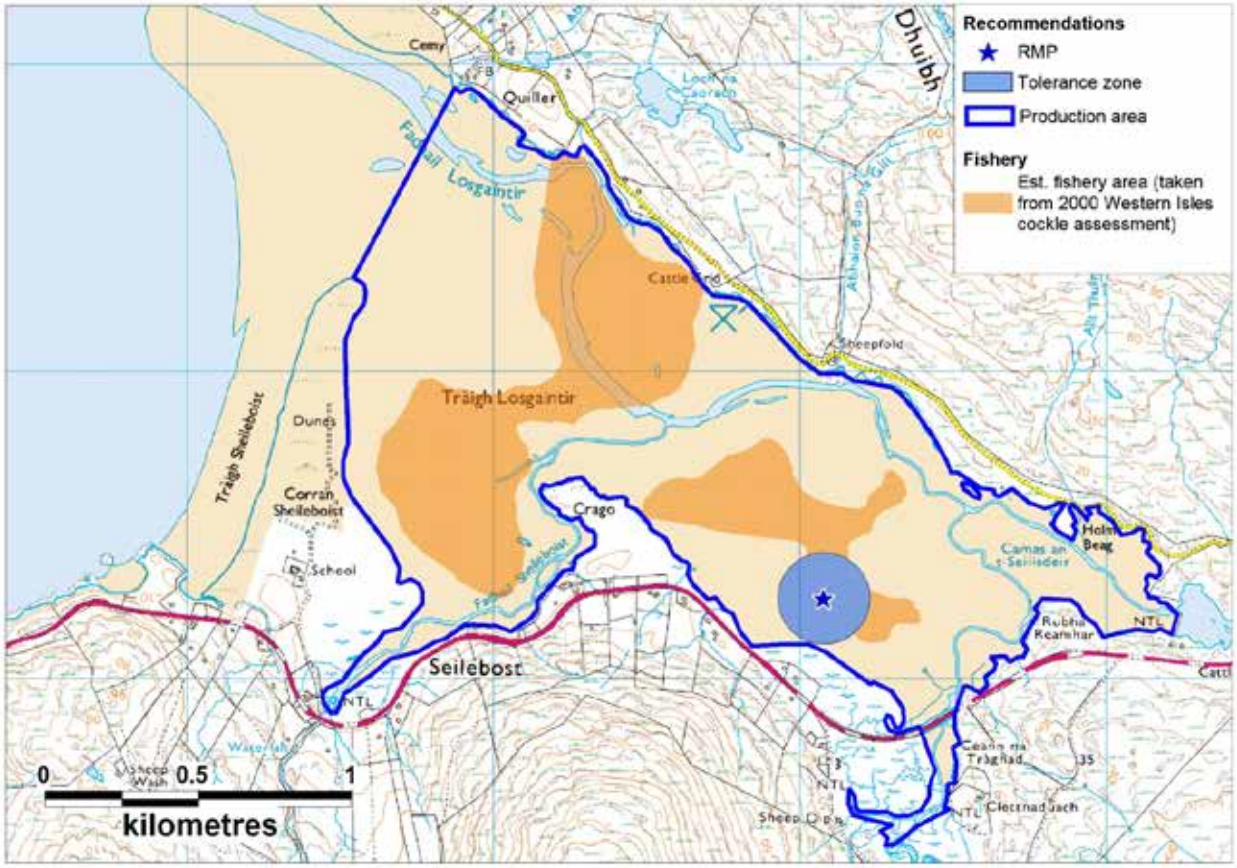


Figure 16.1 Map of recommendations at Seilebost

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18. List of Figures and Tables

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2. **Tables of Typical Faecal Bacteria Concentrations**
3. **Statistical Data**
4. **Hydrographic Section Glossary**
5. **Shoreline Survey Report**

