Scottish Sanitary Survey Programme

Sanitary Survey Report
Stromness Voe
SI-273 and New Site
November 2013

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Partner Organisation

The hydrographic assessment and the shoreline survey and its associated report were undertaken by SSQC, Scalloway.

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Appendices

I. Executive Summary

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

The purpose of the sanitary survey is to demonstrate compliance with the requirements stated in Annex II (Chapter II Paragraph 6) of Regulation (EC) 854/2004. The sanitary survey results in recommendations on the location of RMPs, the frequency of sampling for microbiological monitoring, and the boundaries of the production areas deemed to be represented by the RMPs.

A sanitary survey was undertaken on the mussel fishery at Stromness Voe 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.

Stromness Voe is long narrow voe located on the west side of Mainland Shetland, opening to the waters around the Scalloway archipelago. It is flanked by two promontories of land: Strom Ness on the western side and White Ness on the eastern side. The area around the voe is sparsely populated with crofts lining the adjacent Whiteness Voe, and the small settlement of Haggersta located near the head of the voe.

Stromness Voe fishery is a common mussel (*Mytilus edulis*) aquaculture fishery made up of three separate mussel farm sites.

The principal sources of faecal contamination to this fishery are:

- Diffuse pollution from livestock, mainly sheep.
- Wildlife present at or near the fisheries (mainly seabirds)
- Septic tank discharges associated with houses around the north end of the voe and in the southern part of Loch of Stromness.

One septic tank at the north end of the voe was found to be malfunctioning. Faecal contaminants are likely to be carried only short distances by tidal transport, and therefore wind-driven flows may be predominant. Prevailing winds would tend to drive these northward in the voe. Contaminants arising to the north of the fisheries are likely to be carried in lower salinity surface waters moving out from the Loch of Strom. The bacteriological survey showed higher contamination levels in samples taken from the tops of the mussel lines at the northeast end of the Burra Voe site.

Higher mussel *E. coli* results were found to occur at high and ebb tides and also when the tides were increasing from neap to springs.

Summary of recommendations

Based on the locations of the currently active fisheries, it was recommended that the production area boundaries be curtailed in the north to exclude potential septic tank sources around the north end of the voe and at the south east to exclude the septic tank at Pund. The recommended monitoring point should remain at Burra Holm, but be relocated to the northeast extent of the farm to better reflect sources arising to the north of the fishery as well as along the adjacent shoreline. Further details on recommendations can be found in the sampling plan overleaf and in Section 17.

II. Sampling Plan

Production Area	Stromness Voe
Site Name	Burra Holm
SIN	SI-273-467-08
Species	Common mussel
Type of Fishery	Longline aquaculture
NGR of RMP	HU 3858 4558
East	438580
North	1145580
Tolerance (m)	40
Depth (m)	1
Method of Sampling	Hand
Frequency of Sampling	Monthly
Local Authority	Shetland Islands Council
Authorised Sampler(s)	Sean Williamson Marion Slater Agnes Smith Alan Harpin Vicki Smith
Local Authority	Shetland Islands Council
Production Area Boundary	The area bounded by lines drawn between HU3846 4572 and HU 3862 4569 and between HU 3804 4336 and HU 3811 4347 and between HU 3798 4335 and HU 3787 4325, extending to MHWS

III. Report

1. General Description

Stromness Voe is long narrow voe located on the west side of Mainland Shetland, opening to the waters around the Scalloway archipelago. It is flanked by two promontories of land: Strom Ness on the western side and White Ness on the eastern side. The head of the voe (at the north end) opens to the semi-tidal Loch of Strom. The mouth of the voe lies at the southern end and is flanked by Binna Ness to the west and Usta Ness to the east. The map in Figure 1 shows the general location of Stromness Voe.

The Voe has a southerly aspect and is a total of 5.5 km long. It has a fairly uniform width of 250 m along its length with a constriction and sill near the mouth which separates the deeper part of the outer voe from the shallower inner voe. The depth ranges from over 40 m in the outer part to as little as 3 m at the sill.

The area around the voe is sparsely populated with crofts lining the adjacent Whiteness Voe, and the small settlement of Haggersta located near the head of the voe.

A sanitary survey was undertaken on the classified mussel fishery at Stromness Voe 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.

Figure 1.1 Location of Stromness Voe

2. Fishery

Stromness Voe fishery is a common mussel (*Mytilus edulis*) aquaculture fishery made up of three separate mussel farm sites. The site details are shown in Table 2.1.

Table 2.1 Shellfish farm sites in Stromness Voe production area

Site	SIN	Species	RMP	Production Area Boundary
Burra Holm	SI-273-467-08	*Mytilus edulis*	HU 3851 4549	Area bounded by a line drawn between HU 3780 4330 and HU 3795 4330 extending to mean high water springs
Site 1	New Site	*Mytilus edulis*		
Stromness Voe*	SI-273-446-08	*Mytilus edulis*		

* Identified as Site 2 in shoreline survey

At the time of shoreline survey, the Burra Holm site consisted of four, double-headed, long lines approximately 150 m in length with 4 metre droppers, running parallel to the shoreline. The site is licensed for four 150 metre double-headed long-lines.

Site 1 was not previously identified and a site identification number (SIN) has not yet been assigned. This site consisted of four, double-headed, longlines with 10 meter droppers, running parallel to the shoreline. The site is licensed for four 200 meter double-headed long-lines.

Stromness Voe site (Site 2) consisted of four, double-headed, longlines with 10 meter droppers, running parallel to the shoreline. The site is licensed for four 100 meter double-headed long-lines.

The mussel farm locations, as recorded during the shoreline survey, are shown in Figure 2.1 together with the boundaries of the seabed lease areas and the present RMP.

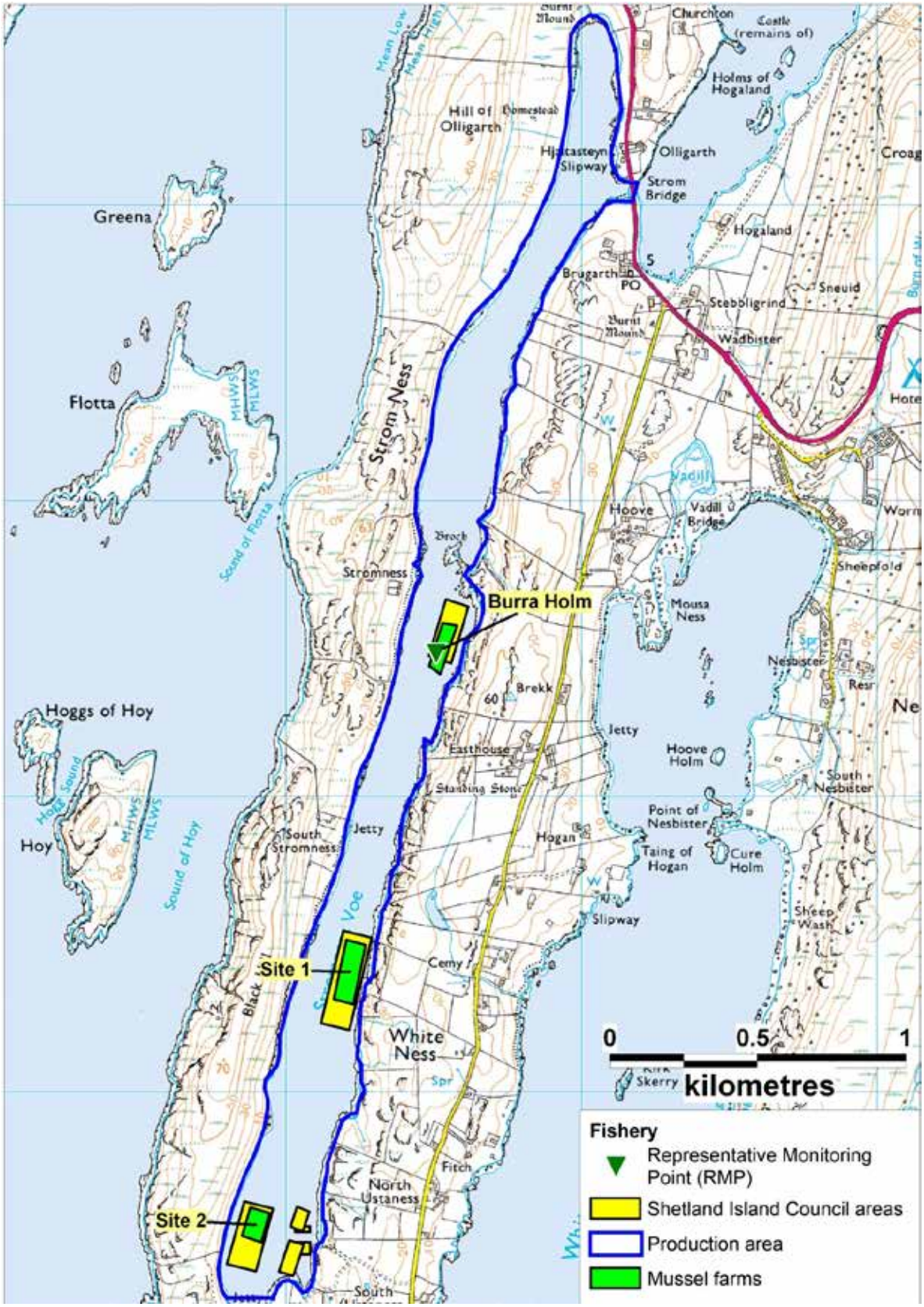

Figure 2.1 Stromness Voe Fishery

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 Stromness Voe. The last census was undertaken in 2011. The census output areas surrounding Stromness Voe are shown thematically mapped by the 2011 population densities in Figure 3.1. The figure shows that population density is higher on the eastern shoreline compared to the western shoreline of the voe.

The western shoreline of the voe (Black Hill) has no road infrastructure and is inaccessible by car reflecting the low population density. There are no named settlements along the eastern shoreline, however there are dwellings located along the road that runs down the length of White Ness. During the shoreline survey, dwellings were observed on the northern shoreline of the Voe. A holiday home was observed at the southern end of the voe and there is a B&B (sleeps 8) with onsite campsite inland to the east.

There is a pier north of Strom Bridge. At the southern end of the voe there was a jetty with three moored boats and a rowing boat. There was also a pier where the mussel farm shore base is located. A small number of work and leisure boats were seen along the southeast shore of the voe near the shore base pier. Although there are no commercial anchorages were identified on the nautical chart for the area, there is a recommended yacht anchorage near the shore base pier. (Clyde Cruising Club, 2005).

Overall, impacts from human sources to the water quality of the shellfish farm are likely to be low due to the low population density of the area, with any effects predominating on the eastern side of the voe.

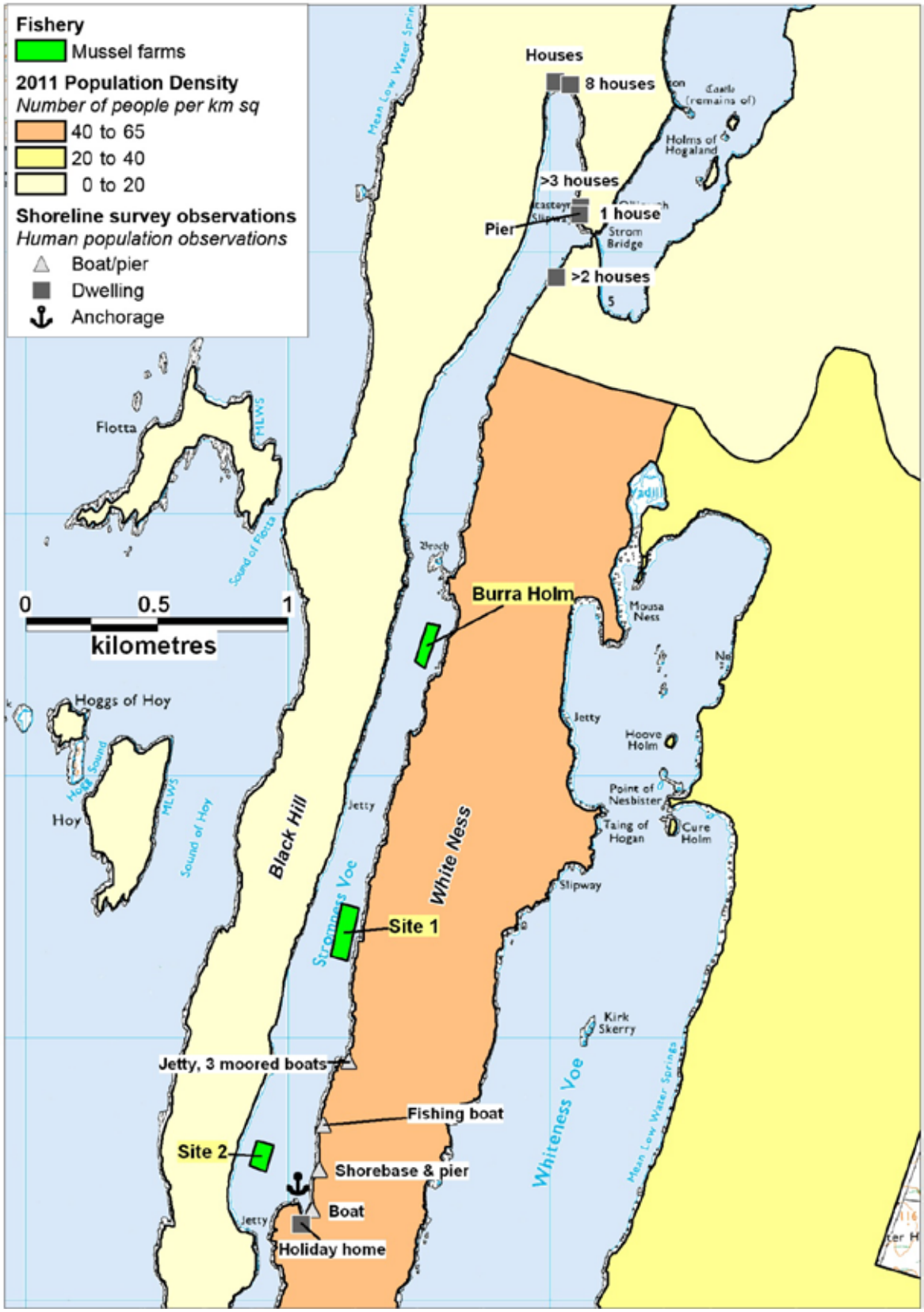

Figure 3.1 Population map for the area in the vicinity of Stromness Voe

4. Sewage Discharges

Information on sewage discharges for an area of radius 6 km around point HU 39119 47290 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, to waterbody or to sea), any available dispersion or dilution modelling studies, and whether improvements were in work or planned.

Scottish Water provided information on nine discharges within the area requested, of which three are within the mapped area in Figure 4.1. These are listed below in Table 4.1. None of the reported assets discharge directly to the Stromness Voe production area. The nearest of these discharge to voes adjacent to Stromness Voe: one in Weisdale Voe to the northwest and two others in Whiteness Voe to the east. The remaining six assets are considered unlikely to impact the production area, so have not been included in the current assessment.

Table 4.1 Scottish Water discharges near Stromness Voe

Consent No.	Discharge Name	NGR	Discharge Type	Level of Treatment	DWF (m3/d)	PE
SD13	Clach-na-Strom ST	HU 388 484	Continuous	Septic tank	-	250
-	Nesbister WWPS	HU 3981 4583	Intermittent	-	-	-
T/B21/062/98	Wormadale ST	HU 3959 4470	Continuous	Septic tank	max 60	-

- Data not supplied

Effluent discharged from the septic tank at Clach–na-Strom in Weisdale Voe would need to travel approximately 6.5 km southward beyond the end of Binna Ness in order to reach the mouth of Stromness Voe approximately 1.3 km south of the southernmost mussel farm. Effluent from the Wormadale septic tank would need to travel approximately 3.4 km southwestward to the end of Whiteness and then 1.8 km north to the southernmost mussel farm. Further to the south, and outwith the request area, is the outfall from the Maa Ness septic tank, which serves the town of Scalloway. It is located 4.3 km SSE of the southernmost Stromness Voe mussel farm, and has a consented design PE of 2850.

Consented Discharges

SEPA provided information on 176 discharges within the area requested. Due to the size and shape of the area requested, many of the reported discharges lay outwith the likely catchment area of the voe and were therefore considered highly unlikely to have an impact on water quality at the mussel farms. These included discharges in and around Tingwall, Laxfirth, Gott, Garderhouse, Sand, Tresta, and Bixter.

Several discharges were identified along the Whiteness peninsula, however most are located on the eastern slope and would be more likely to affect water quality within Whiteness Voe.

Identified consents for discharges directly to the production area, waters feeding it or land adjoining it are listed in Table 4.1 below. No information on the treatment level or receiving body was provided for five of the consented discharges listed in the table. Design Population Equivalent (DPE) values have been given for these suggesting these are sewage discharges. For the purposes of this assessment these are presumed to be septic tanks discharging to soakaway.

The entire datasets provided by SEPA and Scottish Water are included as Appendix 6.

Table 4.2 Consented discharges in the immediate vicinity of Stromness Voe

Licence Number	NGR*	Site Name	DPE	Discharge Type	Discharge To	Related shoreline observation
CAR/R/1078321	HU 3917 4680	Brugarth (Shop), Whiteness, Shetland	15	-	-	
CAR/R/1078325	HU 3911 4683	Brugarth (Workshop), Whiteness, Shetland	15	-	-	
CAR/R/1059209	HU 3804 4326	Pund, South Whiteness, Shetland	5	-	-	4
CAR/R/1038727	HU 3972 4844	Lower Quoynessm, Whiteness, Shetland	5	-	-	
CAR/R/1037694	HU 3919 4719	Olligarth House, Whiteness, Shetland	5	-	-	
CAR/R/1035235	HU 3899 4691	Norcrest, Brugarth, Whiteness, Shetland	6	Septic Tank	Stromness voe	2
CAR/R/1036519	HU 3924 4646	Mews, Whitecairns, Shetland	5	Septic Tank	Soakaway	
CAR/R/1036961	HU 3937 4679	Bretthamar & Stromvatn, Whiteness, Shetland	10	Septic Tank	Loch of Strom	
CAR/R/1038725	HU 3984 4848	Quoyness, Whiteness, Shetland	6	Septic Tank	Soakaway	
CAR/R/1038726	HU 3940 4660	Stebbygrind, Whiteness, Shetland	5	Septic Tank	Soakaway	
CAR/R/1058709	HU 3918 4767	Innvik, Whiteness, Shetland	15	Septic Tank	Soakaway	
CAR/R/1075797	HU 3914 4684	Brugarth, Whiteness, Shetland	5	Septic Tank	Soakaway	
CAR/R/1079709	HU 3922 4679	Brugarth & Raldihus, Whiteness, Shetland	11	Septic Tank	Soakaway	
CAR/R/1089611	HU 3913 4775	Hubrake, Whiteness, Shetland	10	Septic Tank	Soakaway	
CAR/L/1003865	HU 4029 4880	Loch of Strom Site, Loch of Strom, Shetland	-	MCFF	Loch of Strom	
CAR/L/1003070	HU 3690 4300	North Havra MCFF, Sound of Havra	-	MCFF	Sound of Havra	
CAR/R/1101986	HU 3910 4718	Westerhouse, Olligarth, Shetland	6	Septic Tank	Soakaway	1

- = No data provided DPE=Design Population Equivalent MCFF=Marine Cage Fish Farm

* All NGRs rounded to 10 m

Two discharges are recorded as discharging to sea water:

- CAR/R/1036961 discharges to Loch of Strom, 350 m from where it feeds into Stromness Voe, and has a DPE of 10;
- CAR/R/1035235 discharges to Stromness Voe and has a DPE of 6.

Eight of the consented discharges identified by SEPA go to soakaways. Two of these soakaways (CAR/R/1079709 & CAR/R/1101986) plot on or below the Mean Low Water springs mark. Soakaways located this close to the tide mark will not necessarily function effectively and may essentially discharge effluent directly into the water.

Information on consents for Marine Cage Fish Farms (MCFF) was included. Nine marine cage fish farms (MCFF) were identified in the waters immediately to the west of Stromness Voe and one in the Loch of Strom. The nearest of these to a mussel farm (North Havra MCFF) is over 2 km away from the southernmost mussel farm. The fish farm in the Loch of Strom is approximately 3.8 km from the Burra Holm mussel farm. No sewage component was identified, but effluent release may be associated with work barges servicing the farms. They are also likely to be a source of chemical contaminants.

Shoreline Survey Discharge Observations

Four observations of sewage infrastructure or evidence of sewage discharge were noted during the shoreline surveys. These are listed in Table 4.3 below.

Table 4.3 Discharge-associated observations made during the shoreline survey

No.	Date	Associated Photograph	Associated Sample	*E. coli* cfu/100ml	Description
1	06/08/2013	Appendix 5; Figure 7 & 12	SMV-SW04	60	Septic tank on the shore with a pipe leading to the sea, consented discharge on the survey plan. Septic tank in a poor state with outer casing of the tank and pipe casing damaged, seepage coming from the tank and black/green algae forming on the tank.
2	06/08/2013	Appendix 5; Figure 8 & Figure 13	SMV-SW06	80000	Consented discharge noted on the survey plan, pipe observed leading to the water but no septic tank located. Grey discharge seen at the end of the pipe. Seawater sample taken (not on survey plan) from the end of the pipe, slight sewage smell noted whilst the sample was being obtained.
3	06/08/2013	Appendix 5; Figure 9			Septic tank of holiday home at Pund.

Observation 1 reported a septic tank on the shore with a pipe leading to the sea. The septic tank was reported as being in a poor state of repair with the outer casing of the tank and pipe damaged. Seepage was reported coming from the tank with a black/green biofilm on the tank. A sea water sample

taken at the discharge point returned a moderately low value of 60 *E. coli cfu*/100ml. This observation correlates with CAR/R/1101986 which is reported as a septic tank with a DPE of 6, discharging to soakaway.

Observation 2 reported a pipe discharging to Stromness Voe. A grey discharge plume was noted along with a smell of sewage. A seawater sample taken from within this plume returned a value of 80000 *E. coli cfu*/100ml. The salinity of this sample was given as 26.93 PSU indicating some mixing. This observation correlates with CAR/R/1035235 which is reported as being a septic tank with a DPE of 6, discharging to Stromness Voe

Observation 3 reported a septic tank associated with a known holiday home. This observation correlates with CAR/R/1059209. No details of receiving body or treatment level were provided for this consent but a DPE of 5 is recorded.

Summary

The area around the production area is sparsely inhabited, and this is reflected in the number of sewage discharges.

The greatest concentration of discharges lies at the north end of the voe, a little over a kilometre north of the Burra Holm mussel site. However, a single septic tank is present at Pund, at the south end of the voe, and this is within 300 m of the Site 2 mussel farm.

List of Acronyms

MDF	Mean daily flow
DWF	Dry weather flow
DPE	Population Equivalent
ST	Septic Tank
WWPS	Wastewater Pumping Station
WWTW	Wastewater Treatment Work

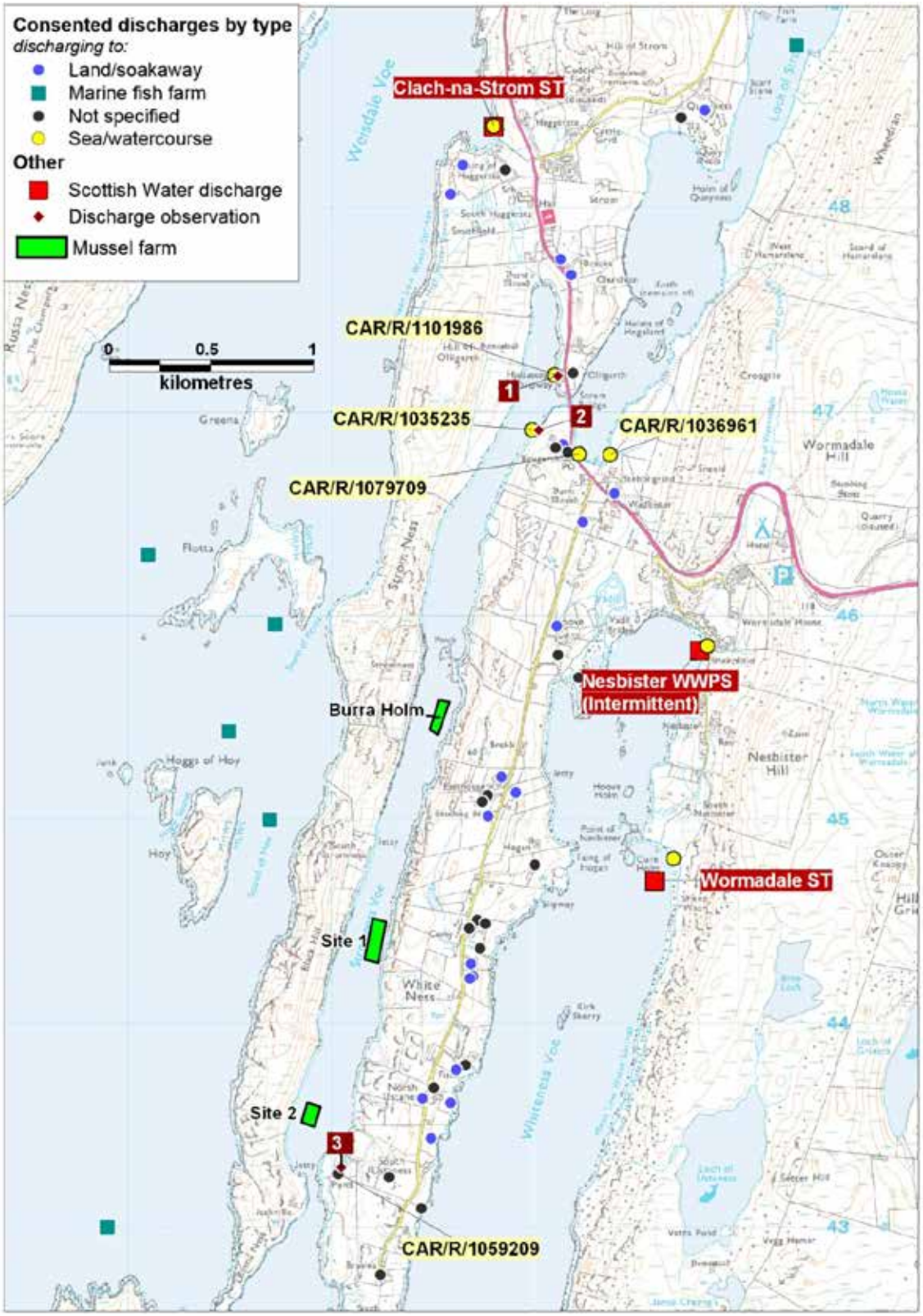

Figure 4.1 Map of discharges for Stromness Voe

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 Whiteness 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 Whiteness agricultural parish 2012

	Whiteness	
	16 km^2	
	Holdings	Numbers
Pigs	*	*
Poultry	7	104
Cattle	*	*
Sheep	20	4,130
Other horses and ponies	*	*

The size of the Whiteness agricultural parish is small enough to be likely to represent the livestock numbers present in the Stromness Voe area, although it is not possible to determine the spatial distribution of these livestock within the parish area. The livestock numbers indicate that sheep are the more dominant livestock type with poultry present in low numbers. The number of pigs, cattle and other horses and ponies were not reported due to the small number of holdings.

An additional significant 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 6th August 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 shoreline survey, approximately 100 sheep in total were observed grazing along the eastern shoreline. Sheep faeces were also present along the majority of the shoreline. Ninety sheep were observed on the western shoreline west of the Burra Holm site with a further, unspecified number further to the south, between Burra Holm and Site 1. Cattle faeces and 6 cattle were observed on the shoreline adjacent to the Burra Holm fishery. At the north eastern end of the voe, a large amount of equine faeces, an equine feed/shelter area and a Shetland pony were observed.

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 along the eastern shoreline would be most likely to affect the eastern side of mussel farms adjacent to the shoreline, where livestock, specifically sheep have been found grazing.

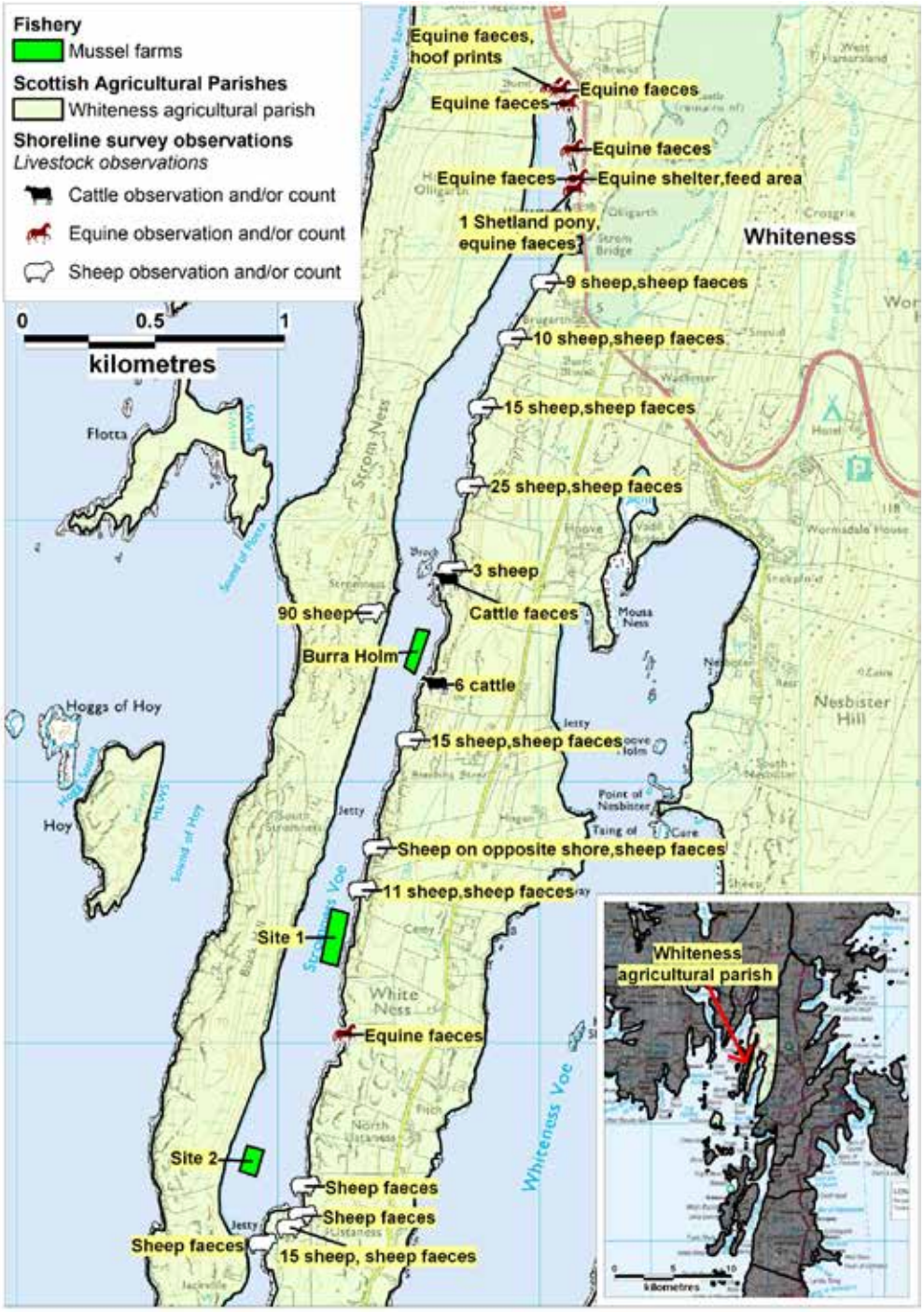

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Figure 5.1 Agricultural parish boundaries and shoreline survey livestock observations

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, whales, dolphins 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 Stromness Voe common mussel fisheries are considered below.

Pinnipeds

Declines of up to 50% have now been documented in harbour seal populations around Shetland (Special Committee on Seals, 2012). In an aerial survey conducted in 2009, 3003 harbour seals were observed in Shetland, compared to 4883 seals seen in 2001 (Special Committee on Seals, 2011). Comparatively, grey seal populations are shown to be booming, with an estimated 3300 grey seal pups alone born in 2010 (Shetland and mainland Scotland) taken from aerial surveys (Special Committee on Seals, 2012). Grey seal colonies are mostly found along uninhabited, rocky shorelines but are shown to have very wide foraging ranges.

In the Marine Spatial Plan for Shetland (2012) Stromness Voe is not a recognised area for seals. However an important location for seals exists in the adjacent Whiteness Voe and seals may also use Stromness Voe from time to time. One seal was observed at the head of the voe during the shoreline survey.

Cetaceans

The waters around Shetland are known to support both native and migrant cetacean species. No cetaceans were observed during the shoreline survey. The Marine Spatial Plan for Shetland (2012) does not identify that Stromness Voe as an important area for cetaceans, though an area to the southeast, at the mouth of Whiteness Voe is recognised as an area used by orcas.

Birds

Seabird 2000 census data (Mitchell, et al., 2004) was queried for the area within a 5 km radius of the Stromness Voe production area and is summarised in Table 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 Stromness Voe

Common name	Species	Count*	Method
Arctic skua	*Stercorarius parasiticus*	2	Occupied territory
Great skua	*Stercorarius skua*	1	Occupied territory
European herring gull	*Larus argentatus*	737	Individuals on land, occupied territory, occupied nests
Common gull	*Larus canus*	236	Individuals on land, occupied territory
Lesser black-backed gull	*Larus fuscus*	30	Individuals on land
Great black-backed gull	*Larus marinus*	71	Individuals on land, occupied territory, occupied nests
Blacked-headed gull	*Larus ridibundus*	82	Individuals on land, occupied territory
Black guillemot	*Cepphus grylle*	69	Individuals on land
Arctic tern	*Sterna paradisaea*	148	Individuals on land
Common tern	*Sterna hirundo*	14	Individuals on land
Northern fulmar	*Fulmarus glacialis*	473	Occupied sites

*Counts where the method was identified as occupied territory/sites/nests were doubled to yield an estimated total count of individual birds.

A large number of seabirds are identified in the Seabird 2000 data. The densest populations are located outside the mouth of Stromness Voe, to the southwest on the island of North Havra and to the west on the small uninhabited island of Hoy. These dense populations of seabirds pose a potential significant source of contamination as these birds may feed and rest in the Stromness Voe area.

In the Marine Spatial Plan for Shetland (2012) Stromness Voe was recorded as being important for several species of seabird, as well as ducks and divers. Winter populations of Eider duck were also noted to the east and west of the Voe (November-March).

During the shoreline survey, birds were the most common wildlife observed. Evidence of seabirds feeding was noted on the southern end of the Voe, with some bird faeces also noted on the mussel floats. Birds noted included terns, curlew, gulls, doves, starlings and one great-skua. The densest populations were found to the north; three large flocks of starlings and 50 terns noted to the south. It should be noted that only the eastern shore and head of the voe were surveyed in detail and so there could have been more birds located on the western shore.

The locations of the SeaBird 2000 records, together with shoreline survey observations of wildlife, are shown in Figure 6.1.

Otters

In the Marine Spatial Plan for Shetland (2012), Stromness Voe was not identified as being an important area for otters. However, otters may use the area around Stromness, particularly the western side of the Voe which is largely uninhabited.

Rabbits

Rabbits (*Oryctolagus cuniculus*) were introduced to Shetland centuries ago, but have since established populations and become a widespread species (Shetland Biological Records Centre, 2013). During the survey 14 rabbits in total were noted along the eastern shoreline, as well as a large number of rabbit holes north of the Burra Holm site. Ten rabbits were noted adjacent to Site 1 mussel farm.

It should be noted that *E. coli* is usually only present inconsistently, and in low concentrations, in weaned healthy rabbits although this changes markedly in colonies suffering from *E. coli* enteritis (Peeters, et al., 1984).

Overall

Species potentially impacting on Stromness Voe include seals, rabbits and birds, including seabirds. That from seabirds will predominate. The available information indicates that deposition of faeces from these sources is likely to be widely distributed around the area.

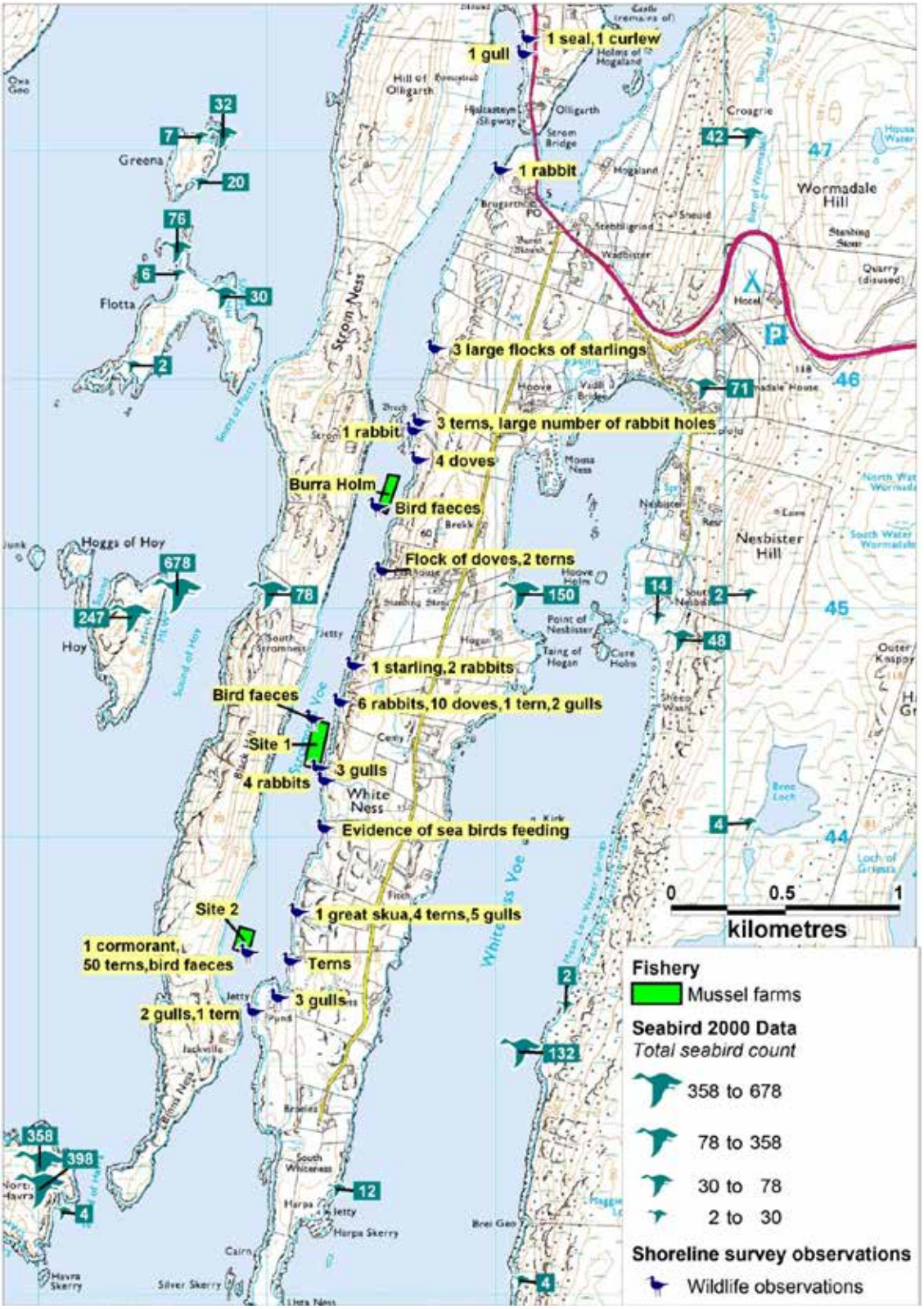

Figure 6.1 Map of wildlife around Stromness Voe.

7. Land Cover

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

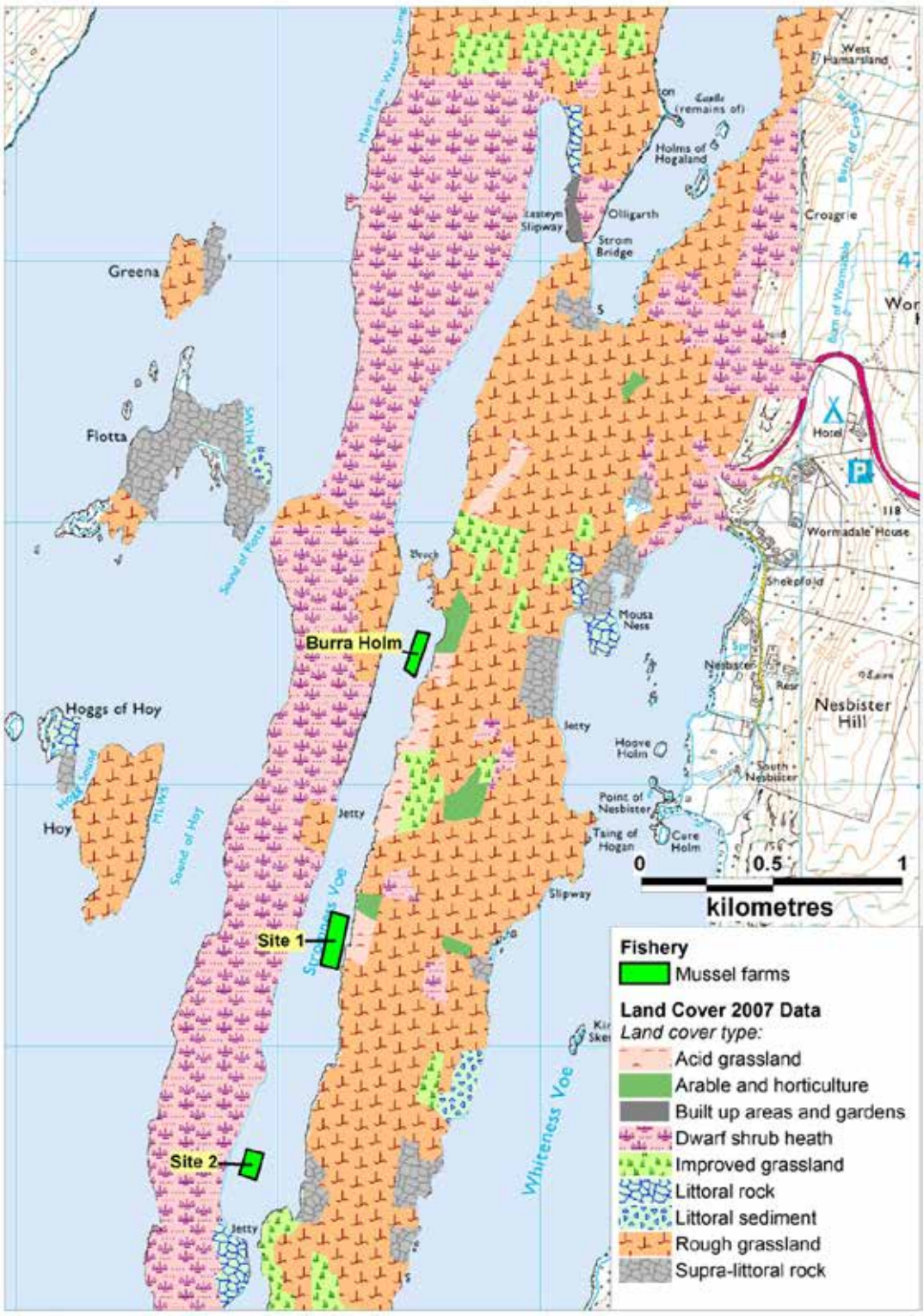

Figure 7.1 LCM2007 land cover for the area around Stromness Voe

Dwarf shrub heath dominates the western shoreline with some smaller areas of rough and improved grassland present. The eastern shoreline is dominated by rough grassland with smaller areas of improved grassland, acid grassland and dwarf shrub heath. The areas of improved grassland are situated both inland and scattered along the eastern shoreline of the voe. Five small areas were identified as arable land (bare), one of which lies immediately NE of Site 1 and another of which lies adjacent and NE of Burra Holm site. No evidence of arable use in these areas was apparent from recent (2012) satellite imagery available on the internet. Therefore, for the purposes of this report, these areas will be considered to have the same cover as land around them.

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 Stromness Voe fisheries are from the areas of improved grassland located on the shoreline southeast of Site 2 and north of Burra Holm. The potential contribution of contaminated run-off to the mussel farms would be highest in these areas. This impact would be expected to increase after rainfall.

8. Watercourses

There are no river gauging stations on watercourses entering into Stromness Voe. The Scottish Sea Lochs Catalogue identifies Stromness Voe as having an annual rainfall level of 1150 mm and freshwater land run-off equates to 1.8 m m^3/yr (Edwards & Sharples, 1986)

The shoreline survey was conducted on the 5th August 2013 under mainly dry weather conditions, though some light showers were recorded in the 24 hr prior to the survey. Only one watercourse could be measured and sampled during the survey. Details of this watercourse are shown below in Table 8.1. The remaining five observed watercourses had insufficient flow to measure and therefore are not included in the table. Two areas of bog were also recorded. The above features are shown in the map in Figure 8.1.

Table 8.1 Watercourse loadings for Stromness Voe

No.	Description	NGR	Width (m)	Depth (m)	Flow (m^3/day)	Loading (*E. coli* per day)
1	Unnamed watercourse	HU 3902 4766	0.45	0.05	29.16	2.6 x10^7

The only watercourse noted during the survey entered from the north of Stromness Voe was estimated to have a low loading of 2.6 x 10^7 *E. coli* per day at the time of the survey. It was situated > 2 km north of the most northern site (Burra Holm).

The majority of the land drainage areas were observed to the southern end of Stromness Voe. These are closer to the Sites 1 and 2, with two areas noted < 250 m south of Site 1 and two areas within < 250 m of Site 2. One area of land drainage was also noted < 250 m north of the Burra Holm site. Two bogs were also noted, one at the head of Stromness Voe, and the other to the south close to Sites 1 and 2.

Overall, it is not expected that freshwater sources will have a significant impact on the extent of contamination of the mussel fisheries at Stromness Voe. Due to the dry weather that was experienced prior to and on the day of survey, it is expected that during or following periods of higher rainfall, the areas of land drainage that were observed during the survey will enter into the voe and may represent additional potential sources of faecal contamination. Freshwater contamination is expected to be greatest at Site 1, where one of the potential sources is close to the southeast end of the mussel farm. Inputs to the Loch of Strom have not been considered due to the distance from the mussel farms.

Figure 8.1 Map of watercourse loadings at Stromness Voe

Where the bacterial loadings is labelled on the map, the scientific notation is written in digital format, as this is the only format recognised by the mapping software. So where normal scientific notation for 1000 is 1x10^3, in digital format it is written as 1E+03.

9. Meteorological Data

The nearest weather station for which rainfall data was available is located at Lerwick, situated approximately 9 km to the south east of the production area. Rainfall data was available for January 2007 – December 2012. The nearest wind station is also situated in Lerwick. Conditions may differ between this station and the fisheries due to the distances between themData for this station 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 Stromness Voe.

9.1 Rainfall

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

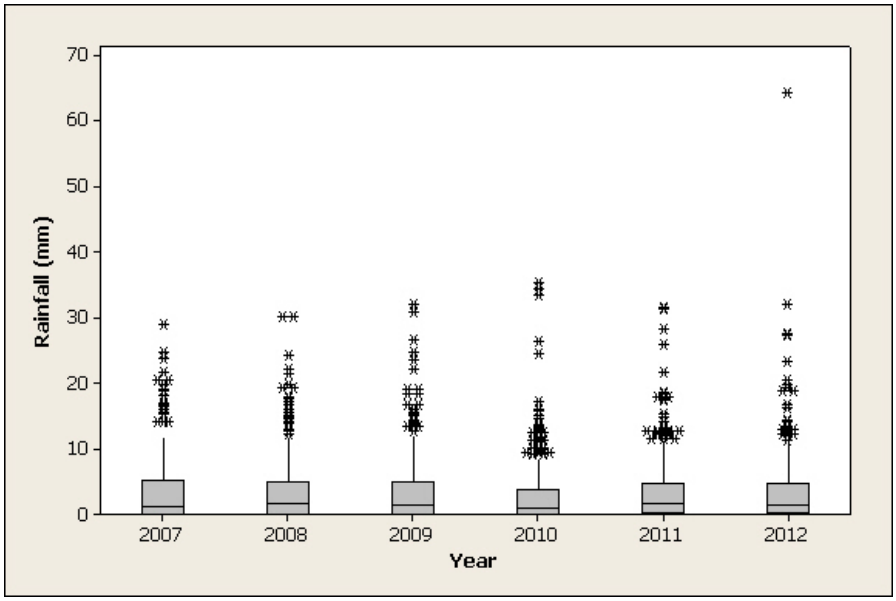

Figure 9.1 Box plot of daily rainfall values by year at Lerwick (2007 – 2012)

Daily rainfall values varied from year to year, with 2010 being the driest year. There was no marked difference in total rainfall between the other years. High rainfall values of more than 30 mm/d occurred in all years but an extreme rainfall event of nearly 70 mm/d was seen in 2012.

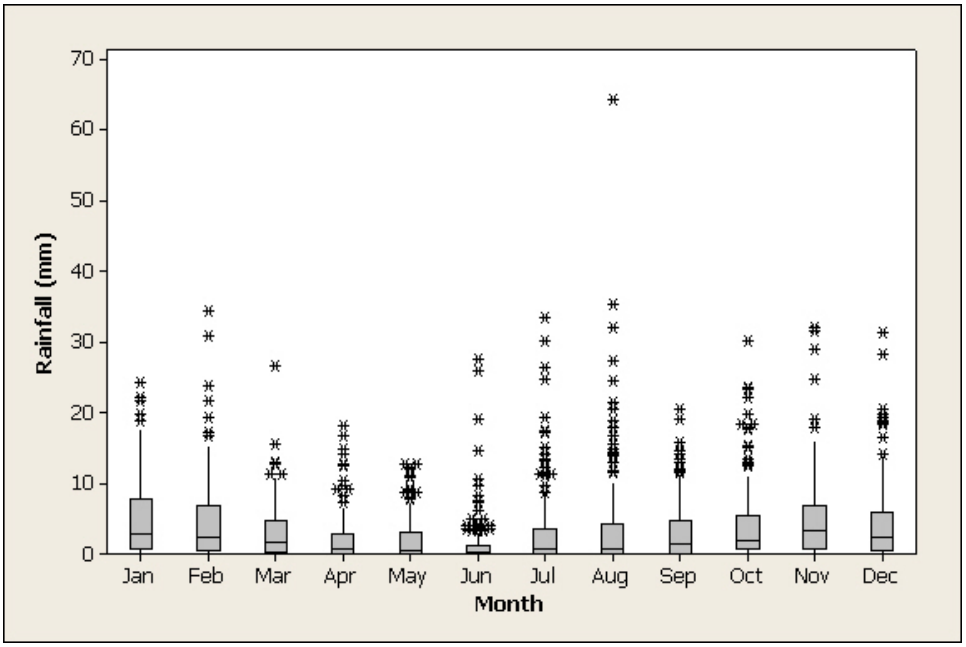

Figure 9.2 Box plot of daily rainfall values by month at Lerwick (2007 – 2012)

Rainfall was higher during the autumn and winter. Rainfall was lowest from April to June. The extreme rainfall of nearly 70 mm/d occurred in August.