1. General Information on Wildlife Impacts

Pinnipeds

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

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

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

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

Other

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

Table 1 - 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	$1.7 \times 10^{7\,*}$ (+)	1.4×10^{7}	2.0×10^{7}	282	$2.8 \times 10^{6\,*}$ (-)	2.3×10^{6}	3.2×10^{6}
Crude sewage discharges	252	$1.7 \times 10^{7\,*}$ (+)	1.4×10^{7}	2.0×10^{7}	79	$3.5 \times 10^{6\,*}$ (-)	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	$1.0 \times 10^{7\,*}$ (+)	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	$3.3 \times 10^{5\,*}$ (-)	2.9×10^{5}	3.7×10^{5}	184	$5.0 \times 10^{5\,*}$ (+)	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	$2.8 \times 10^{5\,*}$ (-)	2.2×10^{5}	3.5×10^{5}	93	$5.1 \times 10^{5\,*}$ (+)	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 2 – 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 3 - 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. Statistical Data

One-way ANOVA: logEC versus Season

```
Source  DF      SS     MS     F      P
Season   3   6.082  2.027  3.67  0.017
Error   63  34.806  0.552
Total   66  40.888
S = 0.7433   R-Sq = 14.87%   R-Sq(adj) = 10.82%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N    Mean   StDev  ------+---------+---------+---------+---
1      18  1.8615  0.6842      (--------*-------)
2      18  2.4288  0.9457                   (--------*-------)
3      14  2.3446  0.5551                 (---------*---------)
4      17  1.7325  0.6909  (--------*--------)
                          ------+---------+---------+---------+---
                              1.60      2.00      2.40      2.80

Pooled StDev = 0.7433

Grouping Information Using Tukey Method

Season   N    Mean  Grouping
2       18  2.4288  A
3       14  2.3446  A B
1       18  1.8615  A B
4       17  1.7325    B

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Season

Individual confidence level = 98.95%

Season = 1 subtracted from:

Season    Lower   Center   Upper  ---------+---------+---------+---------+
2       -0.0861   0.5674  1.2208                    (--------*--------)
3       -0.2155   0.4831  1.1817                  (---------*---------)
4       -0.7919  -0.1289  0.5341          (--------*---------)
                                  ---------+---------+---------+---------+
                                        -0.70      0.00      0.70      1.40

Season = 2 subtracted from:

Season    Lower   Center    Upper  ---------+---------+---------+---------+
3       -0.7828  -0.0842   0.6144          (---------*---------)
4       -1.3593  -0.6963  -0.0333  (--------*---------)
                                   ---------+---------+---------+---------+
                                         -0.70      0.00      0.70      1.40

Season = 3 subtracted from:

Season    Lower   Center   Upper  ---------+---------+---------+---------+
4       -1.3196  -0.6120  0.0955  (---------*---------)
                                  ---------+---------+---------+---------+
                                        -0.70      0.00      0.70      1.40
```

4. Hydrographic Assessment Glossary

The following technical terms may appear in the hydrographic assessment.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Document Number	B0067_Shoreline 0017

Revision History

Revision	Changes	Date
A	Issue for internal review	08/08/2013
01	First formal issue to CEFAS	15/08/2013

	Name & Position	Date
Author	Eilidh Cole & Debbie Brennan	06/08/2013
Checked	John Hausrath, Andrea Veszelovszki	09/08/2013
Approved	John Hausrath	15/08/2013

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

Shoreline Survey Report

Production area:	Seilebost
Site name:	Seilebost
SIN:	LH-249-129-04
Species:	Common cockles
Harvester:	There is no single harvester for this wild fishery.
Local Authority:	Comhairle nan Eilean Siar: Lewis and Harris.
Status:	Existing area
Date Surveyed:	23/07/2013 – 24/07/2013
Surveyed by:	Eilidh Cole and Debbie Brennan
Existing RMP:	NG 0815 9772
Area Surveyed:	The northern shore of Loch Seilebost was surveyed from just south of Luskentyre to the eastern head of the loch at Loch Fincastle. Two short sections on the southern shore of Loch Seilebost were also surveyed at Crago and Corran Seilebost.