For the period considered here (2007-2012) 43 % of days received daily rainfall of less than 1 mm and 9 % of days received rainfall of over 10 mm. It is therefore expected than run-off due to rainfall will be higher during the autumn and winter months. However, extreme rainfall events leading to episodes of high run-off 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 land when greater numbers of livestock are present.

9.2 Wind

Wind data for Lerwick is summarised in seasonal wind roses in Figure 9.3 and an annual wind rose in Figure 9.4.

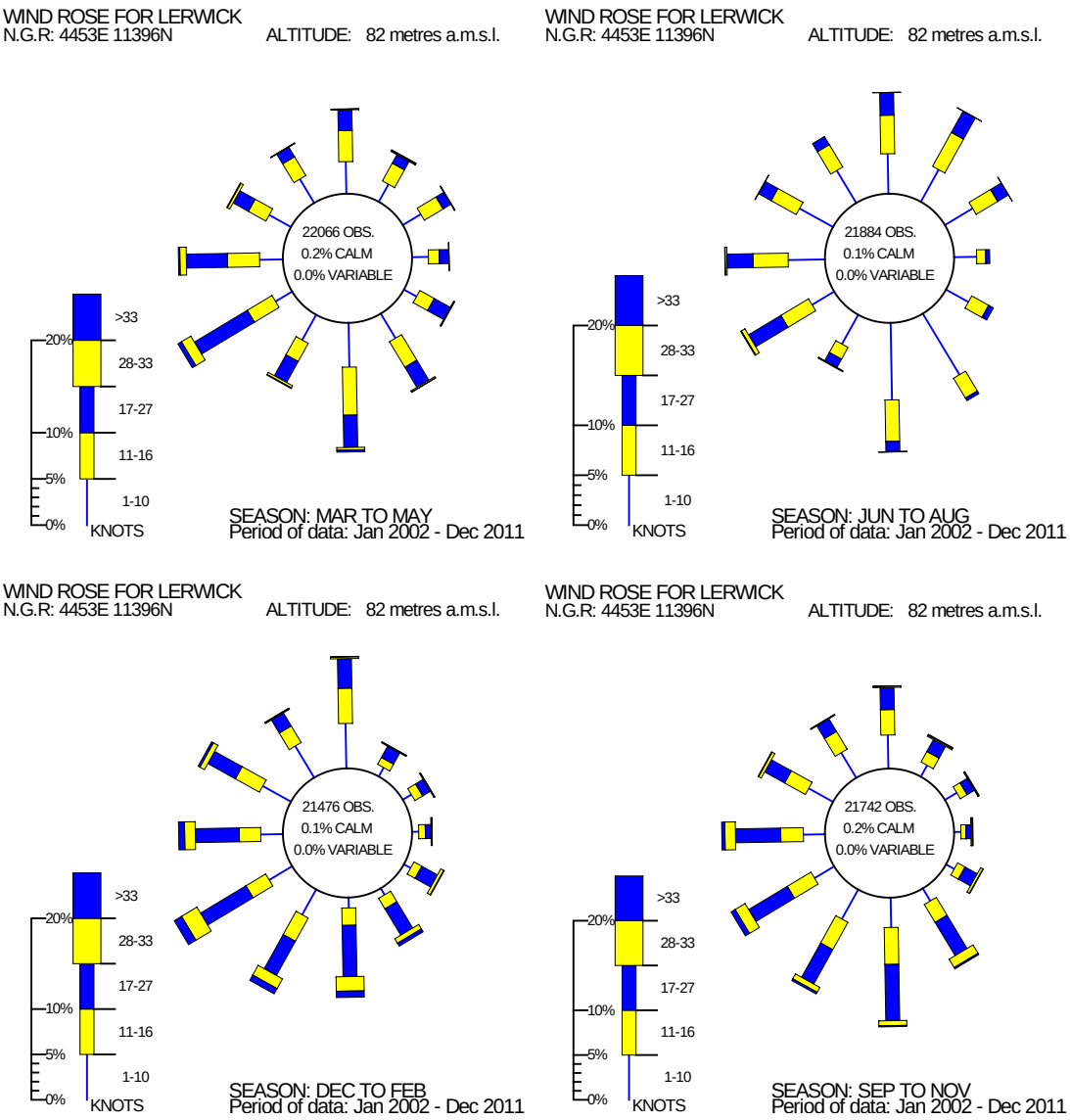

Figure 9.3 Seasonal wind roses for Lerwick

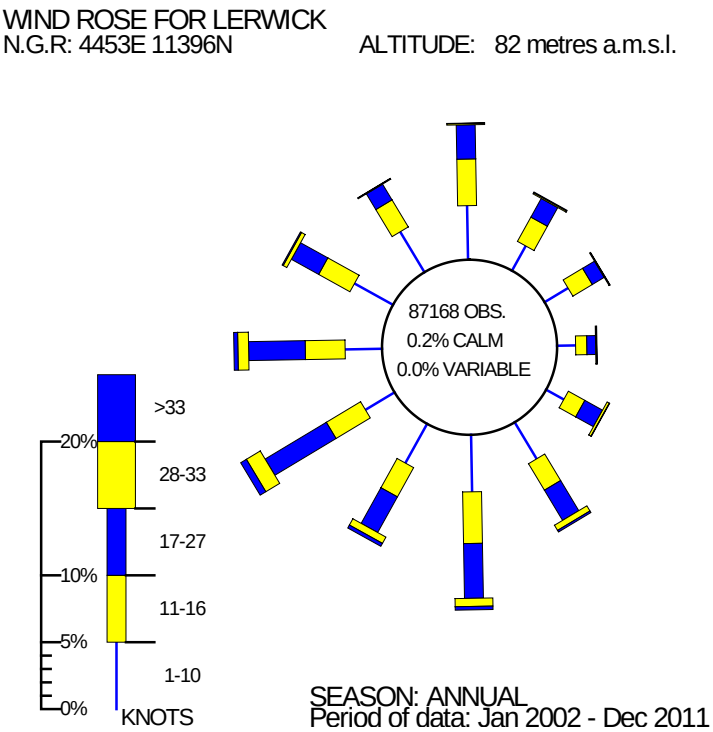

Figure 9.4 Annual wind rose for Lerwick

Overall the annual wind direction showed that wind was stronger when coming from the west than the east, and winds from the southerly direction were stronger than those from the north. Predominant winds were from the SW. Winds changed from NNE in the summer months to SW in the winter months and winds were much stronger in the winter months than in the summer months.

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

10. Classification Information

Stromness Voe has been classified for production of common mussel (Mytilus edulis) since 2004. The classification history since 2008 is listed in Table 10.1. The area has been consistently classified as A over that period.

Table 10.1 Stromness Voe classification history

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

11. Historical *E. coli* Data

11.1 Validation of historical data

Results for all samples assigned against the Stromness Voe production area were extracted from the FSAS database for the period 01/01/2008 to the 25/09/2013 and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. All *E. coli* results were reported as most probable number (MPN) per 100 g of shellfish flesh and intravalvular fluid.

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.

All results were assigned to Burra Holm, with no results returned at Stromness Voe. All 61 samples assigned to Burra Holm were recorded as valid, were received within the 48hr delivery window and had box temperatures of < 8^{o}C. All samples were recorded as having been taken from within the production area and 21 samples had results of < 20 *E. coli* MPN / 100 g.

Historical sampling results are summarised in Table 11.1 below.

11.1 Summary of microbiological results

Table 11.1 Summary of historical sampling and results

Sampling Summary	
Production area	Stromness Voe
Site	Burra Holm
Species	common mussels
SIN	SI-273-467-08
Location	Various
Total no of samples	61
No. 2008	9
No. 2009	10
No. 2010	11
No. 2011	10
No. 2012	12
No. 2013	9
Minimum	< 20
Maximum	490
Median	20
Geometric mean	36
90 percentile	202
95 percentile	320
No. exceeding 230/100g	3 (5%)
No. exceeding 1000/100g	0
No. exceeding 4600/100g	0
No. exceeding 18000/100g	0

Sampling has varied between 9 and 12 samples taken per year. Three samples gave results > 230 *E. coli* MPN/100 g.

11.2 Overall geographical pattern of results

The geographical locations of all 61 sample results assigned to Stromness Voe are mapped thematically in Figure 11.1. There have been three distinct areas of sampling relating to different times during the review period. The current RMP is located at HU 3851 4549, where 15 samples were recorded as having been taken between 2011 and 2012, with one sample from 2010. The remaining samples were all taken within < 100 m of the RMP. Thirty-seven samples from 2008 to 2011 were taken at the southeast end of the Burra Holm site, just outside the current estimated location of the mussel farm. Nine samples from 2012-2013 were recorded as having been taken just to the south at the of the northeast corner of the estimated mussel farm.

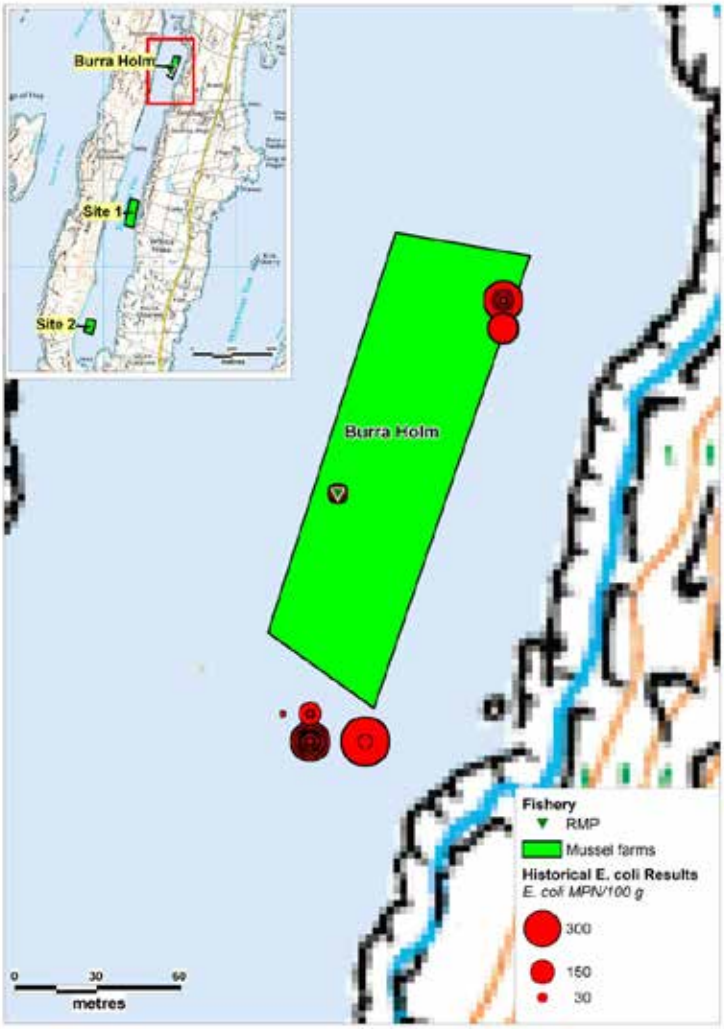

Figure 11.1 Map of reported sampling locations for common mussels at Stromness Voe

Sampling results have varied by location, with the highest result being seen within the group to the south of the present mussel lines.. However, one-way ANOVA using log_{10}-tranformed *E. coli* data showed no significant difference between the mean results from the three groups ($F=1.48$, $df=(2,58)$, $p=0.237$).

11.3 Overall temporal pattern of results

A scatterplot of *E. coli* results against date for Stromness Voe 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.

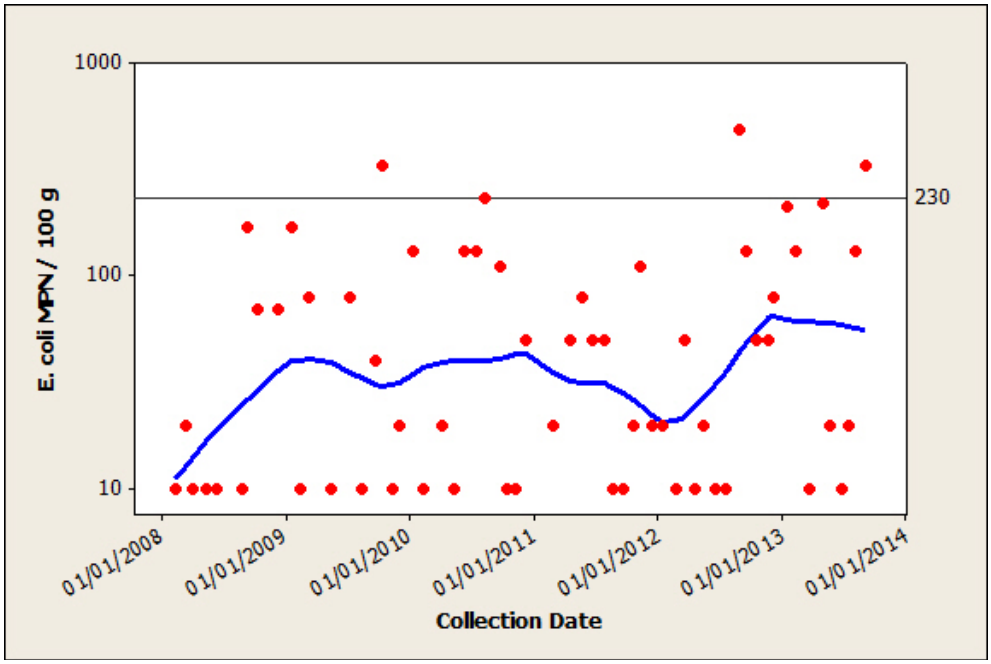

Figure 11.2 Scatterplot of *E. coli* results by collection date at Stromness Voe, fitted with a lowess line

Contamination levels have generally been low over the sampling period, although there is evidence of a slight increase in results over time.

11.4 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.

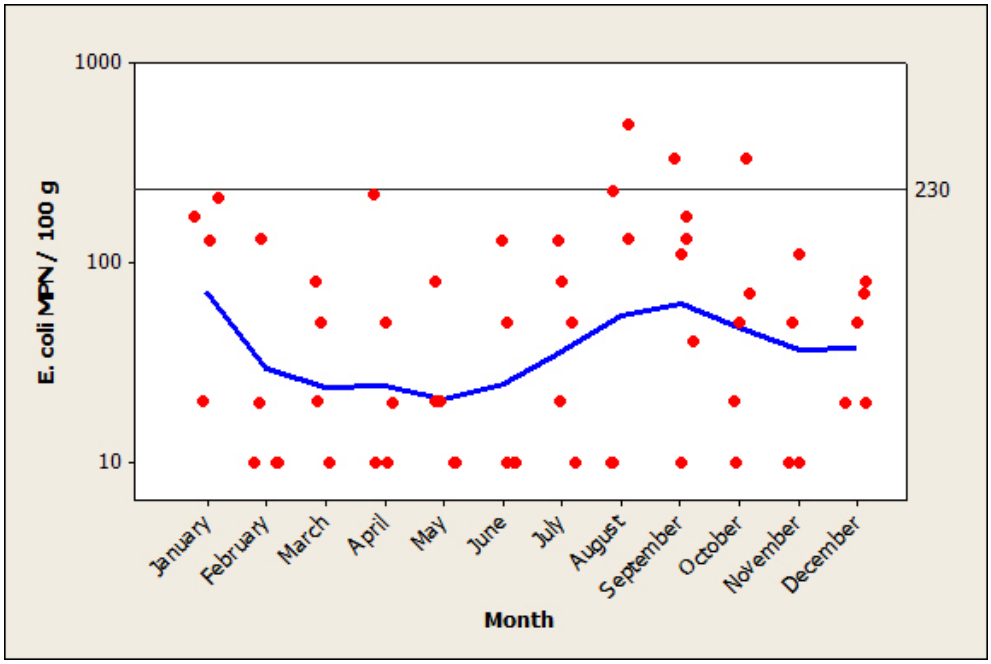

Figure 11.3 Scatterplot of *E. coli* results by month at Stromness Voe, fitted with a lowess line

Contamination levels show some indication of a seasonal increase, with higher results being mostly seen in samples taken in August and September.

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.

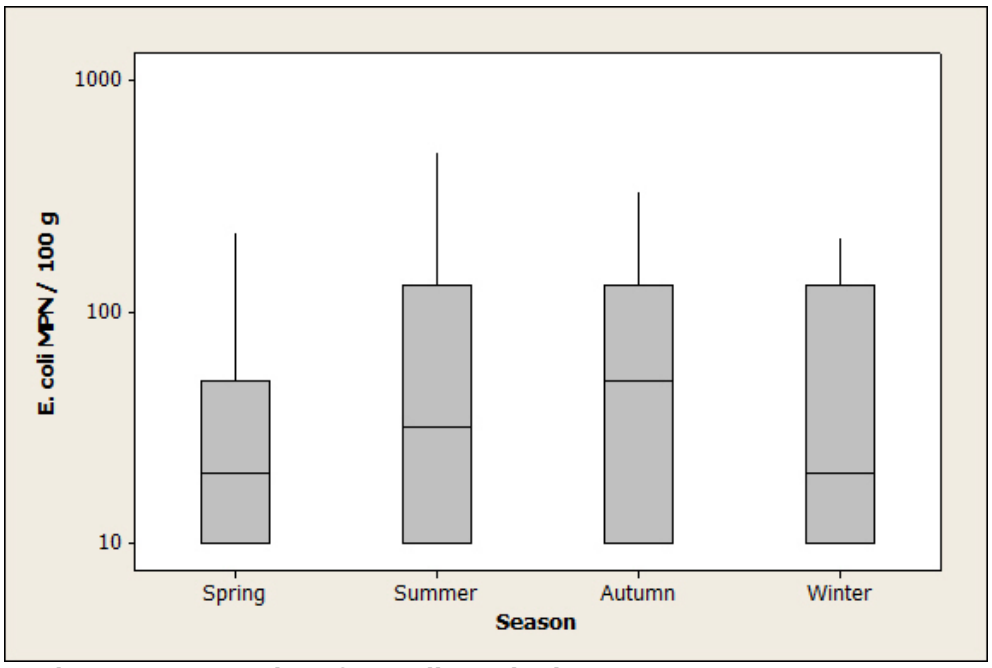

Figure 11.4 Boxplot of *E. coli* results by season at Stromness Voe

No significant difference was found between *E. coli* results by season (one-way ANOVA, p = 0.410, Appendix 4).

11.4.1 Analysis of results against environmental factors

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

11.4.2 Analysis of results by recent rainfall

The nearest weather station with available rainfall data was at Lerwick approximately 9 km southeast of Stromness Voe. 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 Stromness Voe 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.

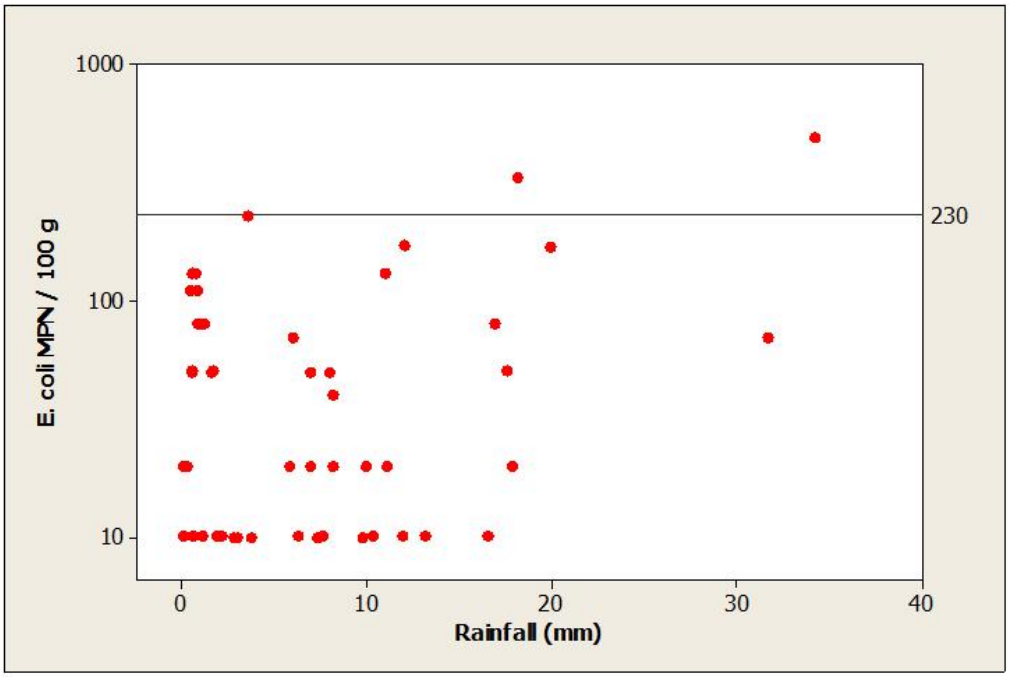

Figure 11.5 Scatterplot of *E. coli* results against rainfall in the previous two days at Stromness Voe

No significant correlation was found between *E. coli* results and the previous two day rainfall (Spearman's rank correlation r = 0.099, p = 0.487), though the highest result of 490 *E. coli* MPN / 100 g taken at the highest rainfall value.

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 Stromness Voe is shown in Figure 11.6. Jittering was applied at 0.02 (x-axis) and 0.001 (y-axis) respectively.

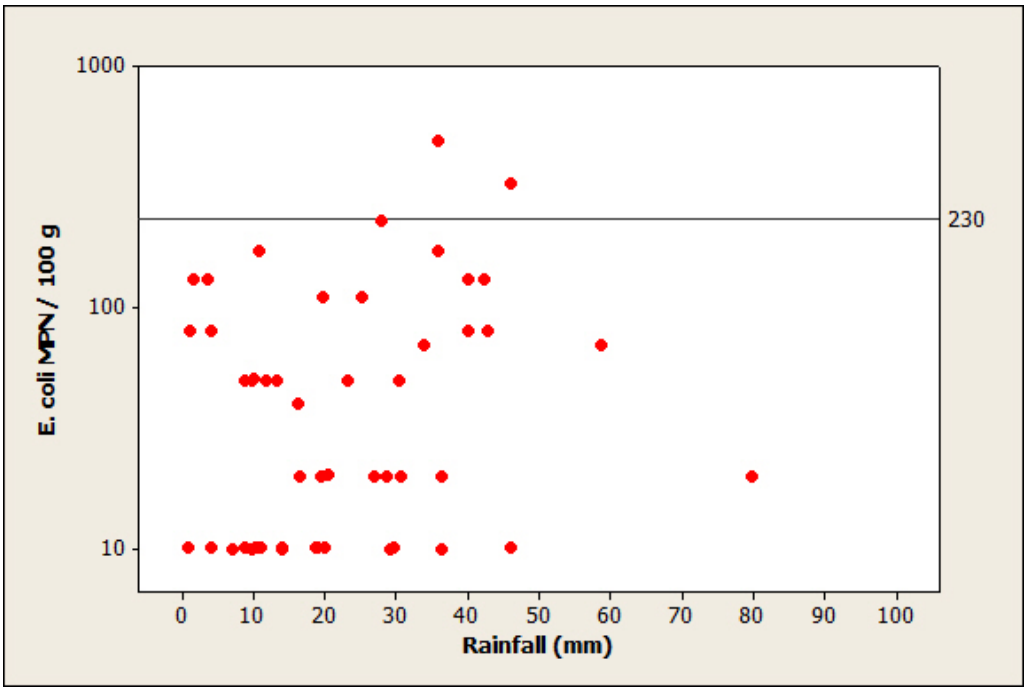

Figure 11.6 Scatterplot of *E. coli* results against rainfall in the previous seven days at Stromness Voe

No significant correlation was found between *E. coli* results and the previous seven day rainfall (Spearman's rank correlation r = 0.234, p = 0.095), with low results taken at high rainfall levels.

11.4.3 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 therefore increase circulation and particle transport distances from potential contamination sources on the shoreline. Figure 11.7 presents a polar plot of *E. coli* results against the lunar cycle**.** The largest spring tides occur approximately two days after the full moon (located at about 45^{o} in the figure), then decreases to the smallest neap tides (at about 225^{o}), before increasing back to spring tides (at about 0^{o}). 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.

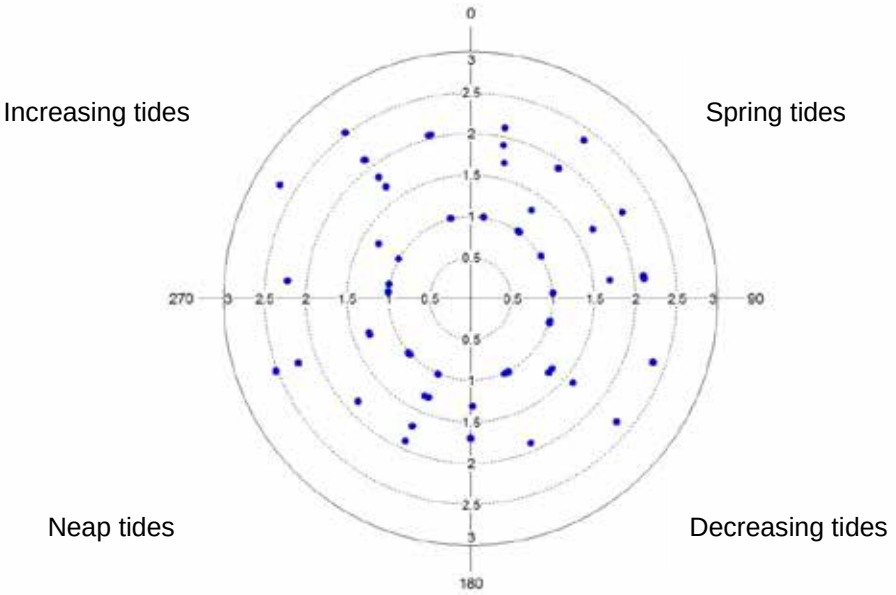

Figure 11.7 Polar plots of Log_{10} *E. coli* results on the spring/neap tidal cycle at Stromness Voe

A significant correlation was found between log_{10} *E. coli* results and the spring/neap tidal cycle (circular-linear correlation r = 0.267, p = 0.016), highest results 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 Scalloway was extracted from POLTIPS-3 in August 2013. This site was the closest to the production area (approximately 13 km to the northwest) and it is assumed that tidal state will be similar between sites.

High

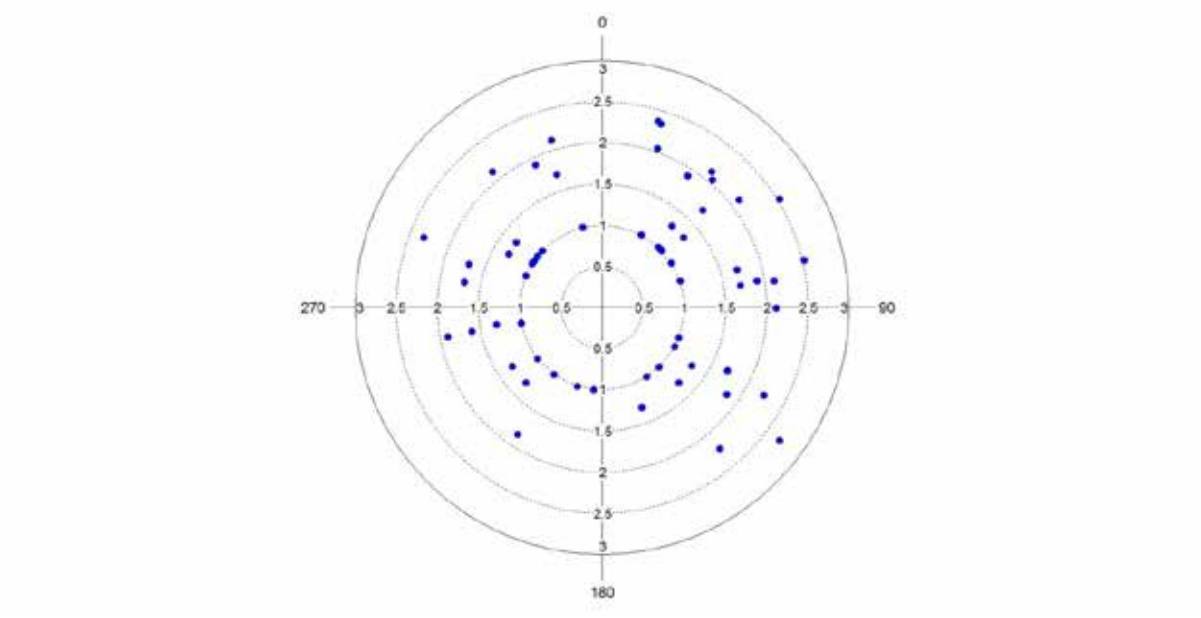

Figure 11.8 Polar plots of log_{10} *E. coli* results on the high/low tidal cycle at Stromness Voe

A significant correlation was found between log_{10} *E. coli* results and the high/low tidal cycle (circular-linear correlation r = 0.298, p = 0.006), highest results were taken on the high and ebb tides.

11.4.4 Analysis of results by water temperature

Water temperature can affect survival time of bacteria in seawater (Burkhardt, et al., 2000). It can also affect the feeding and elimination rates in shellfish and therefore may be an important predictor of *E. coli* levels in shellfish flesh. Water temperature is obviously closely related to season. Any correlation between temperatures and *E. coli* levels in shellfish flesh may therefore not be directly attributable to temperature, but to the other factors e.g. seasonal differences in livestock grazing patterns. Figure 11.9 presents *E. coli* results against water temperature. Water temperature was recorded for all 61 samples. Jittering of results was applied at 0.02 (x-axis) and 0.001 (y-axis) respectively.

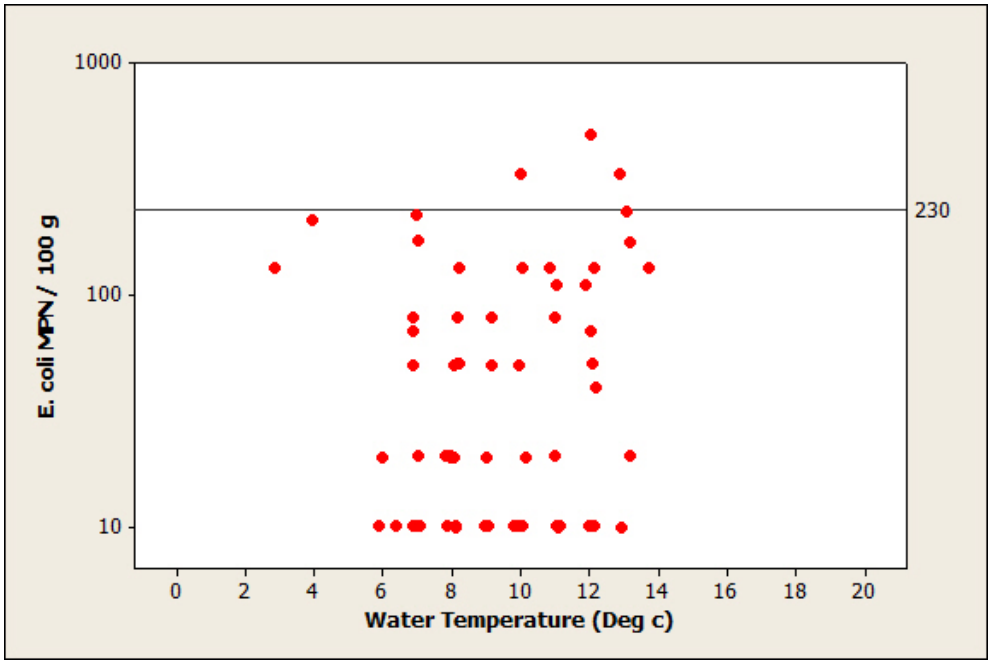

Figure 11.9 Scatterplot of *E. coli* results against water temperature at Stromness Voe

No significant correlation was found between *E. coli* results and water temperature (Spearman's rank correlation r = 0.114, p = 0.381).

11.4.5 Analysis of results by salinity

Salinity will give a direct measure of freshwater influence and hence freshwater borne contamination at a site. Salinity was recorded for 43 out of the 61 samples, and a scatterplot of common mussel *E. coli* results against salinity is shown in Figure 11.10. Jittering of results occurred at 0.02 and 0.001 on the X and Y axis respectively.

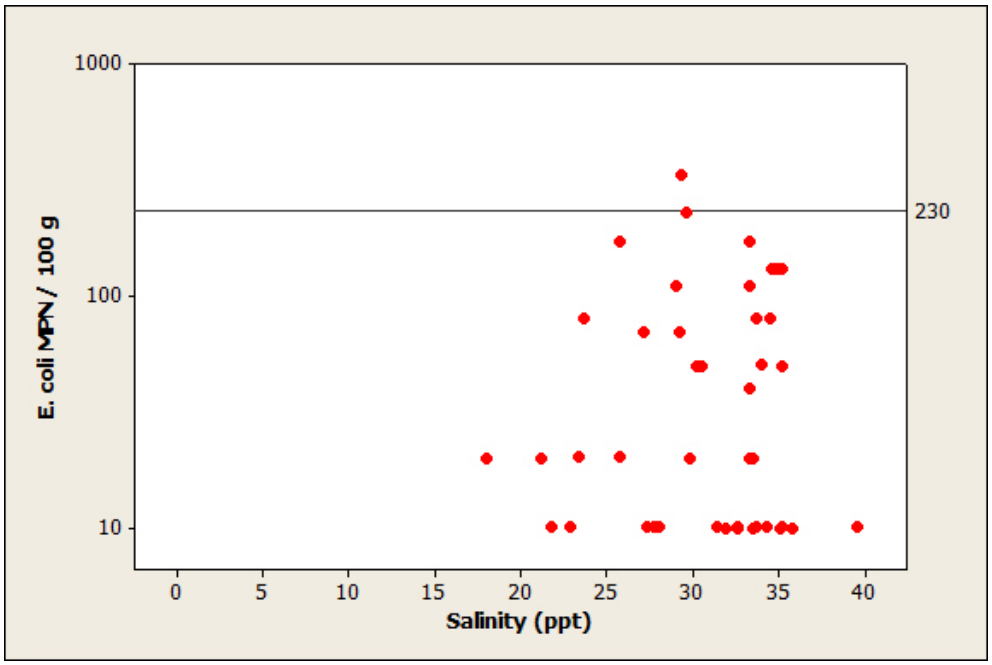

Figure 11.10 Scatterplot of *E. coli* results against salinity at Stromness Voe

No significant correlation was found between common mussel *E. coli* results and salinity (Spearman's rank correlation r = 0.016, p = 0.920).

11.5 Evaluation of results over 230 *E. coli* MPN/100g

Three common mussel samples yielded results > 230 *E. coli* MPN/100 g and these are listed below in Table 11.2.

Table 11.2 Stromness Voe historic *E. coli* sampling results over 230 *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 (spring/neap)	Tidal State (high/low)
14/10/2009	330	HU 385 454	18.6	46.2	10.0	29.22	neap	High
29/08/2012	490	HU 3852 4540	33.8	35.0	12.0	-	Increasing	Ebb
03/09/2013	330	HU 3857 4556	-	-	12.7	-	Increasing	High

-No data available

Elevated results were between 330 and 490 *E. coli* MPN/100 g and were taken in years 2009, 2012 and 2013. They were taken in August, September and October. One sample was taken to the northeast of the RMP and two taken to the south. Rainfall was only available for the two earliest samples and varied between 18.6 and 33.8 mm for the two previous days and 35.0 and 46.2 over the previous seven days. Water temperature was available for all three samples and varied between 10.0-12.7^{o}C, whilst salinity was only available for the 2009 sample and was at 29.22 ppt. Tidal states for 2 of the 3 samples were an increasing and a high tide.

11.6 Summary and conclusions

Overall, *E. coli* results for Stromness Voe show that levels of contamination have been low, with only three results > 230 *E. coli* MPN/100 g. Locations of sampling also varied between three areas relating to sampling year; RMP (2011 and 2012), 90 m northeast (2013) or 90 m southeast (2008-2010).

Statistical analyses found no significant difference between results and location or season. However, all results > 230 *E. coli* MPN/100 g occurred during late summer/early autumn. No statistically significant correlations were found between *E. coli* results and previous two day/seven day rainfall or seawater temperature/salinity.

Statistically significant correlations were found between *E. coli* results and both the high/low tidal and spring/neap tidal cycles with most high results taken at high and ebb tides with respect to the former and increasing tides with respect to the latter.

12. Designated Waters Data

The central section of the Stromness Voe production area is designated as Stromness Voe shellfish growing water (SGW), as shown in Figure 12.1. The designation covers the area bounded by lines drawn between HU 38460 45743 and HU 38604 45746 and between HU 38204 44898 and HU 38388 44877, extending to MHWS. Details of the designation, including the location of the sampling point were not obtainable as the Stromness Voe report was unavailable at the time of writing this report (http://apps.sepa.org.uk/shellfish/pdf/132.pdf). The Scottish Government proposes to extend the current designation of Stromness Voe to match the boundaries of the current production area and encompass the whole of the voe. This will be implemented following the repeal of the Shellfish Waters Directive (2006/113/EC) in December 2013. Since 2007, SEPA has used the FSAS *E. coli* data for assessing compliance with the microbiological guideline standard of the Directive. As this data has been analysed in Section 11, no separate assessment will be undertaken with respect to SGW compliance.

The relative positions of the SGW boundary, mussel farm and production area are shown in Figure 12.1.

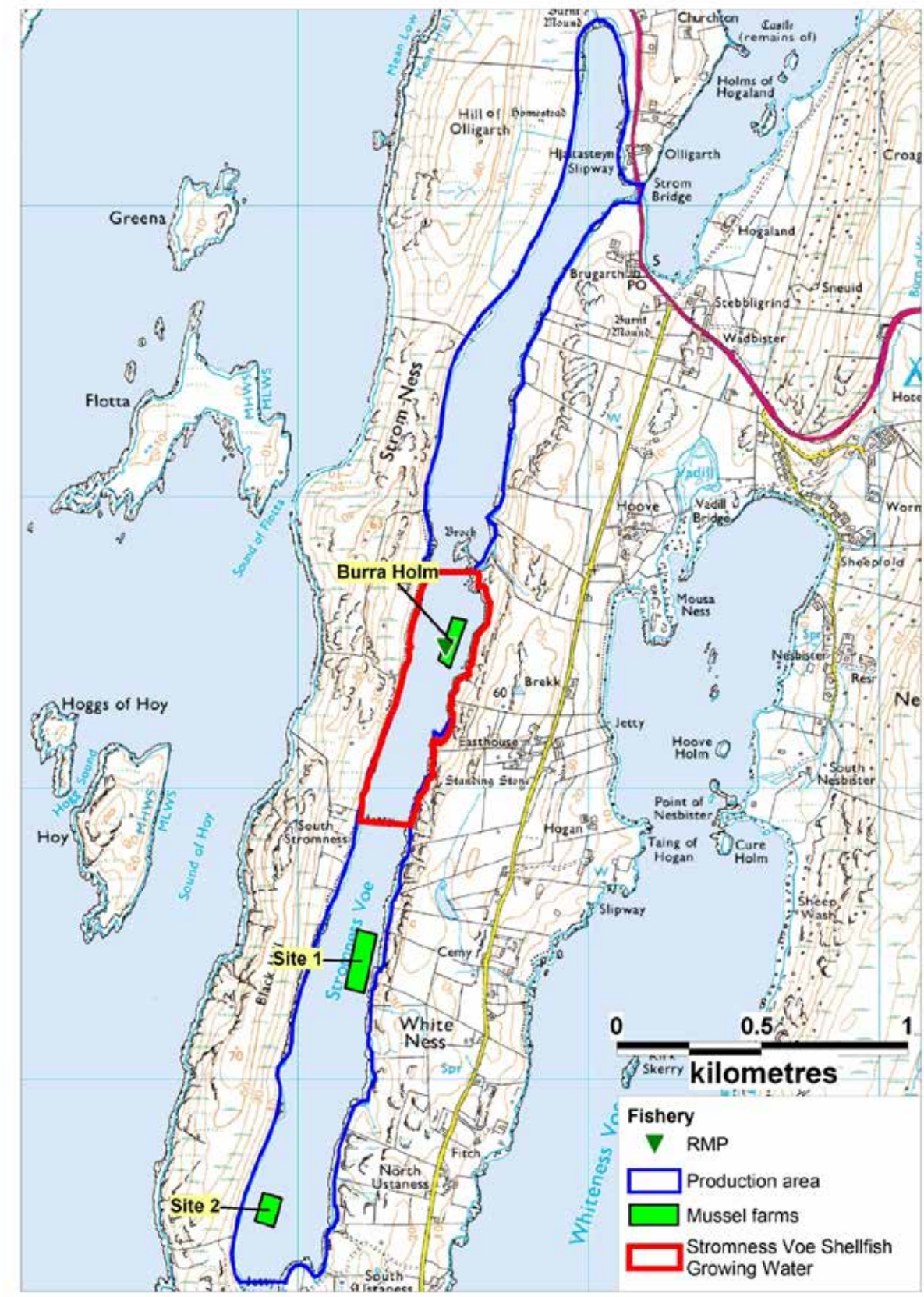

Figure 12.1 Designated shellfish growing water – Stromness Voe

13. Bathymetry and Hydrodynamics

13.1 Introduction

The study area comprises all waters north of a line drawn between HU 373 423 (Binna Ness) and HU 379 418 (Usta Ness), namely Stromness Voe and the approaches thereto. The voe is located on the west Shetland Mainland and is one of several long inlets on this coast which open to the waters around the Scalloway archipelago. The voe is orientated roughly north – south and is characterised by its narrow width and near-uniform linearity. A constriction is present near the mouth at Pund and the voe is also connected to the partially tidal Loch of Strom near the head of the voe.

13.2 Bathymetry

An extract from Admiralty chart BA3294 (1:25,000) annotated with the limits of the study area, production area and the locations of the mussel fisheries is given in Figure 13.1 below.

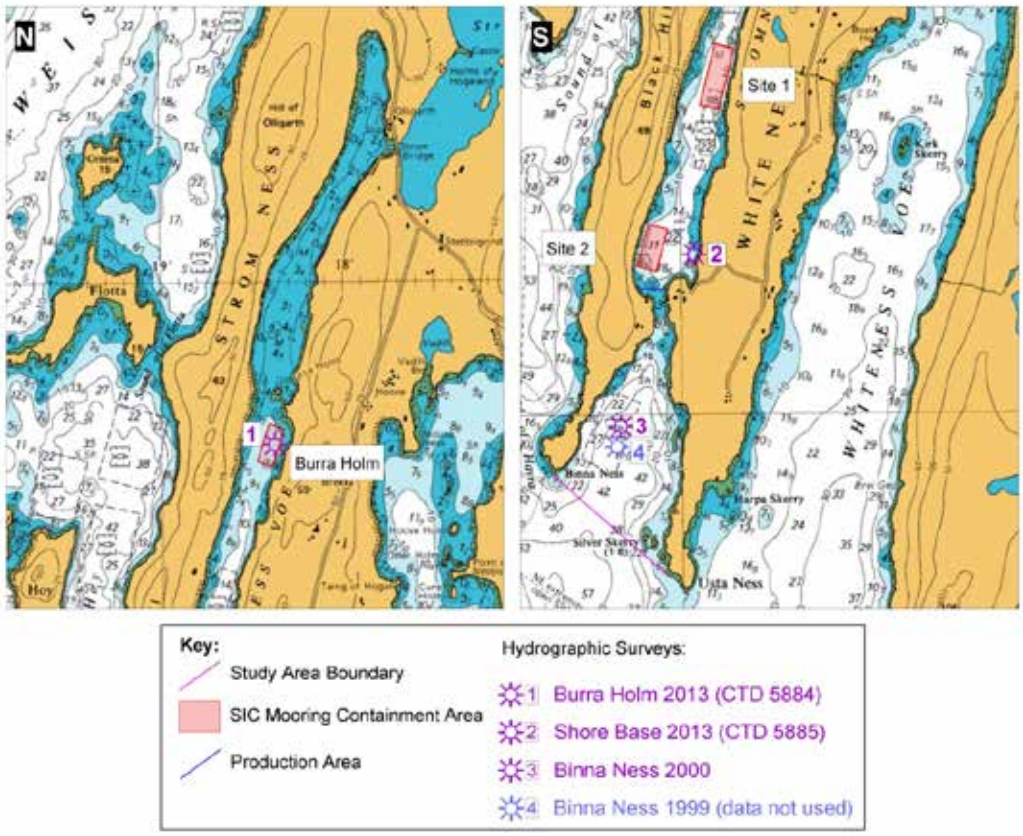

Figure 13.1 Admiralty chart extract

Vector data from an electronic version of this chart was extracted and contoured using Golden Software Surfer 8 (Figure 13.2).

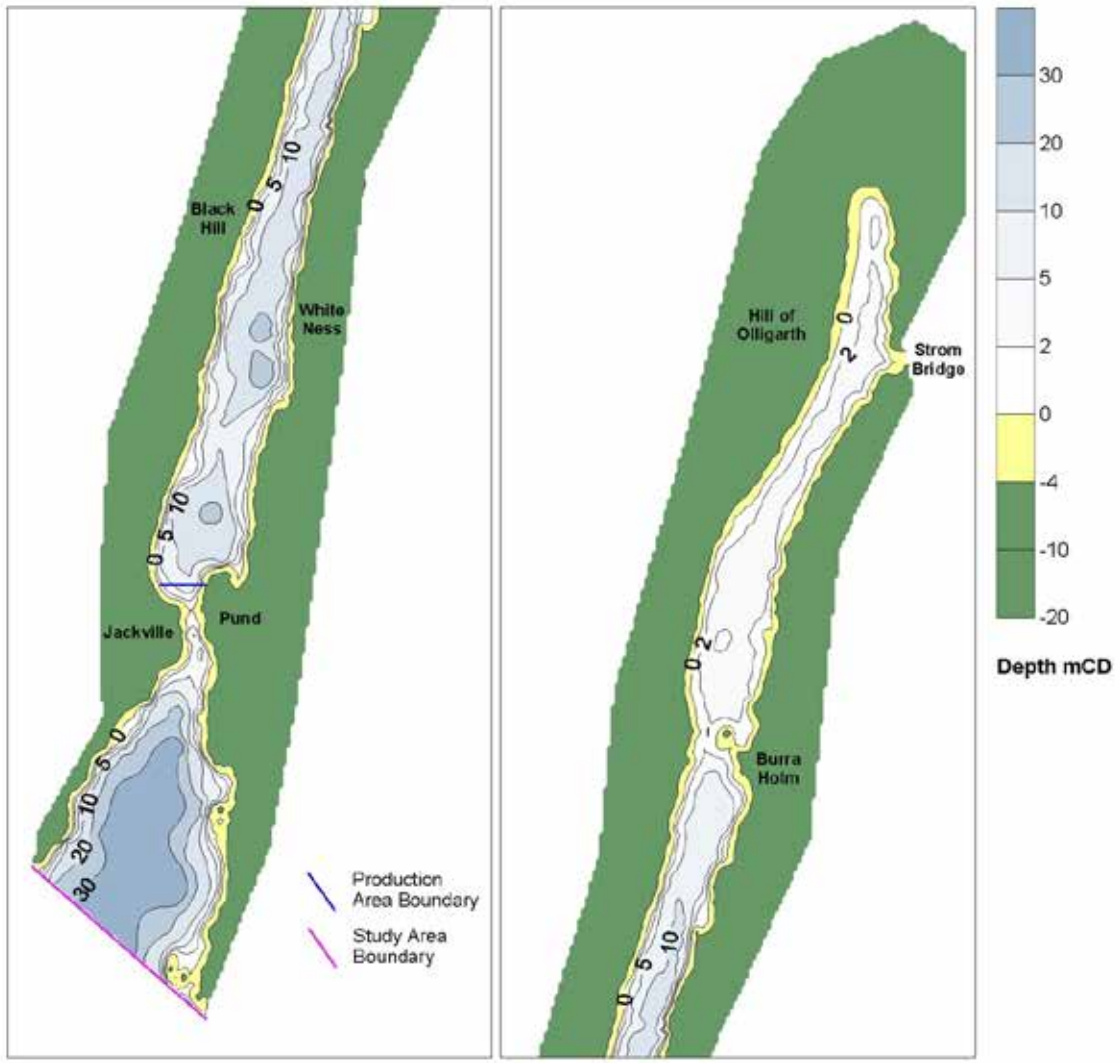

Figure 13.2 Bathymetry of Stromness Voe and approaches. Depths given as metres chart datum.

The contour map illustrates:

- At the approaches to the voe water rapidly deepens from the shoreline to over 30 metres in depth.
- A sill is present at the constriction at the mouth of the voe reducing water depth to 3 metres and isolating deeper waters to the north. The width of the constriction between Jackville and Pund is approximately 40 metres wide at its narrowest.
- A minor sill (14.3 metres) is present which divides the deepest part of the voe into two minor basins (22 metres).
- The depth gradually shoals towards the head of the voe. A second constriction is present at Burra Holm, two thirds of the length of the voe from the south, although this is less significant relative to the width of the voe at this point.

Grid volume computations in Surfer allow for the estimation of the surface area and volume. Positional information is related to the British National Grid to give Eastings as the “x” coordinate and Northings as the “y” coordinate in a three dimensional grid. The values presented in Table 13.1 represent the area and volume at chart datum by defining the surface “z” as zero.

Table 13.1 Area and volume estimations of the study area using Surfer

Parameter*	Study area	Existing production area
Area (km^2)	1.20	0.81
Volume (Mm^3)	13.28	4.91
Mean depth (m)	11.0	6.1
Maximum depth (m)	42	22

* All values at chart datum

The estimated area is smaller than that presented in the Scottish Sea Lochs catalogue (Edwards & Sharples, 1986) which was derived through manual measurement with a planimeter at chart datum (0.9 km^2). The estimate of volume derived through Surfer is also smaller than that given in the Sea Lochs catalogue (7.1 Mm^3). The boundary of the voe as defined in the Scottish Sea Lochs catalogue is analogous to that of the production area.

Near the head of the voe on the eastern shore the Loch of Strom meets the sea via a small, highly tidal strait. Although outwith the study area no modern information concerning the loch’s hydrographic properties was found. In 1908, the loch was surveyed as part of The Bathymetrical Survey of the Fresh Water Lochs of Scotland (Murray, et al., 1910). A plot illustrating the 102 soundings collected during the fieldwork was georeferenced to an Ordnance Survey map which allowed their positions to be extracted and contoured using Surfer for volume and area calculations, given in Table 13.2.