Weather

The weather during the survey was dry and very warm. The only change in this was during one very brief but heavy rain shower on Wednesday the 23rd July later on in the afternoon. On both days of the survey, it was overcast in the morning but clearing with sunshine throughout the afternoon. There was little to no wind on both survey days and the sea state was calm.

Stakeholder engagement during the survey

Seilebost is a natural wild bed of cockles and there is no single harvester for the site. None of the harvesters were available to meet up with the survey team during the survey.

The local sampling officer, Paul Tyler, was very helpful and although he was not available to meet with the survey team at Seilebost during the survey, he was met at the previous survey site at Loch Stockinish.

Fishery

Cockles were collected by hand by the survey team at low tide from the four locations shown in Figure 2. During the survey, cockles were not found to be consistently abundant throughout the production area and some digging in various different areas of the mud/sand was necessary in order to find an area with plentiful cockles for sampling. Mr Paul Tyler suggested that the number of cockle gatherers varies with up to six people being seen there at any one time. As far as Mr Tyler is aware, little harvesting appears to occur at Seilebost between April and November when the site is at classification 'B'. Most of the harvesting seems to occur when the site is at classification 'A', however, as Mr Tyler is there just one day a week, he stressed that he cannot be certain that this is the case and is based only on what he has observed when he is present on-site.

Sewage Sources

Properties are located fairly sparsely all along the shore of Loch Seilebost and consist of both private homes, self-catering holiday cottages and bed and breakfasts as was observed by the signage outside the properties. Any watercourses or discharges running near these properties are marked in the table of observations. There is a school located inland along the single track road at Corran Seilebost and there is also a campsite on the northern shore of Loch Seilebost with tents and mobile caravans observed there. No pipes or discharges were observed coming directly from either the school or campsites.

Seasonal Population

As noted above, a campsite is located along the northern shore of Loch Seilebost. The campsite seems to be a fairly small with only two tents and two mobile caravans observed from the shore during the survey. B&Bs and holiday cottages were observed but were sparse and were present mainly along the very northern most part of the survey route and along the southern shore.

Boats/Shipping

No piers or anchorages were observed during the survey and only one sailing boat was seen out at sea.

Farming and Livestock

A fairly large number of sheep were observed grazing on the land surrounding Loch Seilebost. Some of these sheep were fenced in and others were roaming freely on the shore and surrounding area. Most of the fenced-in sheep appeared to be on the southern shore but sheep were observed all along the shoreline survey. No farms were visible throughout the survey although there were cattle grids on the roads to and from the survey area. No other livestock were seen throughout the survey.

Land Use

Seilebost is a very rural area and the land surrounding Loch Seilebost seemed to be mainly used for rough grazing. Occasionally there were some fields with sheep but no crops or farming was observed. The whole area of Seilebost was sparsely populated with habitation all along the shoreline in small numbers. No forestry was observed.

Land Cover

Land cover surrounding Loch Seilebost consisted mainly of rocky outcrops surrounded by short grass and heather and was consistent along the course of the shoreline survey route. Sand dunes, with coarse grass, were prevalent along the shoreline and no woodland or forestry was observed.

Watercourses

Three large watercourses were observed during the course of the survey, all of which were directed onto the shore. The first was the watercourse, Abhainn Lacasdail, which is associated with Loch Fincastle at the head of Loch Seilebost. The second watercourse, Abhainn Gil an Tailleir, was situated on the southern shore near the head of Loch Seilebost where it was directed under the road. The third major watercourse, Abhainn Sheileboist, was on the south west shore and was directed under the road onto the shore via a causeway. The large majority of the other watercourses observed throughout the survey were much smaller and had little or no measurable flow or were quite dry. All watercourses sampled were distributed fairly evenly along the shoreline of Loch Seilebost.

Wildlife/Birds

Species of birds observed during the survey included seagulls, herring gulls, oyster catchers, crows, ringed plover, arctic tern, common tern and little tern. The majority of birds observed were gulls or oyster catchers. No other wildlife was observed.