Table 13.2 Area and volume estimations of the Loch of Strom using Surfer

Parameter*	Study area
Area (km^2)	1.23
Volume (Mm^3)	2.38
Mean depth (m)	1.93
Maximum depth (m)	3.96

* All values refer to the loch area as illustrated

The influence of the tide is apparent in surface salinity measurements from the 16 July 2013, undertaken from the shore at the fish farm north of Quoyness about mid-way along the length of the loch. A value of 27.07 ppt was recorded, at the higher end of the range defined for brackish waters. Murray & Pullar note that “the tide appears to have little effect on the level of the loch, which was 0.5 foot above sea-level on the date of the survey (August 1, 1903), but it must renew the water with sufficient frequency to permit of the growth of fucoids and other marine organisms over the whole of the bottom, even to the extreme north”

13.3 Field Data

Historically there have been two field studies which give an insight into the current flow patterns in the region, although these only represent the southern extent of the study area to the south of the production area. Summary information of the deployments is given in Appendix 1 while their locations are included at Figure 13.2. Data from these hydrographic studies were provided to Cefas by SEPA which archive information concerning fish farm licensing on their Public Register. For this report only one of these surveys were evaluated and re-processed to the requirements outlined by SEPA in the *Regulation and Monitoring of Marine Cage Fish Farming (Scotland) Attachment VIII* (v2.7 2008) to standardise analysis, discussed in detail in Section 13.5. Of the two surveys at Binnaness the earlier deployment at the site is disregarded from further study in favour of the higher precision survey conducted in 2000. The data is considered to be of reasonable quality in terms of accuracy and therefore can be said to be representative of the location studied.

A former fish farm has been identified as being present to the south of the Site 1, although there are no records of hydrographic data being collected at this site.

In addition two Star-Oddi DST CTD (conductivity, temperature and depth) devices were deployed in two locations the voe to support the sanitary survey process in 2013.

13.4 Tidal Information

Information pertaining to predicted tide height is derived from the UKHO TotalTide prediction for Scalloway, the nearest secondary port some 6 km south east of the study area boundary. Figures 13.3 and 13.4 show tidal curves for a fifteen day period starting on the 29 July and therefore includes the date of the shoreline survey (6 August 2013).

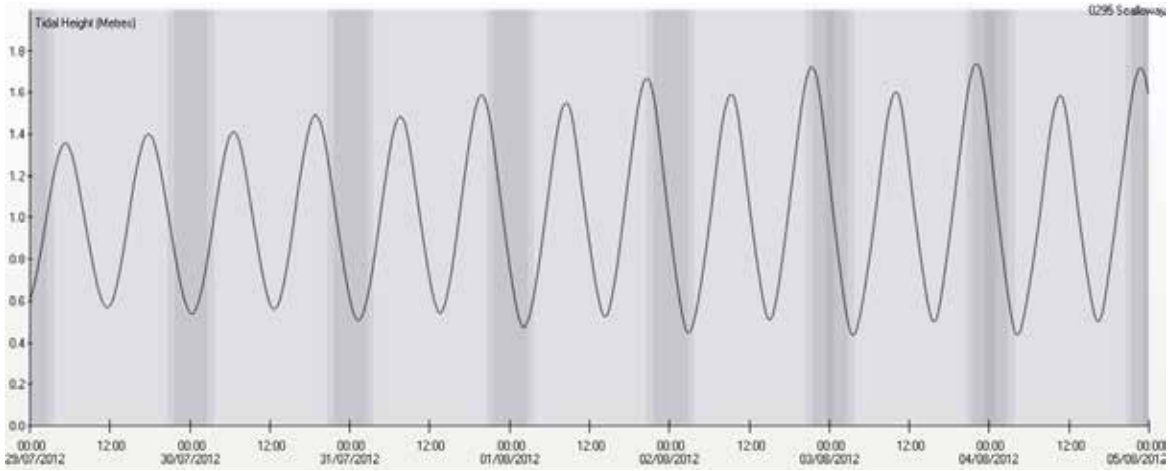

Figure 13.3 Tidal Curve Scalloway; 29 July to 5 August 2013

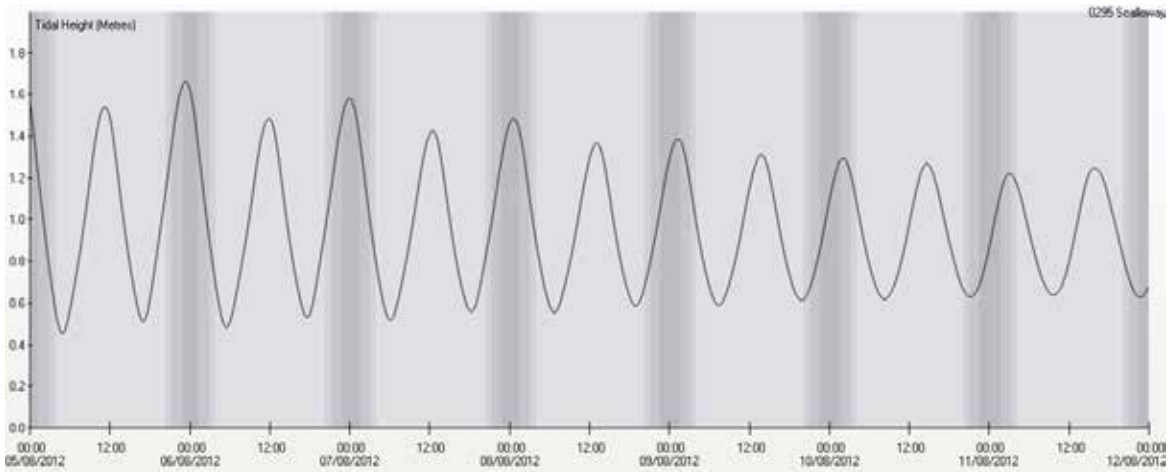

Figure 13.4 Tidal Curve Scalloway; 5 to 12 August 2013

Tide level information from TotalTide is summarised below. Predicted heights are in metres above chart datum.

0295 Scalloway is a Secondary Non-Harmonic port.

The tide type is Semi-Diurnal.

HAT	1.9 m
MHWS	1.6 m
MHWN	1.3 m
MLWN	0.6 m
MLWS	0.5 m
LAT	0.3 m

Based on the above Scalloway would be classified as micro-tidal with a low tidal range of 1.1 m for springs and 0.7 m for neaps. Comparable conditions are likely to be found within the study region on account of similar topography and geographic proximity. Limited validation of this assumption is possible through pressure data collected from *in situ* measurements at the hydrographic survey locations in the area, described in detail in Section 13.3.

13.4.1 Timing

The first six days of the pressure record for the current meter deployment at Binna Ness and the CTD deployment on the seabed at the Stromness Voe shore base were plotted against the Scalloway TotalTide UKHO prediction for the same periods and it is apparent that high and low water, both within the voe and just beyond the mouth, occurs slightly later (for the most part within 0.5 hour) than predicted. More variability in the timing of high and low water relative to the prediction was noted in the data from the Binna Ness survey.

13.4.2 Range

The range of the three largest tides around springs and the three smallest tides around neaps for both deployments was compared to that predicted for the corresponding tides at Scalloway. Within the voe the observed tidal range during spring tides is typically 0.4 m greater than the prediction, while during neap tides the observed range was on average 0.13 m smaller. At the approaches to the voe a similar pattern is seen, with the spring tidal range being 0.17 m greater, and the neap tidal range being 0.17 m smaller than the predicted range at Scalloway. Atmospheric pressure is not accounted for in the survey data.

13.4.3 Tidal Volume

The volume of water entering and leaving Stromness Voe on each tide is estimated by two methods. The first is a simple box model based on a "tidal prism" method (Edwards & Sharples, 1986):

$$T_f \text{ (days)} = 0.52V/0.7A.R$$

where V is the volume of the loch basin (m^3), A is the surface area of the loch (m^2) and R is the spring tidal range (m). The factor 0.52 is the number of days per tidal cycle, and the factor 0.7 approximates the mean tidal range from the spring tidal range, R. As the spring tidal range is used, inputs for volume and area pertain to those calculated for mlWS for the Stromness Voe production area. Based on this method estimates of flushing time (T_f) and flushing rate (Q) are given below in Table 13.3.

Table 13.3 Estimate of flushing rate and tidal volume for Stromness Voe using the tidal prism method.

Input:		
Volume (V)	Mm^3	5.32
Area (A)	km^2	0.83
Tidal range (R)	m	1.1
Output:		
Flushing Time (T_f)	days	4.32
Flushing Rate (Q)	Mm^3/year	450
Flushing Rate (Q)	Mm^3/day	1.23
Flushing Rate (Q)	Mm^3/tidal cycle	0.64

Calculated for mlWS. Note values are slightly greater than those presented in Table 2 which relate to parameters derived for Chart Datum.

The tidal prism method indicates that 12.0 % of the low water volume of the voe is exchanged during each tidal cycle and that total exchange would take just over four days.

The second method again utilises Surfer grid computations to estimate the volume of the region at different tidal states by defining the "z" surface according to the tidal level and subtracting low water from high water (Table 13.4).

Table 13.4 Estimate of flushing rate and tidal volume of Stromness Voe using Surfer grid volume calculation.

Tide	Z (m)	Production Area Volume (Mm^3)
MLWS	0.6	5.32
MHWS	2.2	6.27
Difference (spring tide)		0.95
MLWN	1.0	5.41
MHWN	1.7	6.01
Difference (neap tide)		0.60
Average Difference		0.77

The estimate of the flushing rate is below the average tidal volume. Both estimations of the exchange rate given should be interpreted cautiously as both employ a gross simplification of hydrodynamic properties in a topographically complex area. Sill and basin features will restrict exchange at depth and lead to longer residency times while wind forcing may serve to enhance or compound exchange depending on the direction. Stromness Voe is not typical of a semi-enclosed loch system for which the tidal prism calculation is suited as the voe is the recipient and source of exchange with the partially tidal Loch of Strom to the north. Such interactions are beyond the scope of simple box modelling techniques.

13.5 Currents

Admiralty charts provide no tidal stream information relevant to the study area.

13.5.1 Survey data

An assessment of the hydrographic data collected at the Binna Ness fish farm, located in the embayment near the entrance to Stromness Voe was undertaken with detailed summary statistics tabulated in Appendix 6.2. Figure 13.5 illustrates the frequency of currents by vector and the pertinent summary statistics for near-surface waters in the context of the surrounding area.

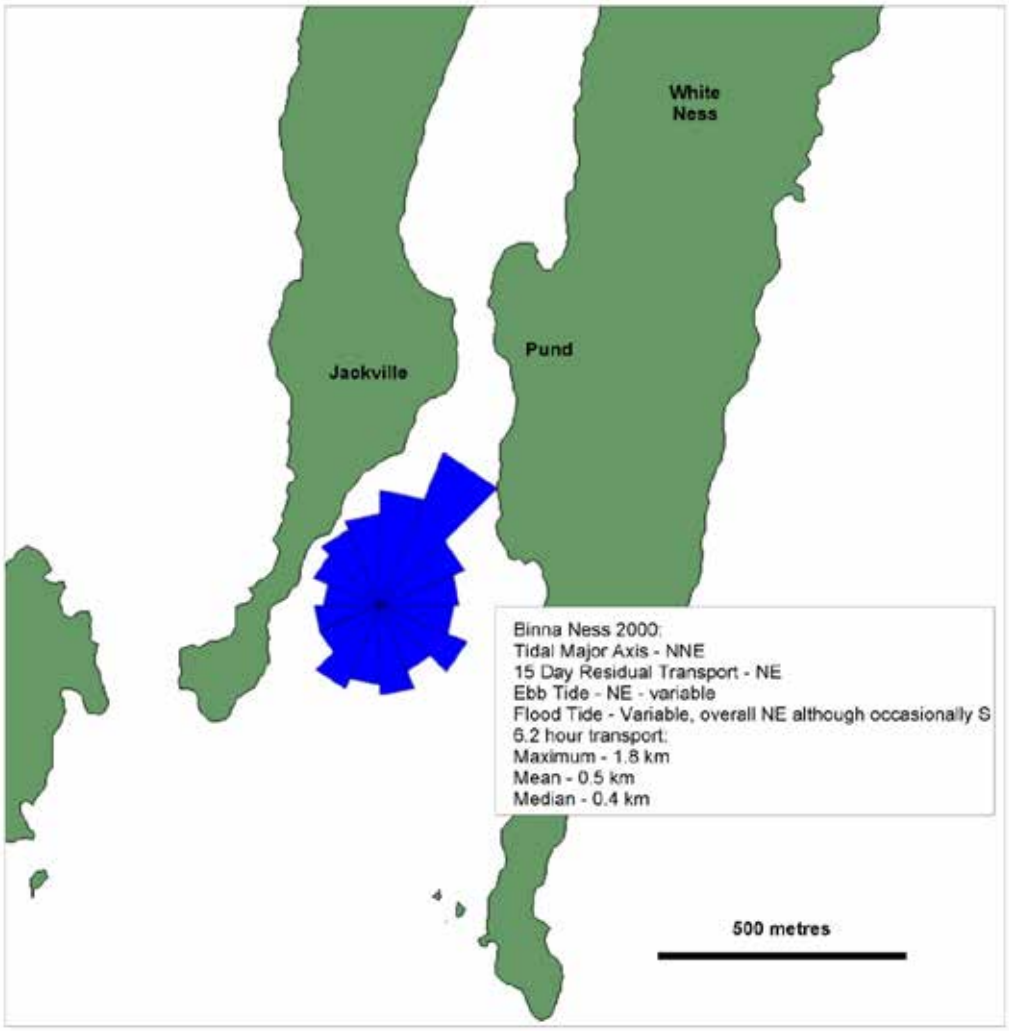

Figure 13.5 Near-surface current direction frequency (bin size 22.5°) for the Binna Ness survey, including a summary of residual and tidal transport at each location.

The hydrographic data collected at Binna Ness in 2000 indicates that the influence from tidal currents is relatively weak in the area. There is no clearly defined bi-directional tidal axis at any level in the water column and the time series of current direction shows a great deal of variability at all stages of the tidal cycle. Currents associated with the flood tide are characterised by general movement to the north in the near surface and near bed layers, however this is also the case for currents associated with the ebb tide. Potentially if the topographical constriction between Jackville and Pund serves to concentrate the ebb tide flowing from Stromness Voe then the latter may be evidence of a counter flow or eddy formation along the shore at this location. Alternatively as there was a dominance of winds from the southwest and southeast during the survey period overall transport in the opposite direction may be expected if the tidal influence is weak. However there is no evidence for counter currents closer to the seabed which would be expected to form in response to surface water transport towards an embayment.

Regarding current velocity there is little evidence to suggest that currents on the flood tide differ to those on the ebb. The exception would be the near-surface layer where occasionally a peak in the velocity time series is present near to the end of the ebb tide. This results in a marginally greater mean velocity of currents associated with the ebb. Periods of more energetic current flow persist over several tides in the near-surface and mid layers which are coincidental with strong (Force 6) south-westerly winds.

Maximum transport during a 6.2 hour period (1.84 km) was coincidental with the ebb tide. The overall mean excursion was just one quarter of this value, which implies that excursion events at this magnitude are rare (See 13.5). Again the greatest excursion appears to correspond to periods of stronger wind forcing. A periodicity in the tidal excursion is present that is coincidental with the ebb tide.

How the currents observed represent conditions within Stromness Voe is difficult to assess with so little data collected from the voe itself. While the production area is semi-enclosed as a result of the constriction at the mouth of the voe this does not serve to reduce the tidal range below that which is predicted at Scalloway. It is therefore likely that the predicted tidal exchange is not inhibited by this; however its influence is very likely to be greater at the mouth of the voe.

The linear topography is conducive to the formation of wind generated currents if the wind blows along the SSW-NNE orientated long axis of the voe for any length of time. The maximum available fetches at the three fisheries are as follows;

- Site 1, 3.2 km from the NNE,
- Site 2, 2.3 km from the NNE
- Burra Holm, 2.3 km from the SSW.

However the presence of the islet at Burra Holm and the associated shoal could potentially affect current propagation as they afford some shelter to the voe to the south.

13.6 Stratification

Salinity and temperature profiles were collected at each of the three sites within the production area during the shoreline survey in August 2013. All three locations showed a decrease from levels typical of normal seawater at depth to reduced salinity at the surface. The degree of change was from 0.85 ppt at Site 1 near the mouth of the voe to 1.91 ppt at the Burra Holm site, located approximately a third of the way along the voe from the head. This pattern was also observed in the surface seawater samples collected at each site with readings of between 33.76 decreasing to 32.25 on the Practical Salinity Scale. Temperature measurements also showed variation with depth, increasing by approximately 2°C from the bottom of the profile to the surface and at Sites 1 and 2 the highest rate of temperature increase occurred between 3 metres and the surface. The increase was more gradual at Burra Holm. At this site readings inconsistent with the

other locations were recorded at 10 metres depth, with warmer, lower salinity (i.e. less dense) waters below those recorded at 5 metres. Complete salinity and temperature profile data and water sample analysis are available in the shoreline survey report.

Salinity readings were collected from the channel between Stromness Voe and the Loch of Strom while the ebb tide was flowing from the latter. Approximately mid-way through the ebb tide salinity was 31.95 ppt and temperature 14.7°C, values comparable to the surface observations further south in the voe.

A reading was also collected on the 16 July 2013, 21 days prior to the shoreline survey at the same location. Salinity was 32.43 ppt and temperature 13.9°C. The timing of the reading was coincidental with the early part of the ebb tide at the shore base according to concurrent data from the CTD logger there; a profile temperature of 12.4 degrees was observed here. Regarding flow rate through the channel, while full characterisation was not deemed safe to undertake, a reading collected adjacent to the bank returned a flow rate of 1.14 m/s (standard deviation = 0.054 m/s). There are no velocity readings available from within Stromness Voe. From the survey undertaken near to the entrance of the voe in 2000 the peak velocity was one quarter of the indicative flow rate observed in the channel (0.282 m/s).

On the same day a salinity reading was taken from shoreline at the Loch of Strom at the shoreline at HU 40076 48914, some 2 km from the channel at Stromness Voe.

A salinity of 27.07 ppt was recorded, with the temperature at 14.2°C, again during the early part of the ebb tide at the shore base.

Two Star-Oddi DST CDT loggers (accuracy 1 psu) were deployed in Stromness Voe for the 21 days prior to the shoreline survey, one at the seabed at the shore base close to the entrance to the voe to characterise the tidal cycle and variation in salinity close to the seabed and the second attached to the lines at the Burra Holm fishery at 1 metre below the sea surface to characterise near surface salinity patterns (Figure 13.6). When the accuracy of the instrument is considered the values must be reported to zero decimal places. While the actual salinity may be within 1 psu of the value recorded by the instrument, as both instruments were calibrated prior to the initiation of data collection it remains possible to have confidence that the spatial and temporal patterns evident in the raw data correspond to actual patterns in the voe.

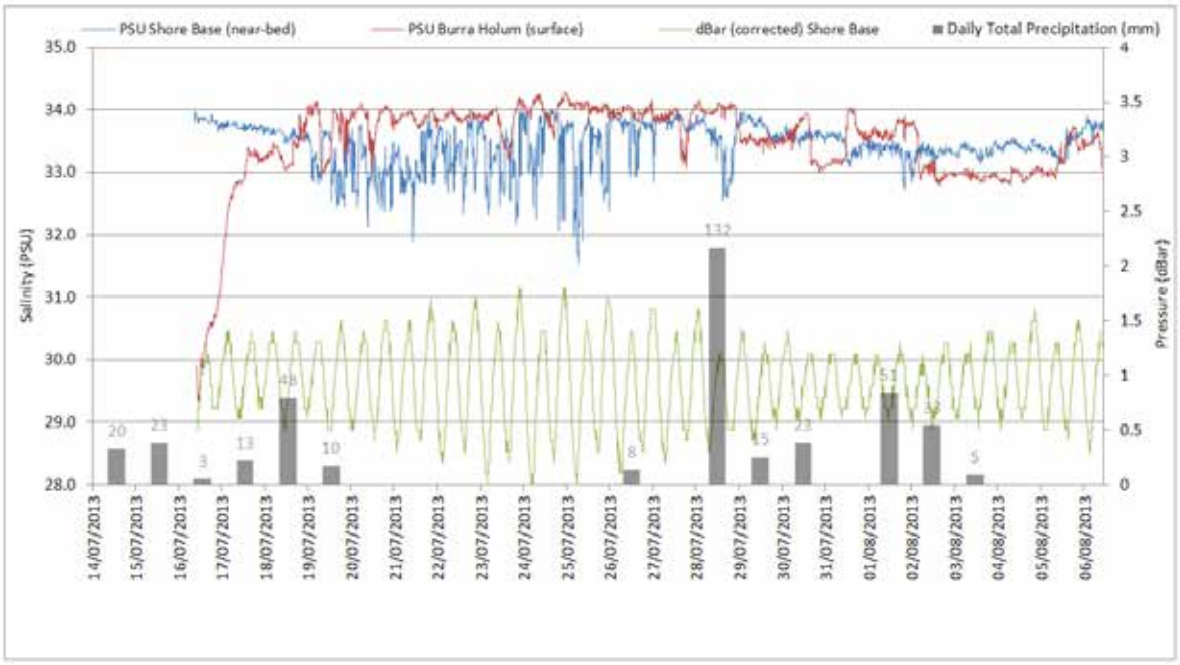

Figure 13.6 Salinity readings at the Stromness Voe shore base and Burra Holm fisheries relative to tide height, including total daily precipitation at Gulberwick.

At the shore base the greatest variability occurred during the springs phase of the tidal cycle with a periodicity that coincides with the ebb and flood cycle. Fluctuations during this period mean that salinity would often (although not always) be depressed at or just after local low water, with the highest values present at or just after high water. During the neap tide there a more gradual variation in salinity not associated with the daily tidal cycle. Overall salinity values were between 32 and 34 psu (range 2 psu) at the shore base.

At Burra Holm salinity values ranged from 29 to 34 psu (range 5 psu). The greatest change occurred for the first 24-hours of the survey with a 4 psu increase. Marginally higher readings are present during springs which decrease a little through the neaps phase. However no regular pattern of salinity variation is seen that can be attributed to the daily tidal cycle. Occasionally at low water there is a slight decrease during spring phase with values recovering at high water. During the neap tidal phase salinity tends to be more stable over several tidal cycles. When a change occurs salinity rises or falls by 0.5 to 1.0 psu typically within one hour, followed by a period of stable readings.

Precipitation data was obtained from the Wunderground website for the survey period for a personal weather station at Gulberwick, 8 km south west of Stromness Voe (Wundergound, 2013). During the neap tide, when salinity readings appear to be less affected by the daily tidal cycle, where the total daily precipitation is elevated there is often a corresponding dip in salinity values. At the shore base the response time to a rainfall event is much swifter than at Burra Holm.

Evidence from salinity and temperature measurements from within the voe would indicate that fresh water input from the adjoining Loch of Strom has an influence on surface waters, potentially for the entire length. It can be expected therefore that annual rainfall patterns will have a corresponding influence. Figure 13.7 illustrates the monthly total rainfall and the 24 hour average rainfall from the Lerwick Meteorological Office from 2007 to 2012.

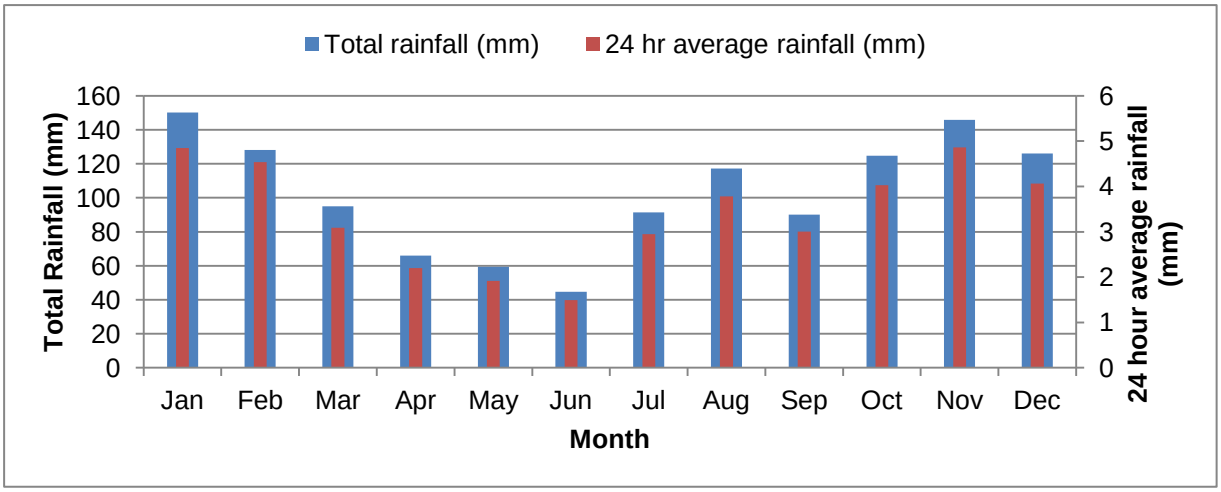

Figure 13.7 Total monthly and mean 24 hour rainfall for the period 2007 to 2012

During winter months the effect may be more pronounced with higher fresh water input. During the summer, although freshwater input will be lower, the density is reduced by elevated temperatures. With weak tidal influence likely for the majority of the length of the voe, resulting in poor mixing of the water column, there is substantial potential for thermal-halo stratification throughout the year. With a layer of warmer water, reduced salinity water above cooler seawater the potential also exists for the formation of density driven currents. However there is no direct observation of this phenomenon.

Various parameters pertaining to freshwater input are described by Edwards and Sharples, 1986 and later by Dixon, 1987 in which the values for the sea water inlets of Shetland were refined. These figures have been updated using digital mapping techniques and modern rainfall totals in Table 13.5 below.

Table 13.5 Comparing freshwater run-off parameters

Parameter	Units	Edwards & Sharples 1986	Dixon 1987	SSQC 2013
Watershed	km^2	2.0	2.8	2.8
Annual Rainfall	(mm)	1,150	1,150	1,223*
Run-off	(Mm^3/yr)	1.8	2.5	2.72
Fresh/tide, per thousand	-	3.5	4.9	5.89
Salinity reduction	ppt	0.12	0.17	0.20
Run-off/width	m^2/d	24	34	40.2

*Annual average 2007-2011. Source Met Office, rainfall data for Lerwick.

It can be seen that values described by Edwards and Sharples, and Dixon are smaller than those derived for the purpose of this report. Notably, there is a higher proportion of freshwater run-off relative to the tidal inflow based on a lower figure for the latter resulting from smaller estimates of high and low water area. This leads to a greater reduction in salinity prediction on average over a year. It is acknowledged that variation from this figure is expected due to seasonal fluctuations in freshwater run-off. Increased run-off leads to a greater value for the run-off/width ratio which indicates greater importance of the freshwater supply.

The watershed area in Table 13.6 pertains to that measured for Stromness Voe alone, while the largest source of freshwater is likely to be from the Loch of Strom with a substantial drainage area which extends to include a large valley present in the central Mainland area. The watershed for this loch was also estimated and combined with that for the voe. The amended parameters for the system are given in Table 13.6 below. The predicted salinity reduction for the voe is comparable to that observed.

Table 13.6 Freshwater run-off parameters for Stromness Voe, including the Loch of Strom watershed.

Parameter	Units	SSQC 2013
Watershed	km^2	23.4
Annual Rainfall	(mm)	1,223
Run-off	(Mm^3/yr)	22.81
Fresh/tide, per thousand	-	49.32
Salinity reduction	ppt	1.68
Run-off/width	m^2/d	336.46

13.7 Summary

- The tidal prediction for Scalloway is applicable to the study area in terms of timing although overall a greater range was observed in the field data. This means more water may be exchanged by the tide than the various modelling techniques employed predict.
- Figures for tidal exchange are derived from the two methods indicate that 12 to 14% of the low water volume of the production area is exchanged during the tidal cycle leading to a flushing time of approximately 4 days. Weather conditions, bathymetric features and the influence of freshwater input via the Loch of Strom may affect this, although to what extent is unknown.
- Field observations from the beyond the mouth of the voe indicate that tidal currents are relatively weak in the area. There may be localised areas of tidal flow attributed to shoreline topography at the mouth and at the Bridge of Strom which may enhance mixing. Flood and ebb tides conform to the expected pattern of water moving into and out of the system defined by the topography.
- The greatest transport during a single tidal period of 1.84 km appears to be a rare event with the average excursion of just one quarter of the peak (mean 0.5 km). Therefore such transport is unlikely to be attributed to the tidal cycle and that wind forcing is likely to be the main influence for surface water movement in the area.
- Salinity profiles collected during the August shoreline survey, and data from CTD sensors deployed in the voe indicate that freshwater influence from the adjoining Loch of Strom causes salinity to be measurably reduced, and temperature to be greater in near-surface waters throughout the voe.

14. Bacteriological Survey

Due to the limited spatial distribution of historic *E. coli* samples, it was decided a bacterial survey would be undertaken. Three locations were sampled at two different depths. The locations are shown in Figure 14.1 and the results are shown in Table 14.1. A summary of the data is presented in Table 14.2.

Figure 14.1 Bacteriological Survey Site Locations

Table 14.1 Location and results of Bacteriological Survey

Location	Collection Date/Time	E. coli / 100g
NE Corner Burra Holm (Bottom)		
	06/08/2013 10:17	40
	21/08/2013 10:56	80
	03/09/2013 09:55	170
NE Corner Burra Holm (Top)		
	06/08/2013 10:17	330
	21/08/2013 10:46	20
	03/09/2013 09:55	490
North SE corner Site 1 (Bottom)		
	06/08/2013 09:56	110
	21/08/2013 10:35	<20
	03/09/2013 10:09	20
North SE corner Site 1 (Top)		
	06/08/2013 09:56	<20
	21/08/2013 10:29	<20
	03/09/2013 10:09	330
SW corner Site 2 (Bottom)		
	06/08/2013 09:32	<20
	21/08/2013 10:19	20
	03/09/2013 10:19	<20
SW corner Site 2 (Top)		
	06/08/2013 09:32	<20
	21/08/2013 10:15	<20
	03/09/2013 10:19	80

Table 14.2 Geometric mean and range of bacteriological survey results

Location	Geometric Mean *E. coli*/100g	Maximum Value *E. coli*/100g	Minimum Value *E. coli*/100g
NE Corner Burra Holm (Bottom)	82	170	40
NE Corner Burra Holm (Top)	148	490	20
North SE corner Site 1 (Bottom)	28	110	<20
North SE corner Site 1 (Top)	32	330	<20
SW corner Site 2 (Bottom)	13	20	<20
SW corner Site 2 (Top)	20	80	<20

The highest geometric mean *E. coli* value was seen at the site “NE Corner Burra Holm (Top)”. This site also yielded the highest individual value of 490 *E. coli*/100g.

15. Shoreline Survey Overview

The Stromness shoreline survey was conducted on Tuesday 6 August 2013. The prevailing weather in the 48 hrs prior to the survey was mostly dry, with some light rain showers. On the day of the survey the weather was dry, with a light to moderate breeze.

There are three fisheries operating within Stromness Voe: Burra Holm, Site 1 and Site 2. All fisheries were stocked at the time of the survey.

Burra Holm – the most northern site: four mussel lines running parallel to shore, with 4 m droppers. Two mussel samples collected from the northeast corner (top and bottom) returned results of 330 and 40 *E. coli cfu* / MPN/100 g respectively.

Site 1 – located south of Burra Holm: four mussel lines running parallel to shore, with 10 m droppers. Two mussel samples were collected close to the southeast corner (top and bottom) returned results of < 20 and 110 *E. coli* MPN/100 g respectively.

Site 2 – the most southerly located fishery: four mussel lines running parallel to shore, with 10 metre droppers. Two mussel samples were collected from the southwest corner (top and bottom), both returned results of < 20 *E. coli cfu*/ MPN/100 g.

Seawater samples against samples returned results ranging from <1 to 3 *E. coli cfu*/100 ml.

Houses were present at the head of the Voe (northeast), south of Strom Bridge and one holiday house was noted south of the Voe at Pund. The western shoreline was uninhabited. No public discharges are present in the area and it was assumed all houses were on private septic tanks.

Two septic tanks (ST) and a discharge pipe from an assumed ST were noted during the survey. One ST was noted north of Strom Bridge and was found to be seeping, with black/green algae present around the tank and the stone casing missing from sections of the discharge pipe. A seawater sample taken close to the pipe (end not visible) returned a result of 60 *E. coli cfu*/100 ml. The second ST was located to the south and was associated with the holiday house in Pund. The discharge pip assumed to be from a third ST was observed just south of Strom Bridge and was associated with a smell of sewage, a grey discharge and large amounts of green algae. The seawater sample taken from the end of this pipe was 80000 *E. coli cfu*/100ml.

A small workboat was observed at the pier and another was seen on land to the south, associated with Scottish Sea Farms Ltd shore-base. A small leisure boat and sailing boat were also noted at the there. A second pier north of Strom Bridge, a small jetty between Sites 1 & 2, and moorings south of Site 2 all had several small leisure boats associated with them. No boats were observed at a small pontoon noted at the head of the Voe. Small pleasure rowing boats were also noted on land in places.

Land was predominantly rough open grazing. Sheep were seen on six occasions, 179 sheep seen in total along the eastern shoreline. The largest flock (90 sheep) was seen on land immediately adjacent to the northeast corner of Burra Holm fishery. Six cows were also observed and were all seen adjacent to the southeast corner of the Burra Holm fishery, where they had shoreline access. One pony was also noted to the north of Strom Bridge in a fenced field, with large piles of manure noted in a field north of Strom Bridge and close to a jetty by Site 1.

Five watercourses were sampled although flow rate was only recorded at one watercourse (at the head of the voe) due to insufficient flow at the other watercourses. All five samples returned relatively low results ranging between 20 and 300 *E. coli cfu*/100ml.

Birds were the most common wildlife species observed, and included curlew, a great skua, Arctic terns, gulls, collared doves and starlings. The majority were seen in flight, with some noted in the water. A cormorant was also seen on the buoys and ropes at Site 2, where a large amount of bird faeces was observed. Bird faeces were also present on buoys at Site 1 and Burra Holm farms. Fourteen rabbits were observed along the eastern shore, south of Strom Bridge, with rabbit holes noted in the hill just south of the Bridge. One seal was observed in the water at the head of the Voe.

Observations and results of samples from the shoreline survey are presented in figure 15.1 below.

Figure 15.1 Principal shoreline survey observations at Stromness Voe

16. Overall Assessment

Human sewage impacts

The area around the production area is sparsely inhabited, and this is reflected in the number of sewage discharges.

The greatest concentration of discharges lies at the north end of the voe, a little over a kilometre north of the Burra Holm mussel site. However, a single septic tank is present at Pund, at the south end of the voe, and this is within 300 m of the Site 2 mussel farm.

The majority of discharges are likely to be to soakaway, and provided these are operating efficiently no significant impact to water quality in the voe would be expected. However, one septic tank was observed to be malfunctioning at the north end of the production area. The highest impact to the fishery from human sewage sources would be likely to occur at the Burra Holm site, which lies closest to the most inhabited areas.

Agricultural impacts

During the shoreline survey, approximately 100 sheep in total were observed grazing along the eastern shoreline. Sheep faeces were also present along the majority of the shoreline. Ninety sheep were observed on the western shoreline west of the Burra Holm site with a further, unspecified number further to the south, between Burra Holm and Site 1. Cattle faeces and 6 cattle were observed on the shoreline adjacent to the Burra Holm fishery. At the north eastern end of the voe, a large amount of equine faeces, an equine feed/shelter area and a Shetland pony were observed.

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 along the eastern shoreline would be most likely to affect the eastern side of mussel farms adjacent to the shoreline, where livestock, specifically sheep have been found grazing.

Wildlife impacts

The main impacts from wildlife in the voe will be from seabirds, which may deposit droppings directly to the fishery by feeding in the area and resting on floats. The available information indicates that deposition of faeces from wildlife sources is likely to be widely distributed around the area. Therefore, any impacts will be assumed to be spatially evenly distributed.

Seasonal variation

Seabirds are likely to be more prevalent in the area during the summer nesting season, when there may be particularly large populations of birds on nearby islands and consequently a larger number of birds feeding in the area. A holiday home present to the southeast of Site 2 is most likely to be occupied mainly during the summer months and therefore impacts from any septic tank discharges from there would be most likely to occur when the home is occupied.

An increase in the numbers of sheep present around the fishery is expected in summer, when lambs are present.

No significant seasonal variation was seen in historical *E. coli* monitoring results, although highest *E. coli* results were recorded during late summer and early autumn.

Watercourses

No significant correlation was found between *E. coli* monitoring results and rainfall in either the two or seven days preceding the sample date. This may be due to the steep sided and small catchment area of the voe, which may result in much shorter flushes after heavy rainfall. Or it may be due to the fact that the area receives regular, low levels of rainfall most of the time which may result in a more continual flow of low levels of faecal contaminants into the voe.

It is expected that during or following periods of higher rainfall, the areas of land drainage that were observed during the survey will enter into the voe and may represent additional potential sources of faecal contamination.

Contamination from freshwater sources was expected to be greatest at Site 1, where one of the potential sources is close to the southeast end of the mussel farm. However, results from the bacteriological survey showed that contamination levels were higher at the northeast end of Burra Holm site.

Movement of contaminants

The hydrodynamic assessment identified that ouflow from the Loch of Strom was expected to contribute to reduced near surface salinities found throughout the voe. Outside of localised areas of tidal flow at the Bridge of Strom and at the mouth of the voe, tidal currents were expected to be relatively weak.

Tidal excursion is expected to be very low, on average 0.5 km and at peak 1.84 km. Therefore such transport is unlikely to be attributed to the tidal cycle and wind forcing is likely to be the main influence for surface water movement in the area.

Statistically significant correlations were found between *E. coli* results and both high/low and spring/neap tidal cycles. Higher results tended to occur when tides were going from neap to springs and when the tide was high or ebbing. The reasons for this are not clear. Though it might be expected that contamination sources arising on the intertidal shore, (ie. livestock or wildlife droppings) would be picked up at high tide and carried across the fishery on the ebb tide, a delay in effect would be expected as the mussels would require time to take up this contamination.

Transport of contaminants around the fishery is likely to be due to a complex mix of tidal flow, wind-driven flow, and lower salinity flows from the Loch of Strom. Contamination arising from within the voe may affect water quality throughout the voe. Prevailing winds may drive surface contaminants northward in the voe, while outflow from the Loch of Strom carries lower salinity water southward.

Temporal and geographical patterns of sampling results

Contamination levels have generally been low over the period of sampling examined in this report, although there is evidence of a slight increase in results over time. The reason for this is not clear. Rainfall amounts appear to have been relatively stable and no information was found on trends in other diffuse agricultural or wildlife sources.

Historical *E. coli* monitoring was undertaken only at the Burra Holm site, and no statistically significant difference was found between geographic sampling locations within the site. Bacteriological survey sampling at all three sites showed highest results at the Burra Holm site. Samples were taken from the north end of the site, on the line nearest the shore.

Conclusions

The area is subject to relatively low levels of faecal contamination, and these have remained largely stable over the period assessed in this survey, although there was some indication of a slight increase over time. The main potential sources of faecal contamination to the fishery are diffuse livestock and wildlife sources, mainly sheep and seabirds. Septic tank discharges arising from houses around the north end of the voe are most likely to affect water quality at the northern end of the production area.

Although freshwater flow to the voe from Loch of Strom is sufficient to lower surface and subsurface salinities throughout the voe, there was little evidence to suggest that this also corresponds with higher *E. coli* results in mussels.

17. Recommendations

Production area

It is recommended that the production area be curtailed somewhat to exclude potential sources nearer the head of the voe and the septic tank at Pund. The recommended boundaries are defined as the area bounded by lines drawn between HU3846 4572 and HU 3862 4569 and between HU 3804 4336 and HU 3811 4347 and between HU 3798 4335 and HU 3787 4325, extending to MHWS.

RMP

It is recommended that the RMP be adjusted to HU 3858 4558, at the NE corner of the Burra Holm mussel farm, which lies nearer to contaminating sources arising to the north of the fishery and closer to the shoreline.

Depth of sampling

As higher results were seen in samples taken from the tops of the lines during the bacteriological survey, the recommended sampling depth is 1 metre.

Tolerance

A sampling tolerance of 40 m is recommended to allow for some movement of the mussel lines.

Frequency

A standard sampling frequency of monthly is recommended as there has been some indication of increasing results over time.

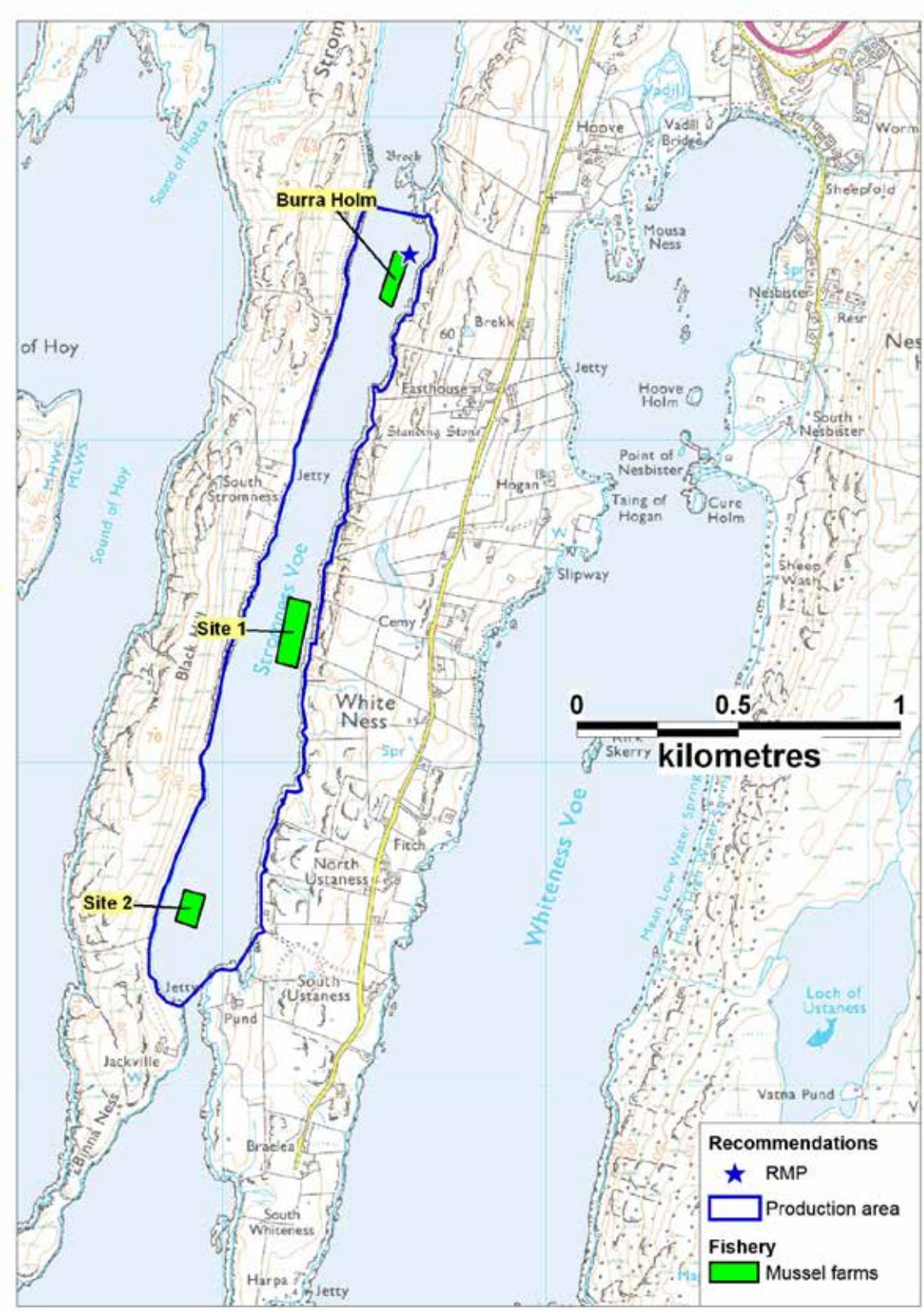

Figure 17.1 Map of recommendations at Stromness Voe

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1. General Information on Wildlife Impacts

Pinnipeds

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

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

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

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

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

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

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

Cetaceans

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

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

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

Birds

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

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

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

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

Deer

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

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

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

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

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

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

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)

References

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

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

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3. Statistical Data

One-way ANOVA: logEC versus season

```
Source DF SS MS F P
season 3 0.792 0.264 0.98 0.410
Error 57 15.387 0.270
Total 60 16.179

S = 0.5196 R-Sq = 4.89% R-Sq(adj) = 0.00%

 Individual 95% CIs For Mean Based on
 Pooled StDev
Level N Mean StDev -----+---------+---------+---------+----
1 15 1.3834 0.4283 (---------*----------)
2 16 1.5622 0.5921 (---------*----------)
3 15 1.7074 0.5461 (---------*----------)
4 15 1.5621 0.4917 (---------*----------)
 -----+---------+---------+---------+----
 1.25 1.50 1.75 2.00

Pooled StDev = 0.5196
Grouping Information Using Tukey Method

season N Mean Grouping
3 15 1.7074 A
2 16 1.5622 A
4 15 1.5621 A
1 15 1.3834 A

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 -0.3150 0.1789 0.6727 (-----------*------------)
3 -0.1778 0.3240 0.8257 (-----------*------------)
4 -0.3230 0.1787 0.6805 (-----------*------------)
 ------+---------+---------+---------+---
 -0.40 0.00 0.40 0.80

season = 2 subtracted from:

season Lower Center Upper ------+---------+---------+---------+---
3 -0.3487 0.1451 0.6389 (------------*-----------)
4 -0.4939 -0.0001 0.4937 (-----------*-----------)
 ------+---------+---------+---------+---
 -0.40 0.00 0.40 0.80


season = 3 subtracted from:

season Lower Center Upper ------+---------+---------+---------+---
4 -0.6470 -0.1452 0.3565 (-----------*------------)
 ------+---------+---------+---------+---
 -0.40 0.00 0.40 0.80
```

4. Hydrographic Assessment Glossary

The following technical terms may appear in the hydrographic assessment.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5. Shoreline Survey Report

Shoreline Survey Report

Production Area:	Stromness Voe
Site Names:	Burra Holm
	Site 1
	Site 2
SIN:	Burra Holm: SI-273-467-08
	Site 1: New site
	Site 2: SI-273-446-08
Species:	Common Mussel
Harvesters:	Blueshell Mussels – Michael Laurenson (Site 1 & Site 2)
	East Voe Shellfish – Kenny Pottinger (Burra Holm)
Local Authority:	Shetland Islands Council
Status:	Existing area
Date surveyed:	6 August 2013
Surveyed by:	Sean Williamson (Hall Mark Meat Hygiene Ltd.)
	Vicki Smith (SSQC Ltd.)
	We are grateful to Blueshell Mussels for providing assistance during the marine survey work.
Existing RMP:	Burra Holm - HU 3851 4549
Area Surveyed:	See Figure 1

Specific observations made on site are mapped in Figure 1 and listed in Table 1. Water and shellfish samples were collected at the locations marked on Figures 2 and 3. Bacteriology results are given in Tables 2 and 3. Salinity profiles are presented in Table 4 with profile locations marked on Figure 2. Photographs are presented in Figures 4-21.

Weather

Tuesday 6 August 2013

The wind built from a south westerly F2 light breeze in the morning to a gentle to moderate breeze (F3/F4) which persisted throughout the shoreline survey with scattered clouds and breaks of sunshine.

Preceding the shoreline survey, Sunday 4 August was a cloudy day with a few light rain showers in the early hours of the morning and afternoon. A strong southerly breeze (F6) eased moving into the evening to a fresh south westerly F5 breeze. Monday 5 August remained a dry day with cloudy conditions persisting throughout. A light to gentle (F2/F3) south westerly breeze moved easterly into the early evening.

Fishery

The location of the Burra Holm, Site 1 and Site 2 mussel lines are mapped in Figure 1. All fisheries had stocked mussel lines on site at the time of the survey. Harvesting was not occurring at any of the fisheries at this time.

The Burra Holm fishery consisted of four mussel lines running parallel to the shoreline (Figure 4). All lines were double headed long lines with 4 metre droppers. Two mussel samples were collected from the north east corner of the site from the line closest to the shore taken from the top and bottom of a mussel line. The site is licenced for four 150 metre twin-headline longlines.

The Site 1 fishery consisted of four mussel lines running parallel to the shoreline (Figure 5). All lines were double headed long lines with 10 metre droppers. Two mussel samples were collected just north of the south east corner of the site from the line nearest the shore taken from the top and bottom of a mussel line. The site is licenced for four 200 metre twin-headline longlines.

The Site 2 fishery consisted of four mussel lines running parallel to the shoreline (Figure 6). All lines were double headed long lines with 10 metre droppers. Two mussel samples were collected from the south west corner of the site from the line

nearest the shore taken from the top and bottom of a mussel line. The site is licenced for four 100 metre twin-headline longlines.

Sewage/Faecal Sources

Human – No dwellings are present on the western shoreline of Stromness Voe. On the eastern shoreline the main dwelling area was found at the head of the voe near the Strom Bridge. Four houses were noted below the road north of the bridge with more houses present above the road. Just south of the bridge another two houses were observed from the shore with more houses and a shop present just over the hill still below the road. A septic tank was identified north of the bridge and a discharge pipe assumed to be linked to a septic tank was identified south of the bridge, both were detailed on the survey plan as consented discharges. It is not known how many houses were using these septic tanks as there is no community sewerage system in the area. The septic tank north of the bridge (Figure 7) was in a poor condition with the stone casing of the tank damaged and seepage present with a black/green algae forming on the outside of the tank. The stone casing covering the discharge pipe leading to the sea was also damaged with the plastic pipe being visible in some places (Figure 8). A plastic discharge pipe was visible coming down the hill leading to the water south of the Strom Bridge (Figure 9) however the septic tank associated with the pipe could not be located. The discharge from the pipe had a slight smell and grey colouration and there was a large area of green algal growth in the water surrounding the pipe (Figure 10). Only one other house was noted on the walk near the south end of the voe at Pund. This house is known to be a holiday home and a septic tank was identified for this property (Figure 11). A number of houses are present in South Whiteness further east of the voe over the hill but none are visible from the Stromness Voe shore due to the hill acting as a barrier.

Sample analysis

Five freshwater samples were obtained from watercourses on the shoreline survey, all of which were outlined on the sampling plan. Another two freshwater samples were outlined in the plan but on approaching the locations no watercourses were present only areas of boggy ground but no water flowing. Of the five watercourses sampled, three were found to have *E.coli* levels between 20-140 cfu/100ml. The other two samples were from small watercourses, the first just north of the Site 2 fishery which had a small water discharge (Figure 12) recording an *E.coli* count of 240 cfu/100ml. The second sample was collected from a stagnant pool of water (Figure 13) in a watercourse above a small jetty situated between the Site 1 and Site 2 fisheries which recorded an *E.coli* count of 300 cfu/100ml.