Shoreline Survey Maps

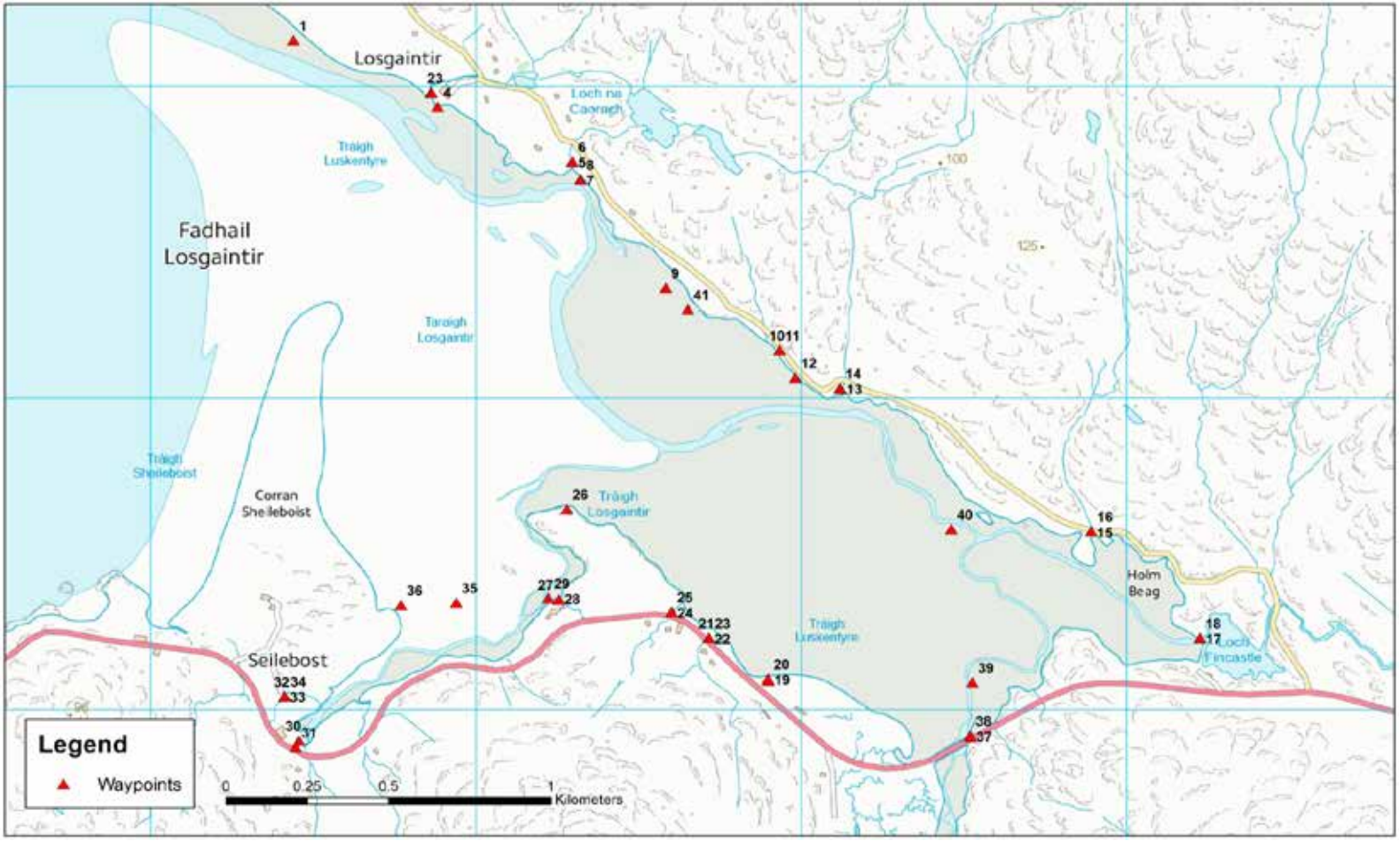

Figure 1. Seilebost waypoints

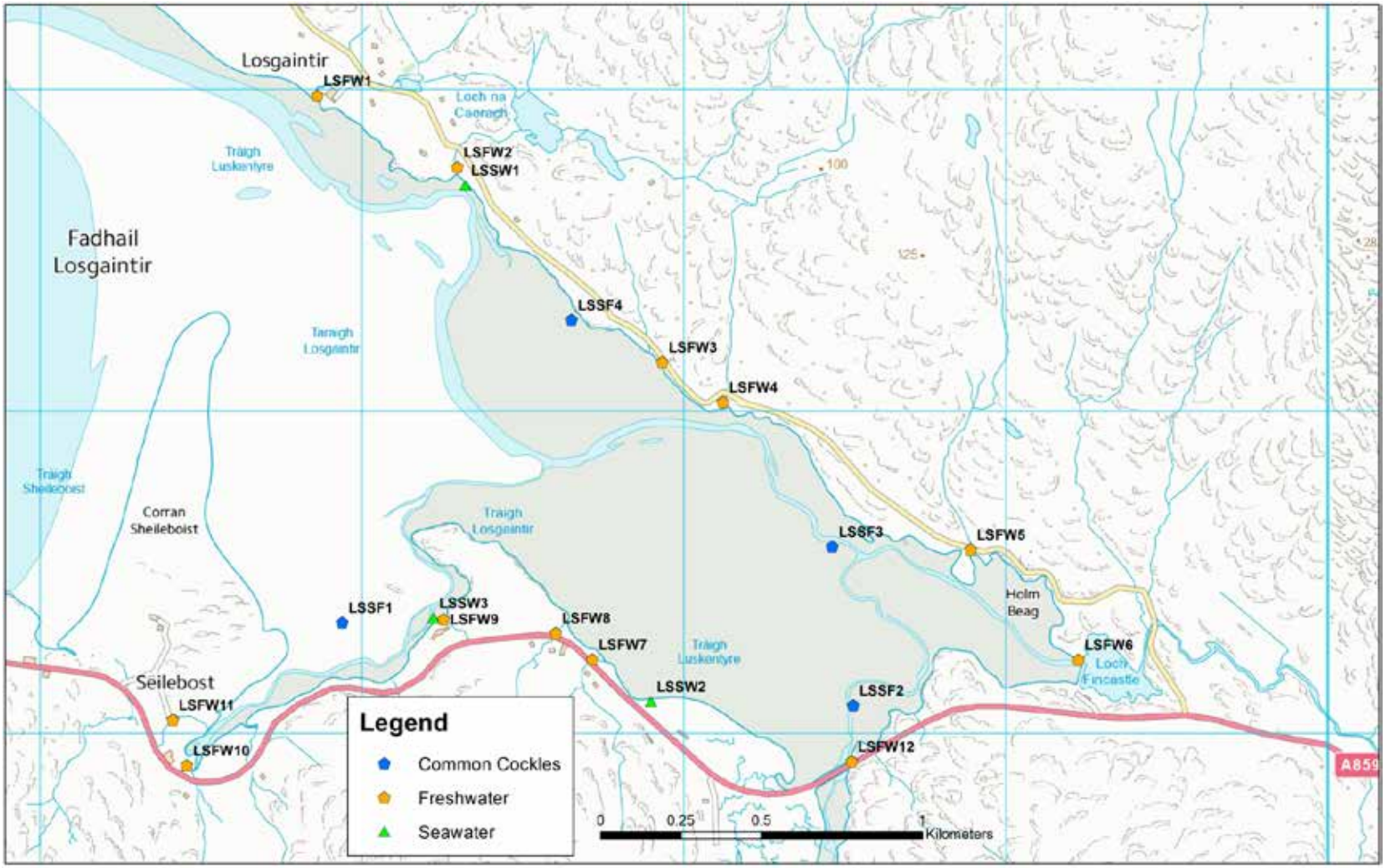

Figure 2. Seilebost samples

Table 1. Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	23/07/2013	13:49	NG 06438 99148	106438	899148	Figure 3		Start of survey at Seilebost. Land cover here is mostly sand and sand dunes with rough grass. Open sea with no boats visible. No birds. Three houses visible.
2	23/07/2013	14:03	NG 06861 98980	106861	898980		LSFW1	Planned freshwater sample. Associated with waypoint 3.
3	23/07/2013	14:04	NG 06863 98978	106864	898979			River running onto shore from sand dunes. Width = 26 cm; Depth = 1.6 m; Flow = 0.029 m/s; SD = 0.019. Two houses behind river. No pipes or septic tanks visible. Approximately twenty one houses on opposite side of the shore. Three fish jumping in the river.
4	23/07/2013	14:12	NG 06881 98934	106882	898934	Figure 4		Concrete structure in front of house behind river. Two sheep, two crows and one seagull on shore. Eight houses and one static caravan behind shore.
5	23/07/2013	14:32	NG 07296 98758	107296	898759		LSFW2	Planned freshwater sample. Associated with waypoint 6.
6	23/07/2013	14:33	NG 07296 98759	107296	898759			Small river barely flowing, next to house. Flow was measured by using a graduated container and watch. Lots of green algae growing on shore beside river. Width = 55 cm; Depth = 2 cm; Approximate Flow » 25 ml/3s. Four ringed plover and two seagulls on beach.
7	23/07/2013	15:07	NG 07320 98701	107321	898701		LSSW1	Planned seawater sample. Associated with waypoint 8.
8	23/07/2013	15:07	NG 07321 98700	107321	898700			Seawater sample taken but no cockles available for sampling. No cockle shells observed on this part of the beach. One seagull on shore.
9	23/07/2013	15:16	NG 07582 98353	107583	898353			Two mobile caravans and two tents pitched next to shore.