Six seawater samples were obtained on the shoreline walk, four of which were outlined on the survey plan. Those outlined in the survey plan had *E.coli* levels between <1-3 cfu/100ml. The two additional seawater samples not outlined in the survey plan were obtained near the head of the voe in the vicinity of discharge pipes. The first sample was taken north of the Strom Bridge in the water surrounding a discharge pipe which was associated with a septic tank. The end of the pipe was not visible so the sample was taken in the water near where the pipe entered the water. The sample obtained was found to have an *E.coli* count of 60 cfu/100ml. The second additional sample obtained was from the end of a discharge pipe just south of the Strom Bridge. The sample returned a result of $8.0x10^4$ cfu/100ml.

Two mussel samples were obtained from the Burra Holm fishery at the north east corner of the site. The two samples collected were obtained from the top and bottom of a mussel line. The sample obtained from the top of the mussel line was found to have a count of 330 *E.coli* MPN/100g with the bottom sample returning levels of 40 *E.coli* MPN/100g. Two mussel samples were obtained from the Site 1 fishery just north of the south east corner of the site. The samples were again obtained from the top and bottom of a mussel line. The sample obtained from the top of the mussel line recorded a count of <20 *E.coli* MPN/100g with the bottom sample returning levels of 110 *E.coli* MPN/100g. Two mussel samples were obtained from the Site 2 fishery from the south west corner of the site. The samples were obtained from the top and bottom of a mussel line. Both the samples returned counts of <20 *E.coli* MPN/100g.

Salinity profiles were collected at all three fisheries from the north end of the Burra Holm fishery and the south ends of the Site 1 and Site 2 fisheries. A salinity reading was also obtained from the surface of the water under the Strom Bridge (Figure 14). The profiles obtained from the fisheries all showed a decrease in salinity from 10 metres to the surface greater than 0.35 ppt which is out with the accuracy of the probe (± 0.35 ppt). The salinity profile which showed the greatest difference (1.91 ppt) in salinity was recorded at the Burra Holm fishery which saw the salinity peak at 5 metres before decreasing to the surface. A full salinity profile could not be obtained at the Strom Bridge as the water was too shallow under the bridge and there was a strong flow of water from the Strom Loch into Stromness Voe which would have made taking more readings at a greater depth difficult. The salinity recorded under the Strom Bridge was 31.95 ppt which is lower than full strength seawater although this would be expected with the strong influence of freshwater coming from the Strom Loch.

The three temperature profiles recorded from the fisheries all showed an increase in temperature from 10 metres to the surface. The profiles showed similar differences

in temperature although the greatest difference from 10 metres to the surface was the profile recorded at the SE corner of the Site 1 fishery (2.1°C). The profile taken at the Burra Holm fishery showed the highest temperature being recorded at 5 metres before increasing to the surface. The temperature of the surface water recorded under the Strom Bridge was 14.7°C which was similar to the surface readings recorded at the three fisheries.

Salinities of the seawater samples analysed at the laboratory showed salinities ranging from 26.93-33.76 PSU which is a large range and the highest salinity recorded still being below full strength seawater.

Seasonal population

There is one known bed and breakfast property in the Stromness Voe area. The Omaruru bed and breakfast is situated in South Whiteness near the south end of Stromness Voe. It is located some distance up the hill from the Scottish Sea Farms shorebase and the property is not visible from the shore. The property can sleep up to seven people.

Boats/Shipping

Boat traffic in the Stromness Voe area is largely associated with mussel farming and also leisure boats. Blueshell Mussels who manage both the Site 1 and Site 2 fisheries on behalf of Pund Shellfish berth a small workboat at the Scottish Sea Farms Ltd. shorebase near the mouth of the voe to service sites both in Stromness Voe and the surrounding area. A large Blueshell Mussel workboat was present at the pier during the shoreline walk which had been servicing a mussel farm outside Stromness Voe that day (Figure 15). Scottish Sea Farms Ltd. do have salmon farms in the surrounding area outside Stromness Voe but the shorebase is not frequently used for servicing their sites, it is more commonly used for storage (Figure 16). A number of leisure boats were observed during the shoreline survey, aswell as three privately owned jetties (Figure 17).

Farming and Livestock

The land on the shoreline survey was dominated by rough open grazing. Ninety sheep were observed during the boat work grazing on the western shoreline near the Burra Holm fishery with the animals having access to the shore. On the eastern shoreline sheep were frequently observed (103 in total) on the hill south of the Strom Bridge to the end of the shoreline walk at Pund. All the sheep had access to the shore on the eastern shoreline however steep escarpments may have prevented

access in some locations. Sheep faeces were noted in most areas where animals were observed but there were four occasions where sheep faeces were noted but no animals were observed.

A Shetland pony was observed in a fenced area north of the Strom Bridge adjacent to a house (Figure 18). Equine faeces were observed on five occasions in fields from the head of voe until the Strom Bridge, however no animals were present but there was evidence of grazing with hoof prints, feed buckets and a small wooden shelter (Figure 19) noted. On two of the occasions large piles of equine faeces had been gathered near the shore in the north and south corners of a field (Figure 20). Equine faeces was also noted south of the Site 1 fishery near a small jetty, however no animals were present but animals grazing at this location would have access to the shore.

Six cows were observed during the boat work on the eastern shoreline at the top of the hill, near the Burra Holm fishery. Cow faeces were noted on the shoreline north of the Burra Holm fishery however no animals were observed but animals at this location would have been able to access the shore.

Land Use and Land Cover

Rough grassland dominated the eastern shoreline of the production area. Wet boggy areas were noted on five occasions and a meadow like flora was noted in fields at the start of the shoreline walk north of the Strom Bridge. A large number of thistles were observed on the hill north of the Burra Holm fishery.

The eastern shoreline was characterised by undulating landscape alternating between steep cliffs and escarpments with no access to the shore, to lowland areas with small stony beaches where access to the shore was possible. Grazing was dominated by open grazing with only fields used for grazing horses or ponies being fenced, north of the Strom Bridge. Areas of the shoreline south of the Strom Bridge may have prevented animals from accessing the shore due to the steep escarpments.

There was very little rainfall in the days preceding the shoreline walk with wet boggy areas noted on five occasions on the shoreline walk, however two watercourses that were outlined on the survey plan to be sampled were not, as there was no areas of running water at these locations just wet boggy ground.

Watercourses

Five watercourses were sampled on the shoreline walk, all of which were on the sample plan. Two watercourses which were outlined in the plan, one south of the Site 1 fishery and the other south of the Site 2 fishery near Pund were not sampled as there was no running water at these locations. Flow rate was only recorded at the first watercourse sampled at the head of the voe due to the low volume of water or insufficient flow found in the other watercourses.

Wildlife/Birds

During the boat work and on the shoreline walk large numbers of artic terns were observed on buoys or mussel ropes, in the water or in flight around the Site 2 fishery. One cormorant was also present on a buoy at the Site 2 fishery during the boat work. Large amounts of bird faeces were noted on the buoys at the Site 2 fishery. Birds were not as common at the Site 1 and Burra Holm fisheries with only small amounts of bird faeces noted on the buoys at these sites and only three gulls observed at the Site 1 fishery in the water and on buoys. A number of bird species were noted along the shoreline walk including a curlew, a great skua, artic terns, gulls and flocks of collared doves and starlings. Most of the birds observed were seen in flight but some gulls were observed in the water or on the shore and the great skua was observed feeding on a rabbit carcass at the edge of an escarpment (Figure 21). Sea urchin and crab carcasses were noted near the edge of an escarpment south of the Site 1 fishery which could indicate an area where birds may have been feeding.

Seventeen rabbits were observed on the hill south of the Strom Bridge to the end of the shoreline walk, with rabbit holes being common along the eastern shoreline. One seal was observed in the water at the start of the shoreline walk near the head of the voe.

General observations

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

Dimensions and flows of watercourses are estimated at the most convenient point of access and not necessarily at the point at which the watercourse enters the voe.

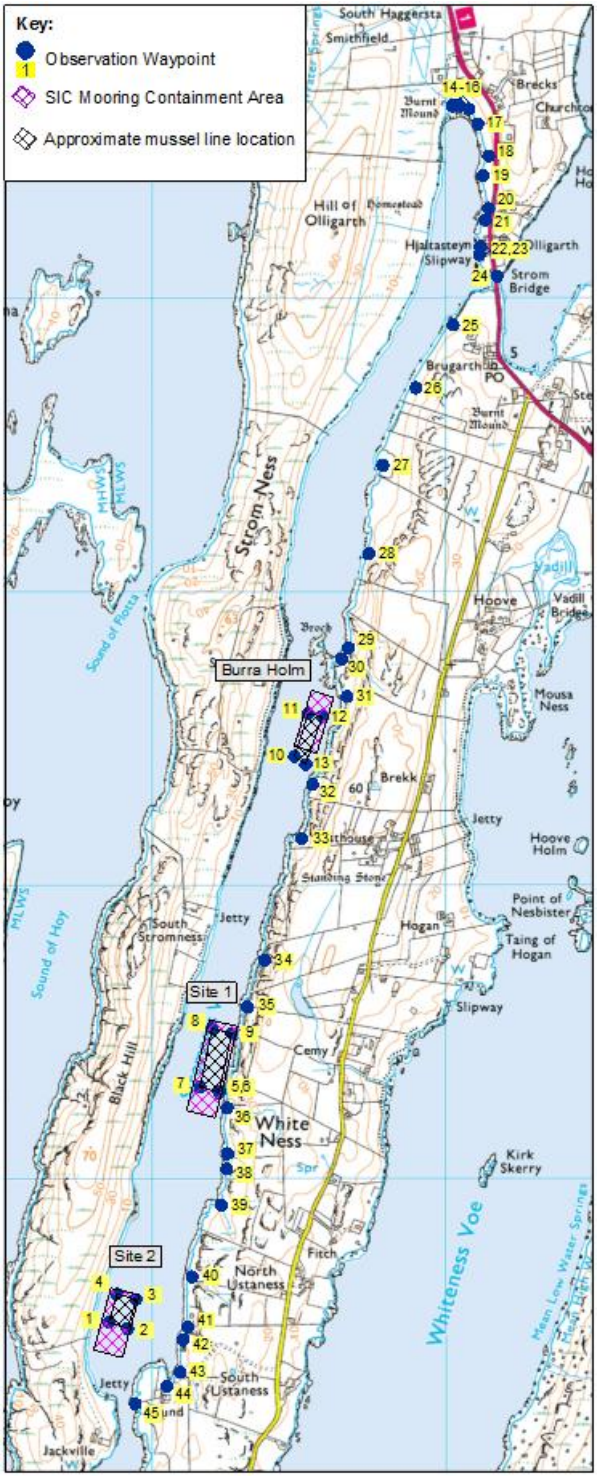

Figure 1 Map of shoreline observations

Table 1 Shoreline Observations

No.	Date/Time (UT)	NGR	Easting	Northing	Associated Photograph	Associated Sample	Description
1	06/08/2013 09:32	HU 37853 43511	437853	1143511	Figure 6	SMV-MUSS01 (Top), SMV-MUSS02 (Bottom), SMV-SW01	Weather: Mostly cloudy with breaks of sunshine, gentle south westerly wind. SW corner of Site 2 fishery, located at the mouth of the voe. 4x double header long lines. Droppers 10m, mussels on site. Salinity Profile 1 collected (ppt/°C): 10m 35.26/12.6, 5m 35.09/12.8, 3m 35.07/12.9, surface 34.41/14.6. Mussels collected from furthest west line at the SW corner buoy. Surface sample collected from the top of a mussel line, bottom sample collected from the bottom of a mussel line. Seawater sample collected.
2	06/08/2013 09:46	HU 37917 43489	437917	1143489			SE corner of Site 2 fishery. One cormorant on a buoy and approximately 50 artic terns perched on buoys or mussel ropes, in the water or in flight around the fishery. Large amounts of bird faeces present on the buoys at the fishery.
3	06/08/2013 09:48	HU 37945 43588	437945	1143588			NE corner of Site 2 fishery.
4	06/08/2013 09:49	HU 37881 43607	437881	1143607			NW corner of Site 2 fishery.
5	06/08/2013 09:53	HU 38228 44294	438228	1144294			SE corner of Site 1 fishery, located north of Site 2 moving closer to the head of the voe. 4x double header long lines. Droppers 10m, mussels on site.
6	06/08/2013 09:56	HU 38230 44296	438230	1144296		SMV-MUSS03 (Top), SMV-	Salinity Profile 2 collected (ppt/°C): 10m 35.21/12.8, 5m 35.13/13.0, 3m 35.05/13.2, surface

						MUSS04 (Bottom), SMV-SW02	33.85/14.9. Mussels collected from furthest east line just north of the SE corner buoy. Surface sample collected from the top of a mussel line, bottom sample collected from the bottom of a mussel line. Seawater sample collected. One gull on the SW corner buoy and two gulls in the water.
7	06/08/2013 10:08	HU 38163 44312	438163	1144312			SW corner of Site 1 fishery.
8	06/08/2013 10:10	HU 38205 44513	438205	1144513			NW corner of Site 1 fishery. Small amounts of bird faeces on some of the buoys at the fishery.
9	06/08/2013 10:10	HU 38270 44495	438270	1144495			NE corner of Site 1 fishery.
10	06/08/2013 10:14	HU 38485 45439	438485	1145439			SW corner of Burra Holm fishery, located nearest the head of the voe. 4x double header long lines. Droppers 4m, mussels on site. Small amounts of bird faeces on some of the buoys at the fishery.
11	06/08/2013 10:15	HU 38531 45584	438531	1145584			NW corner of Burra Holm fishery. Ninety sheep noted on the hill on the western shore.
12	06/08/2013 10:17	HU 38580 45576	438580	1145576		SMV-MUSS05 (Top), SMV-MUSS06 (Bottom), SMV-SW03	NE corner of Burra Holm fishery. Salinity Profile 3 collected (ppt/°C): 10m 33.97/13.8, 5m 35.12/12.9, 3m 34.79/13.9, surface 33.21/14.9. Mussels collected from furthest east line at the NE corner buoy. Surface sample collected from the top of a mussel line, bottom sample collected from the bottom of a mussel line. Seawater sample collected.
13	06/08/2013 10:36	HU 38523 45412	438523	1145412			SE corner of Burra Holm fishery. Six cows noted on the hill on the eastern shore.

14	06/08/2013 11:34	HU 39020 47657	439020	1147657		SMV-FW01	Start of the shoreline walk, head of Stomness Voe. Weather: Cloudy with breaks of sunshine, fresh breeze. Small watercourse, very silty and large amounts of vegetation surrounding the watercourse, including yellow iris. Freshwater sample taken (on survey plan) and flow rate measured; width 45 cm, depth 5 cm, flow 0.015 m/s, st. dev. 0.005 m/s. Small pontoon to the west of the watercourse. House located some distance up the hill. Lowland area, slight incline up hill leading to the road.
15	06/08/2013 11:39	HU 39049 47656	439049	1147656			Equine faeces and hoof prints noted in the field above the shore, no animals present but area fenced so animals could not access the shore. Small stony beach at the shore.
16	06/08/2013 11:41	HU 39077 47646	439077	1147646			Large pile of equine faeces in the north west corner of a field just up from the shore, fenced area evidence of equine grazing but no animals present. Escarpments steepening slightly, land rough grazing. Eight houses noted above the road.
17	06/08/2013 11:43	HU 39108 47594	439108	1147594	Figure 20		A second large pile of equine faeces noted in the south west corner of the same field mentioned above.
18	06/08/2013 11:47	HU 39145 47486	439145	1147486			Stagnant pool of water observed in the middle of a field possibly from a spring, wet ground leading to

							the shore but no water flowing. Meadow like flora with longer grass and flowers, rough grazing. One seal observed in the water and one curlew seen in flight.
19	06/08/2013 11:49	HU 39126 47420	439126	1147420			Equine faeces, not fresh noted in a fenced field above the shore, no animals present. Fences look to be electric but not turned on. One gull observed in the water. Escarpments steepening.
20	06/08/2013 11:52	HU 39144 47307	439144	1147307	Figure 19		Fenced area with feed buckets and a wooden shelter with hay present. Equine faeces observed but no animals present.
21	06/08/2013 11:55	HU 39134 47268	439134	1147268	Figure 18		Shetland pony noted in a fenced area no access to the shore, equine faeces present.
22	06/08/2013 12:00	HU 39117 47177	439117	1147177	Figure 7 & Figure 8	SMV-SW04	Septic tank on the shore with a pipe leading to the sea, consented discharge on the survey plan. Three houses above the shore, not sure how many houses the tank is servicing as there is no sewerage system in the area, more houses noted above the road. Septic tank in a poor state with outer casing of the tank and pipe casing damaged, seepage coming from the tank and black/green algae forming on the tank. Yacht and small leisure boat moored in the voe. Two small rowing boats observed on the shore. Seawater sample collected (not on survey plan) from the shore next to the pipe, end of the pipe not visible.
23	06/08/2013 12:06	HU 39114 47149	439114	1147149			Small pier just north of the Strom Bridge, divers on site working on the pier at the time of the survey. Associated with property directly up from the pier.

24	06/08/2013 12:17	HU 39174 47076	439174	1147076	Figure 14	SMV-SW05	Seawater sample taken from under the Strom Bridge (on survey plan), large water flow from Strom Loch to Stromness Voe.
25	06/08/2013 12:27	HU 39024 46910	439024	1146910	Figure 9 & Figure 10	SMV-SW06	Consented discharge noted on the survey plan, pipe observed leading to the water but no septic tank located. Two houses observed from the shore but more houses and a shop located just over the hill. Large area of green algae in the water around the end of the pipe. Grey discharge seen at the end of the pipe. Seawater sample taken (not on survey plan) from the end of the pipe, slight sewage smell noted whilst the sample was being obtained. Lowland area with small stony beach and seaweed. Small boathouse noted at the shore just south of the discharge pipe. Nine sheep observed on the hill with access to the shore, sheep faeces also present. One rabbit seen on the hill.
26	06/08/2013 12:39	HU 38897 46695	438897	1146695			Ten sheep observed on the hill with access to the shore, sheep faeces present. Wet boggy ground noted.
27	06/08/2013 12:45	HU 38785 46431	438785	1146431			Lowland area leading to steep hill. Fifteen sheep observed with access to the shore. Sheep faeces present.
28	06/08/2013 12:49	HU 38737 46130	438737	1146130			Escarpments steepening with shear rock faces up from the shore. Twenty five sheep present on the hill with access to the shore. Sheep faeces present. Three large flocks of starlings.

29	06/08/2013 12:57	HU 38669 45809	438669	1145809		SMV-FW02	Three sheep observed on the hill. Three artic terns seen in flight. Large number of rabbit holes observed on the hill. Small watercourse, small water flow through vegetation. Freshwater sample obtained (on survey plan), volume of water too low to measure flow rate. Green algal growth at the shore.
30	06/08/2013 13:02	HU 38644 45771	438644	1145771			Cow faeces noted but no animals present, would have access to the shore. Small lowland area. One rabbit observed and large numbers of thistles growing.
31	06/08/2013 13:04	HU 38663 45643	438663	1145643			Four collared doves in flight.
32	06/08/2013 13:10	HU 38546 45344	438546	1145344	Figure 4		Clouds clearing, sunshine more frequent. Burra Holm fishery.
33	06/08/2013 13:15	HU 38508 45158	438508	1145158			Wet boggy area, flock of collared doves noted. Fifteen sheep observed on the hill, sheep faeces noted. Small windmill present on the top of the hill. Rocky faces to side of hills, escarpments steepening no stony beaches below. Two artic terns observed in flight.
34	06/08/2013 13:25	HU 38382 44744	438382	1144744			Two rabbits observed. Sheep observed on the western shore across the voe, noted in WP011. Sheep faeces noted but no animals observed, animals would have access to the shore. One starling in flight.

35	06/08/2013 13:29	HU 38324 44584	438324	1144584	Figure 5		Six rabbits and ten sheep observed on the hill with access to the shore. Sheep faeces present. One sheep observed on the shore, on a small stony beach. Ten collared doves in flight. One artic tern and one gull seen in the water. One gull observed in flight. Site 1 fishery.
36	06/08/2013 13:42	HU 38255 44241	438255	1144241		SMV-FW03	Small watercourse flowing through vegetation on the hillside. Cream coloured algae formation with a green tinge present, also noted small brown/black globules. Green algae present on the rocks at the shore. Freshwater sample taken (on survey plan) from a small stagnant pool, insufficient flow to record flow rate. Four rabbits observed on the hill.
37	06/08/2013 13:49	HU 38257 44085	438257	1144085			Wet ground no water flowing. Location of freshwater sample on survey plan, not possible to obtain a sample.
38	06/08/2013 13:51	HU 38254 44033	438254	1144033			Sea urchin and crab carcasses possibly where birds have been feeding. Equine faeces noted, not fresh, no animals present but would be able to access the shore.
39	06/08/2013 13:56	HU 38235 43910	438235	1143910	Figure 13 & Figure 17	SMV-FW04	Lowland area with a jetty and three boats moored. Rowing boat also present on land above the jetty. Shed, quad and trailer present. Small watercourse beside the jetty surrounded by yellow iris. No water flowing just stagnant pools of water. Discarded

							bottles in the watercourse. Freshwater sample obtained (on survey plan), insufficient flow to record flow rate.
40	06/08/2013 14:09	HU 38136 43665	438136	1143665	Figure 12 & Figure 21	SMV-FW05	Great Skua observed feeding on a rabbit carcass. Small watercourse, very slight water flow through vegetation. Freshwater sample obtained (on survey plan), volume of water too low to record flow rate. Small boat with a creel inside present on the shore. Four artic terns and five gulls observed in flight.
41	06/08/2013 14:16	HU 38120 43494	438120	1143494	Figure 15 & Figure 16		Lowland area, Scottish Seafarms Ltd. shorebase, used mainly for storage. Blueshell Mussels use pier to moor a small workboat used for monthly sampling. A large workboat was at the pier which had been servicing a site in the area. Also another small leisure boat was moored at the pier. A small sailing boat was observed out of the water, on the pier. On shore there was one small Scottish Sea Farms workboat and a number of storage units.
42	06/08/2013 14:21	HU 38105 43452	438105	1143452			Slight incline up hill, small bench at the top. Sheep faeces present, two rabbits observed. Artic terns heard and observed in flight around Site 2 fishery.

43	06/08/2013 14:25	HU 38095 43340	438095	1143340			Rowing boat observed on land and small leisure boat moored in the water. Small watercourse, very slight water flow through vegetation. Surrounded by yellow iris. Ground wet unable to obtain a freshwater sample or flow rate. Sheep faeces present.
44	06/08/2013 14:28	HU 38050 43292	438050	1143292	Figure 11		Septic tank of holiday home at Pund. Three sheds associated with the house. Fifteen sheep observed able to access the shore, sheep faeces present. Small rowing boat moored on the beach below the septic tank. Three gulls in flight.
45	06/08/2013 14:33	HU 37943 43232	437943	1143232			End of the shoreline walk. Two gulls on the edge of the escarpment and one artic tern observed in flight. Sheep faeces present.

Sampling

Water and shellfish samples were collected at the locations indicated in Figures 2 and 3. Two freshwater samples outlined in the survey plan were not obtained due to there being no water flowing at the two locations outlined. All samples were transported initially by a cool backpack and then in a cool box to SSQC Ltd. for analysis within 24 hours of sample collection.

Bacteriology results are present in Table 2 and 3 and mapped in Figures 2 and 3.

Seawater samples were also tested for salinity at SSQC Ltd. In the field salinity profiles were collected using a YSI Professional Plus handheld meter and CT probe which had an accuracy of (± 0.35 ppt). Results are presented in Table 4 and locations of the profiles are mapped in Figure 2.