10	23/07/2013	15:25	NG 07932 98153	107933	898153		LSFW3	Planned freshwater sample. Associated with waypoint 11.
11	23/07/2013	15:26	NG 07932 98152	107933	898153			Black plastic pipe running under road onto shore, barely flowing. Flow was measured by using graduated container and watch. No smell. Diameter = 40 cm; Depth = 7 cm; Approximate Flow » 25 ml/4s.
12	23/07/2013	15:31	NG 07980 98065	107981	898065			Road drainage pipe. Dry, no flow. Twenty two oyster catchers on the beach.
13	23/07/2013	15:38	NG 08120 98028	108121	898029	Figure 5	LSFW4	Planned freshwater sample. Associated with waypoint 14.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
14	23/07/2013	15:38	NG 08118 98030	108118	898031	Figure 5		Sheep fold next to road with no sheep. Two pipes running under road and under sheep fold. Pipes merge to form one river. Water present but not flowing, therefore no flow measurement taken. Width = 1.5 m; Depth = 7 cm.
15	23/07/2013	16:00	NG 08890 97570	108890	897571		LSFW5	Planned freshwater sample. Associated with waypoint 16.
16	23/07/2013	16:01	NG 08891 97570	108891	897571			Water under road, running through stones. Running water heard but the visible water not flowing. Width = 1.3 m; Depth = 10 cm. One brief but heavy rain shower.
17	23/07/2013	16:13	NG 09224 97228	109225	897229	Figure 6	LSFW6	Planned freshwater sample.
18	23/07/2013	16:13	NG 09224 97228	109225	897229	Figure 6		Fourteen sheep behind Loch Fincastle at the head of Loch Seilebost. River flowing out from Loch Fincastle towards shore. Width = 1 m; Depth = 15 cm; Flow = 0.350 m/s; SD = 0.191.
19	24/07/2013	10:20	NG 07899 97092	107899	897093			Start of survey day two.
20	24/07/2013	10:21	NG 07897 97098	107898	897098	Figure 7	LSSW2	Planned seawater sample. Associated with waypoint 21.
21	24/07/2013	10:31	NG 07715 97229	107715	897229	Figure 7		Public discharge onto shore, smell of sewage. Discharge appears to be piped underground and covered over with stones until it reaches the beach. Seawater sample taken where discharge reaches sea where it was accessible.
22	24/07/2013	10:32	NG 07715 97229	107715	897230	Figure 8	LSFW7	Planned freshwater sample. Associated with waypoint 23.
23	24/07/2013	10:34	NG 07716 97229	107716	897229	Figure 8		Concrete pipe directing a burn under the road from a hill onto shore. Flow was measured by using a graduated container and watch. Two properties observed across the road. Twenty sheep in field. River width = 50 cm; Depth = 2 cm; Approximate Flow » 30 ml/5s.
24	24/07/2013	10:41	NG 07601 97312	107602	897312	Figure 9	LSFW8	Planned freshwater sample. Associated with waypoint 25.
25	24/07/2013	10:43	NG 07600 97313	107601	897313	Figure 9		Watercourse piped under road onto shore from hill. Four houses on other side of road. Pipe width = 50 cm; depth = 4 cm; No flow, just dripping. Sixteen sheep in field.
26	24/07/2013	11:04	NG 07278 97643	107279	897643	Figure 10		Eighteen herring gulls, four oyster catchers, three arctic terns, four common terns and one little tern on shore. One sailing boat out to sea.
27	24/07/2013	11:27	NG 07253 97353	107254	897353	Figure 11	LSFW9	Planned freshwater sample. Associated with waypoint 28.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
28	24/07/2013	11:28	NG 07254 97352	107254	897353	Figure 11		Watercourse running from under road onto shore. Flow was measured by using a graduated container and watch. Width = 70 cm; Depth = 3 cm; Flow » 30 ml/2 sec. Three houses, one close. Strong smell of sewage, lots of green algae on shore.
29	24/07/2013	11:33	NG 07222 97357	107222	897358		LSSW3	Planned seawater sample.
30	24/07/2013	12:17	NG 06456 96899	106456	896900	Figure 12	LSFW10	Planned freshwater sample. Associated with waypoint 31.
31	24/07/2013	12:20	NG 06445 96879	106445	896880	Figure 12		Two large pipes of 1.5 m width directing watercourse under road onto shore. Width = 2.2 m; Depth = 10 cm; Flow = 0.133 m/s; SD = 0.004.
32	24/07/2013	12:31	NG 06412 97041	106412	897041		LSFW11	Planned freshwater sample. Associated with waypoint 33.
33	24/07/2013	12:31	NG 06409 97041	106410	897042			Small watercourse directed under road towards a grassy, sandy plain along the shoreline. Width = 45 cm; Depth = 2 cm; No flow.
34	24/07/2013	12:33	NG 06411 97042	106411	897043			Three houses close to watercourse. Fifty sheep. Forty gulls in a mix of common and herring. Three oyster catchers. Small school seen inland further down single track road towards Corran Seilebost. No visible discharges.
35	24/07/2013	13:27	NG 06938 97343	106939	897344		LSSF1	Planned shellfish sample on shore opposite school. Not many cockles found at this location, with the majority of those found being quite small. Cockles collected between sites 4 and 5 on Survey Plan Map.
36	24/07/2013	13:30	NG 06769 97335	106769	897335			Start of cockle collection.
37	24/07/2013	14:25	NG 08520 96912	108521	896913		LSFW12	Planned freshwater sample. Associated with waypoint 38.
38	24/07/2013	14:26	NG 08518 96916	108519	896916			Watercourse running under road via causeway. Width = 3 m; Depth 1 = 40 cm; Flow 1 = 0.057 m/s; SD 1 = 0.005. Depth 2 = 45 cm; Flow 2 = 0.029 m/s; SD 2 = 0.001.
39	24/07/2013	15:03	NG 08525 97087	108526	897087		LSSF2	Planned shellfish sample. Site 3 on Survey Plan Map.
40	24/07/2013	15:56	NG 08461 97579	108461	897579	Figure 13	LSSF3	Planned shellfish sample. Site 2 on Survey Plan Map.
41	24/07/2013	16:41	NG 07650 98283	107651	898284		LSSF4	Planned shellfish sample. Site 1 on Survey Plan Map.

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

Sampling

Water samples were collected at sites marked on the map shown in figure 2.

Samples were transferred to Biotherm 10 or Biotherm 30 boxes with ice packs and posted to Glasgow Scientific Services (GSS) for *E. coli* analysis. All samples were posted on the day of collection and all of them were received and analysed the following day. The sample temperatures on arrival to the laboratory ranged between 1.6 ˚C and 2.6 ˚C.

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

Salinity (ppt) = 0.0018066 X Cl^- (mg/L)

Common cockle samples were collected by the survey team from the shore during low tide.

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (cfu/100ml)	Salinity (ppt)
1	23/07/2013	LSFW1	NG 06861 98980	Freshwater	460	
2	23/07/2013	LSFW2	NG 07296 98758	Freshwater	230	
3	23/07/2013	LSFW3	NG 07932 98153	Freshwater	570	
4	23/07/2013	LSFW4	NG 08120 98028	Freshwater	<10	
5	23/07/2013	LSFW5	NG 08890 97570	Freshwater	190	
6	23/07/2013	LSFW6	NG 09224 97228	Freshwater	20	
7	24/07/2013	LSFW7	NG 07715 97229	Freshwater	100000	
8	24/07/2013	LSFW8	NG 07601 97312	Freshwater	670	
9	24/07/2013	LSFW9	NG 07253 97353	Freshwater	630000	
10	24/07/2013	LSFW10	NG 06456 96899	Freshwater	10	
11	24/07/2013	LSFW11	NG 06412 97041	Freshwater	150000	
12	24/07/2013	LSFW12	NG 08520 96912	Freshwater	360	
13	24/07/2013	LSSW1	NG 07320 98701	Seawater	17	34.87
14	24/07/2013	LSSW2	NG 07897 97098	Seawater	3800	35.95
15	24/07/2013	LSSW3	NG 07222 97357	Seawater	42	36.13

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (MPN/100g)
1	24/07/2013	LSSF1	NG 06938 97343	Common Cockles	310
2	24/07/2013	LSSF2	NG 08525 97087	Common Cockles	3000
3	24/07/2013	LSSF3	NG 08461 97579	Common Cockles	3000
4	24/07/2013	LSSF4	NG 07650 98283	Common Cockles	310

Salinity Profiles

No salinity profiles were taken at this site as common cockles are collected at the intertidal zone on the shore when the tide is out.

Shoreline Survey Photographs

Figure 3. Land cover along the shoreline survey route at Seilebost is mostly sand and sand dunes with rough grass. Associated with waypoint 1.

Figure 4. Concrete structure in front of house behind river. Two sheep on shore. Associated with waypoint 4.

Figure 5. Two pipes running under road and under sheep fold next to road. Associated with waypoints 13 and 14. Planned freshwater sample LSFW4.

Figure 6. River flowing out from Loch Fincastle at the head of Loch Seilebost. Associated with waypoints 17 and 18. Planned freshwater sample LSFW6.

Figure 7. Public discharge onto shore, covered over with stones until it reaches the beach. Associated with waypoint 20 and 21. Planned seawater sample LSSW2.

Figure 8. Concrete pipe directing a burn under the road from a hill onto shore. Associated with waypoints 22 and 23. Planned freshwater sample LSFW7.

Figure 9. Watercourse piped under road onto shore from hill. Associated with waypoints 24 and 25. Planned freshwater sample LSFW8

Figure 10. One sailing boat out to sea. Associated with waypoint 26.

Figure 11. Watercourse running from under road onto shore with of green algae present. Associated with waypoints 27 and 28. Planned freshwater sample LSFW9.

Figure 12. Two large pipes of 1.5 m width directing watercourse under road onto shore. Associated with waypoints 30 and 31. Planned freshwater sample LSFW10.

Figure 13. Associated with waypoint 40. Planned shellfish sample LSSF3.