Table 2 Water sample *E.coli* results

No.	Sample Ref.	Date/Time (UT)	Position	Type	*E.coli* (cfu/100ml)	Salinity*
1	SMV-SW01	06/08/2013 09:32	HU 37853 43511	Sea Water	<1	33.76
2	SMV-SW02	06/08/2013 09:56	HU 38230 44296	Sea Water	2	33.04
3	SMV-SW03	06/08/2013 10:17	HU 38580 45576	Sea Water	1	32.25
4	SMV-FW01	06/08/2013 11:34	HU 39020 47657	Fresh Water	90	-
5	SMV-SW04	06/08/2013 12:00	HU 39117 47177	Sea Water	60	30.19
6	SMV-SW05	06/08/2013 12:17	HU 39174 47076	Sea Water	3	31.01
7	SMV-SW06	06/08/2013 12:27	HU 39024 46910	Sea Water	$8.0x10^4$	26.93
8	SMV-FW02	06/08/2013 12:57	HU 38669 45809	Fresh Water	20	-
9	SMV-FW03	06/08/2013 13:42	HU 38255 44241	Fresh Water	140	-

10	SMV-FW04	06/08/2013 13:56	HU 38235 43910	Fresh Water	300	-
11	SMV-FW05	06/08/2013 14:09	HU 38136 43665	Fresh Water	240	-

*Practical Salinity Scale 1978 (PSS-78)

Table 3 Shellfish sample *E.coli* results

No.	Sample Ref.	Date/Time (UT)	Position	Type	Depth	*E.coli* (MPN/100g)
1	SMV-MUSS01	06/08/2013 09:32	HU 37853 43511	Common Mussel	Top	<20
2	SMV-MUSS02	06/08/2013 09:32	HU 37853 43511	Common Mussel	Bottom	<20
3	SMV-MUSS03	06/08/2013 09:56	HU 38230 44296	Common Mussel	Top	<20
4	SMV-MUSS04	06/08/2013 09:56	HU 38230 44296	Common Mussel	Bottom	110
5	SMV-MUSS05	06/08/2013 10:17	HU 38580 45576	Common Mussel	Top	330
6	SMV-MUSS06	06/08/2013 10:17	HU 38580 45576	Common Mussel	Bottom	40

Table 4 Salinity profiles

Profile	Date/Time (UT)	Position	Depth (m)	Salinity (ppt) (± 0.35 ppt)	Temperature (°C)
1	06/08/2013 09:32	HU 37853 43511	surface	34.41	14.6
			3	35.07	12.9
			5	35.09	12.8
			10	35.26	12.6
2	06/08/2013 09:56	HU 38230 44296	surface	33.85	14.9
			3	35.05	13.2
			5	35.13	13.0
			10	35.21	12.8
3	06/08/2013 10:17	HU 38580 45576	surface	33.21	14.9
			3	34.79	13.9
			5	35.12	12.9
			10	33.97	13.8
4	06/08/2013 12:17	HU 39174 47076	surface	31.95	14.7

Figure 2 Map of water sample results and salinity profile locations

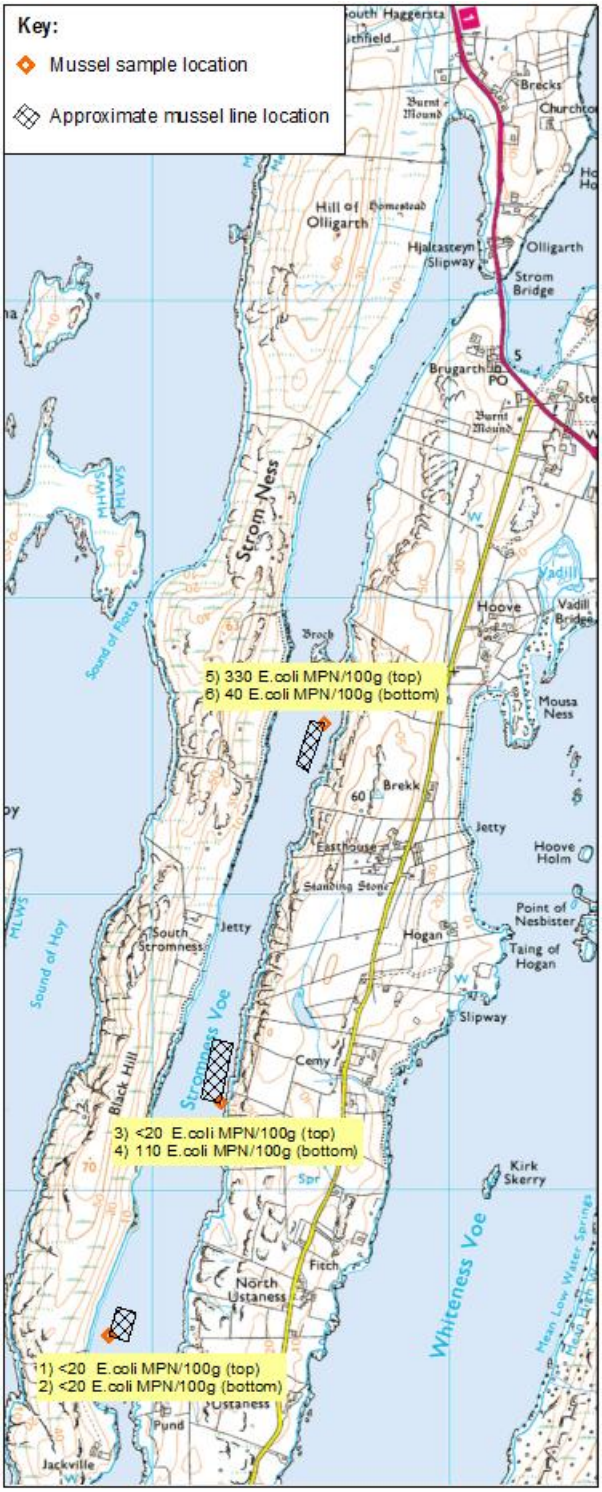

Figure 3 Map of shellfish sample results

Photographs

Figure 4 – Mussel lines at the Burra Holm fishery looking north.

Figure 5 – Mussel lines at the Site 1 fishery looking south.

Figure 6 – Mussel lines at the Site 2 fishery looking north from the SW corner.

Figure 7 – Septic tank located north of the Strom Bridge.

Figure 8 – Additional seawater sample obtained in the vicinity of a discharge pipe north of the Strom Bridge.

Figure 9 – Discharge pipe leading to the water south of the Strom Bridge.

Figure 10 – Additional seawater sample obtained from a discharge pipe south of the Strom Bridge.

Figure 11 – Septic tank associated with a holiday home at Pund.

Figure 11 – Septic tank associated with a holiday home at Pund.

Figure 12 – Small watercourse sampled north of the Site 2 fishery.

Figure 13 – Watercourse sampled up from a jetty situated between the Site 1 and Site 2 fisheries.

Figure 14 – Water flowing under Strom Bridge from Strom Loch to Stromness Voe.

Figure 15 – Workboats berthed at the shorebase near the mouth of Stromness Voe.

Figure 16 – Equipment being stored at the Scottish Sea Farms Ltd. shorebase.

Figure 17 – Leisure boats moored at a jetty between the Site 1 and Site 2 fisheries.

Figure 18 – Shetland pony grazing in a field adjacent to a house north of the Strom Bridge.

Figure 19 – Equine shelter in a field north of the Strom Bridge.

Figure 20 – Large pile of equine faeces observed in a field near the head of Stromness Voe.

Figure 21 – Great Skua feeding on a rabbit carcass north of the Site 2 fishery.

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1. SEPA discharge consents and Scottish Water discharges

SEPA discharge consents:

Licence Number	NGR	Site Name	Location Description	MDF	DWF	DPE	Discharge Type
CAR/L/1001818	HU 35700 46500	Brei Geo Offshore MCFF, Sandsound Voe	Brei Geo MCFF, Sandsound Voe, Shetland				
CAR/L/1001852	HU 43276 48136	Vatster Quarry	Vatster Quarry final effluent - discharge to Loch of Vatster	40			Other Effluent
CAR/L/1001965	HU 39684 44808	Nesbister	Nesbister STW, FE to Whiteness Voe, Whiteness, Shetland			0	Sewage (Public) Primary
CAR/L/1001966	HU 3985 4585	Wormadale	Wormadale CSO to Whiteness Voe, Whiteness, Shetland				Sewage (Public) Combined Sewer Overflow (CSO)
CAR/L/1002228	HU 43066 50590	Fish Hatchery Unit, Keolka, Girlsta	Millbrook Fisheries Smolt Farm,Girlsta - Fish farm eff.				Fish Farm Freshwater Tank or Hatchery
CAR/L/1002229	HU 43158 46130	Strand Pumping Station, Gott	Strand PS EO to Burn of Strand, Gott, Shetland	1	1	1	Sewage (Public) Emergency Overflow (EO)
CAR/L/1002230	HU 42633 44625	Veensgarth Pumping Station, Veensgarth	Veensgarth PS, Shetland, EO to Burra Burn				Sewage (Public) Emergency Overflow (EO)
CAR/L/1002237	HU 38746 50148	Kalliness Outfall, Weisdale Voe, Shetland	Kalliness STW, Shetland, ZE2 9NX			1	
CAR/L/1002243	HU 44290 47150	Tronafirth Septic Tanks, Tronafirth, Gott	Tronafirth STW, FE to Lax Firth, Gott, Shetland			1	Sewage (Public) Primary
CAR/L/1002244	HU 43264 46153	Strand Pumping Station, Strand, Gott	Strand PS, Gott, Shetland, ZE2 9SF				
CAR/L/1002277	HU 35700 51400	Tresta Outfall, Westerfield, Tresta	Tresta STW, Crude sewage discharge to Tresta Voe, Westerfield, Shetland			0	Sewage (Public) Untreated
CAR/L/1002278	HU 39200 51900	Swedish Houses Outfall, Swedish Houses	Swedish Houses STW, FE to Weisdale Voe, Shetland			0	Sewage (Public) Untreated
CAR/L/1002281	HU 38800 48400	Clach-na-Strom Outfall, Clach-na-Strom, White	Clach-na-Strom STW, FE to Welsdale Voe			0	Sewage (Public) Untreated
CAR/L/1002343	HU 38613 49967	Kalliness West	Kalliness West STW, FE to Weisdale Voe, Shetland			1	Sewage (Public) Primary

Licence Number	NGR	Site Name	Location Description	MDF	DWF	DPE	Discharge Type
CAR/L/1003058	HU 37100 46300	Flotta West MCFF, Weisdale Voe	Mouth of Weisdale Voe MCFF, W of Flotta, Shetland				
CAR/L/1003070	HU 36900 43000	North Havra MCFF, Sound of Havra	North Havra MCFF, Sound of Havra, Whiteness, Shetland				
CAR/L/1003114	HU 37700 45000	Sound Of Hoy MCFF, Weisdale Voe	Sound of Hoy MCFF, Weisdale Voe, Shetland				
CAR/L/1003865	HU 40290 48800	Loch of Strom Site, Loch of Strom, Shetland	Norman William Leask, Loch of Strom MCFF, Whiteness, Shetland				
CAR/L/1003898	HU 37499 45434	North of Hoy MCFF, Weisdale Voe	North of Hoy MCFF, Hogg Sound, Whiteness, Shetland				Fish Farm Marine Cage
CAR/L/1004043	HU 44500 48200	Lax Firth West MCFF, Lax Firth	Laxfirth Voe West MCFF, Lax Firth, Gott, Shetland				Fish Farm Marine Cage
CAR/L/1004044	HU 43678 49952	Wadbister MCFF, Wadbister Voe	Wadbister MCFF, Wadbister Voe, Girlsta, Shetland				
CAR/L/1004068	HU 37724 45959	Binna Ness MCFF, Stromness Voe	Binna Ness MCFF, Sound of Flotta, Shetland				
CAR/L/1004156	HU 35750 47350	Brei Geo Inshore MCFF, Sandsound Voe	Brei Geo Inshore MCFF, Sandsound Voe, Sand, Shetland				
CAR/L/1004206	HU 35510 45000	Fore Holm MCFF, Haddock Sands	Haddock Sands MCFF, Fore Holm, Shetland				Fish Farm Marine Cage
CAR/L/1004217	HU 35300 43400	Easter Score Holm MCFF, Haddock Sands	Easter Score Holm MCFF, Haddock Sands, Easter Score Holm Island, Shetland				
CAR/L/1015762	HU 33310 46000	Selivoe MCFF, Shetland	Seli Voe MCFF, Sandsting, Shetland				Fish Farm Marine Cage
CAR/L/1015765	HU 44900 48100	Lax Firth East MCFF, Lax Firth	Laxfirth Voe (Salmon) Ltd, East MCFF to Laxfirth Voe, Gott, Shetland				Fish Farm Marine Cage
CAR/R/1008974	HU 39013 52314	Springwater Factory, Heglabister, Weisdale	COPE Springwater & Lemonade Factory, Weisdale, Shetland, ZE2 9LW				
CAR/R/1014567	HU 38663 43795	Fitch, Whiteness, Shetland	Fitch, Whiteness, Shetland, ZE2 9LL			5	
CAR/R/1016057	HU 39430 52450	Brighouse, Weisdale, Shetland	Brighouse, Weisdale, STE to Land			6	Sewage (Private) Primary
CAR/R/1017430	HU 40900 51890	Stovadaal, Stromfirth, Shetland	Stovadaal, Stromfirth, Shetland			12	

Licence Number	NGR	Site Name	Location Description	MDF	DWF	DPE	Discharge Type
CAR/R/1018645	HU 43250 49552	Nordstrand, Wadbister, Shetland	Nordstrand, Wadbister, Shetland, ZE2 9SQ			15	
CAR/R/1020807	HU 43076 50594	Millbrook Fisheries, Girlsta, Shetland	Millbrook Fisheries, Girlsta, Shetland, ZE2 9SQ				
CAR/R/1021629	HU 43225 49557	Beulah, Wadbister, Shetland	Beulah, Wadbister, Shetland, ZE2 9SQ			5	
CAR/R/1023106	HU 33853 47697	Leans & Sandhoulland, Sand, Shetland	Leans & Sandhoulland, Sand, Shetland, ZE2 9NQ			10	
CAR/R/1025577	HU 39110 45950	Hoove, Whiteness, Shetland	Hoove, STE to soakaway, Whiteness, Shetland			5	Sewage (Private) Primary
CAR/R/1025719	HU 41000 52110	Burnside, Stromfirth, Shetland	Burnside, STE to Land, Shetland			5	Sewage (Private) Primary
CAR/R/1025721	HU 40788 52029	Parkhead, Stromfirth, Shetland	Parkhead, Stromfirth, Shetland, ZE2 9LH			6	
CAR/R/1025761	HU 38590 43610	(Grains), North House, Shetland	Grains, North House, STE to Land, Shetland			6	Sewage (Private) Primary
CAR/R/1028322	HU 38050 49530	North Taing, Cott, Weisdale, Shetland	North Taing, STW FE to Weisdale Voe, Cott, Weisdale, Shetland			6	Sewage (Private) Secondary
CAR/R/1029123	HU 38492 43435	da Moorings, South Ustaness, South Whiteness	da Moorings, STE to soakaway, South Ustaness, South Whiteness, Shetland			15	Sewage (Private) Primary
CAR/R/1029301	HU 35509 48428	Tartaraghan, Sand Sound, Shetland	Tartargain, Sand Sound, Shetland, ZE2 9LU			14	
CAR/R/1030388	HU 39486 52808	Koopins (+4 others),Gardie, Weisdale	Koopins, Arisdale, Atlascord, Brekka & Hellor, STE to soakaway, Weisdale			25	Sewage (Private) Primary
CAR/R/1030458	HU 43042 50569	Girlsta Bridge, Shetland	Girlsta Bridge Eng Wks, Girlsta, Shetland			5	
CAR/R/1030507	HU 40870 51780	Arcadia, Stromfirth, Shetland	Arcadia, STE to soakaway, Stromfirth, Shetland				Sewage (Private) Primary
CAR/R/1031970	HU 34270 47350	Pund, Sand, Bixter, Shetland	Pund, STE to soakaway, Sand, Bixter, Shetland			6	Sewage (Private) Primary
CAR/R/1033150	HU 38719 44505	Veghamar, Whiteness, Shetland	Veghamar, Whiteness, Shetland, ZE2 9LL			5	
CAR/R/1033872	HU 39100 49350	Upper Hellister, Weisdale, Shetland	Upper Hellister, STE to soakaway, Weisdale, Shetland			5	Sewage (Private) Primary

Licence Number	NGR	Site Name	Location Description	MDF	DWF	DPE	Discharge Type
CAR/R/1035235	HU 38990 46910	Norcrest, Brugarth, Whiteness, Shetland	Norcrest, STE to Stromness Voe, Brugarth, Whiteness, Shetland			6	Sewage (Private) Primary
CAR/R/1035717	HU 43260 48150	Vatster Waste Facility Vatster Gott Shetland	Vatster Waste Facility, STE to soakaway, Vatster, Gott, Shetland			5	Sewage (Private) Primary
CAR/R/1036077	HU 38508 43683	The Gardenlea & Chalet, Whiteness, Shetland	Gardenlea & Chalet, Whiteness, Shetland, ZE2 9LL			5	
CAR/R/1036200	HU 35454 48759	Struy, Sandsound, Tresta, Shetland	Struy, Sandsound, Tresta, Shetland, ZE2 9LU			5	
CAR/R/1036214	HU 39049 51946	Braeburn, Weisdale, Shetland	Braeburn, Weisdale, Shetland, ZE2 9LN			5	
CAR/R/1036220	HU 36083 50971	Hogar, Tresta, Shetland	Hogar, Tresta, Shetland, ZE2 9LT			6	
CAR/R/1036221	HU 36173 50927	Hillview Chalet & Bungalow, Tresta, Shetland	Hillview Chalet, Tresta, Shetland, ZE2 9LT			5	
CAR/R/1036280	HU 39117 45808	Southerhouse, Whiteness, Shetland	Souther House, Whiteness, Shetland, ZE2 9LL			6	
CAR/R/1036346	HU 36108 50933	Glenlea, Tresta, Shetland	Glenlea, Tresta, Shetland, ZE2 9LT			5	
CAR/R/1036519	HU 39240 46460	Mews, Whitecairns, Shetland	Mews, STE to land, Whitecairns, Shetland			5	Sewage (Private) Untreated
CAR/R/1036633	HU 39270 52610	Stenswall, Weisdale, Shetland	Stenswall, STE to soakaway, Weisdale, Shetland			5	Sewage (Private) Primary
CAR/R/1036705	HU 35732 48373	The Back, Sandsound Shetland	The Back, Sandsound, Shetland			5	
CAR/R/1036961	HU 39372 46787	Bretthamar & Stromvatn, Whiteness, Shetland	Bretthamar & Stromvatn, STE to Loch of Strom, Whiteness, Shetland			10	Sewage (Private) Primary
CAR/R/1037363	HU 33370 48180	Sigra, Garderhouse, Shetland	Sigra, STE to soakaway, Garderhouse, Shetland			5	Sewage (Private) Primary
CAR/R/1037416	HU 39200 50648	South Huxter, Weisdale, Shetland	South Huxter, Weisdale, Shetland, ZE2 9LQ			5	
CAR/R/1037694	HU 39190 47190	Olligarth House, Whiteness, Shetland	Olligarth House, Whiteness, Shetland, ZE2 9GJ			5	
CAR/R/1037992	HU 38950 51730	Da Braes, Weisdale, Shetland	Da Braes, Weisdale, Shetland, ZE2 9LN			5	

Licence Number	NGR	Site Name	Location Description	MDF	DWF	DPE	Discharge Type
CAR/R/1038356	HU 42647 43804	13 Veensgarth & The Stables, Shetland	13 Veensgarth & The Stables, STE to Soakaway, Veensgarth, Tingwall, Shetland			12	Sewage (Private) Primary
CAR/R/1038384	HU 41080 41840	Solbrekka, Asta, Scalloway, Shetland	Solbrekka, Asta, Scalloway, Shetland, ZE1 0UQ			5	
CAR/R/1038390	HU 35509 49031	Ominsgarth, Sandsound, Shetland	Ominsgarth, Sandsound, Shetland, ZE2 9LU			5	
CAR/R/1038527	HU 38902 51598	Heglabister, Weisdale, Shetland	Heglabister, Weisdale, Shetland, ZE2 9LN			5	
CAR/R/1038553	HU 34990 48310	Grianan, Mayfield, Sand, Bixter	Grianan, STE to Soakaway, Mayfield, Sand, Bixter, ZE2 9NQ			5	Sewage (Private) Primary
CAR/R/1038567	HU 34350 47780	Chapelside, Sand, Shetland	Chapelside, Sand, Shetland, ZE2 9NQ			5	
CAR/R/1038610	HU 34904 48396	Annfield Old & New Houses, Sand, Shetland	Annfield New & Old Houses, STE to soakaway, Sand, Bixter, Shetland			10	Sewage (Private) Primary
CAR/R/1038725	HU 39840 48480	Quoyness, Whiteness, Shetland	Quoyness, STE to land, Shetland			6	Sewage (Private) Primary
CAR/R/1038726	HU 39395 46601	Stebbygrind, Whiteness, Shetland	Stebbigrind, STE to land, Shetland			5	Sewage (Private) Primary
CAR/R/1038727	HU 39722 48444	Lower Quoynessm, Whiteness, Shetland	Lower Quoyness, Whiteness, Shetland, ZE2 9GL			5	
CAR/R/1038733	HU 43579 49471	Anderlea, Wadbister, Shetland	Anderlea, Wadbister, Girlsta, Shetland, ZE2 9SQ			5	
CAR/R/1038736	HU 41029 41769	Chaloah, Asta, Scalloway, Shetland	Chaloah, Asta, Scalloway, Shetland, ZE1 0UQ			5	
CAR/R/1038739	HU 38650 48210	Taing, Whiteness, Shetland	Taing, STE to land, Shetland			6	Sewage (Private) Primary
CAR/R/1038786	HU 43264 49372	Garths, Wadbister, Girlsta, Shetland	Garths, Wadbister, Girlsta, Shetland, ZE2 9SQ			7	
CAR/R/1038794	HU 41202 41978	Club House, Asta, Scalloway, Shetland	Club House, Asta, Scalloway, Shetland, ZE1 0UQ			50	
CAR/R/1038805	HU 41109 42032	Garth Lodge, Asta, Scalloway, Shetland	Garth Lodge, Asta, Scalloway, Shetland, ZE1 0UQ			5	
CAR/R/1039084	HU 38860 48189	Haagarth, Whiteness, Shetland	Haagarth, Whiteness, Shetland, ZE2 9GJ			5	

Licence Number	NGR	Site Name	Location Description	MDF	DWF	DPE	Discharge Type
CAR/R/1039201	HU 35680 51615	West Gate, Tresta, Bixter, Shetland	West Gate, Tresta, Bixter, Shetland, ZE2 9LT			5	
CAR/R/1039247	HU 44029 48276	North Hamarsfield, Tingwall, Shetland	North Hamarsland, Tingwall, Shetland, ZE2 9SG			5	
CAR/R/1039252	HU 35818 51392	Sevilla Cottage, Tresta, Shetland	Sevilla Cottage, Tresta, Shetland, ZE2 9LT			5	
CAR/R/1039562	HU 42936 46343	Cherryburn, Upper Strand, Tingwall, Shetland	Cherryburn, Upper Strand, Tingwall, Shetland, ZE2 9SG			5	
CAR/R/1039569	HU 35620 51510	Themaro, Tresta, Bixter	Themaro, STE to land, Tresta, Shetland			5	Sewage (Private) Primary
CAR/R/1039619	HU 42864 50949	Lochend, Girlsta, Shetland	Lochend, STE to soakaway, Shetland			5	Sewage (Private) Primary
CAR/R/1039706	HU 38120 49410	New House, North Taing, Weisdale, Shetland	New House, STE to Weisdale Voe,North Taing, Weisdale, Shetland			5	Sewage (Private) Primary
CAR/R/1039710	HU 35575 49676	Seaview (Burraland), Sandsound, Bixter	Seaview, Sandsound, Bixter, Shetland, ZE2 9LU			6	
CAR/R/1039737	HU 42590 43720	Veensgarth, Tingwall, Shetland	(Sinclair), Veensgarth, STE to soakaway, Tingwall, Shetland			10	Sewage (Private) Primary
CAR/R/1039759	HU 42764 50687	Roselea, Girlsta, Shetland	Roselea Cottage, Girlsta, Shetland, ZE2 9SQ			5	
CAR/R/1039778	HU 38244 42766	Ambervale, South Whiteness, Shetland	Ambervale, South Whiteness, Shetland, ZE2 9LL			5	
CAR/R/1039783	HU 38890 49490	Caiystane, Weisdale, Shetland	Caiystane, Weisdale, Shetland, ZE2 9LQ			5	
CAR/R/1039819	HU 42450 44100	Brake Park, Gott, Shetland	Brake Park, Gott, Shetland, ZE2 9SB			5	
CAR/R/1039820	HU 36225 51043	Bungalow, Tresta, Bixter, Shetland	Bungalow, STE to Burn of Tresta, Shetland			5	Sewage (Private) Primary
CAR/R/1039822	HU 36230 51110	Albany, Tresta, Bixter, Shetland	Albany, STE to soakaway, Shetland			5	Sewage (Private) Primary
CAR/R/1039849	HU 41640 43690	Tingview, Gott, Shetland	Tingview, Gott, Shetland, ZE2 9SB			5	
CAR/R/1039850	HU 41594 43694	Sunnyside, Grimsta, Tingwall	Sunnyside, Grimsta, Shetland, ZE2 9SB			5	
CAR/R/1039857	HU 33154 47969	Marvik, Garderhouse, Bixter, Shetland	Marvik, Garderhouse, Bixter, Shetland, ZE2 9NH			5	

Licence Number	NGR	Site Name	Location Description	MDF	DWF	DPE	Discharge Type
CAR/R/1039865	HU 33330 47920	Seaview, Garderhouse, Shetland	Seaview, STE to soakaway, Shetland			5	Sewage (Private) Primary
CAR/R/1039894	HU 38680 44470	Pineridge & Haddlea, South Whiteness, Shetlan	Pineridge & Haddlea, South Whiteness, Shetland, ZE2 9LL			10	
CAR/R/1039897	HU 38915 49450	Kolrona, Weisdale,Shetland	Kolrona, Weisdale, Shetland, ZE2 9LQ			6	
CAR/R/1039900	HU 40890 50970	Setter, Stromfirth, Weisdale, Shetland	Setter, Stromfirth, STE to soakaway, Weisdale, Shetland			5	Sewage (Private) Primary
CAR/R/1039903	HU 35799 51329	Fairview, Tresta, Bixter, Shetland	Fairview, STE to Tresta Voe, Tresta, Shetland			5	Sewage (Private) Primary
CAR/R/1039932	HU 44396 46462	Mouswall, Gott, Tingwall, Shetland	Mouswall, Gott, Tingwall, Shetland, ZE2 9SF			5	
CAR/R/1039994	HU 35210 47541	Mailands Sand Bixter Shetland	Mailands, Sand, Bixter, Shetland, ZE2 9NQ			5	
CAR/R/1039996	HU 43369 49536	Skagus, Wadbister, Girlsta, Shetland	Skagus, Wadbister, Girlsta, Shetland, ZE2 9SQ			5	
CAR/R/1040150	HU 41650 45450	Bailister Gott Shetland	Balister, STE to soakaway, Shetland			5	Sewage (Private) Primary
CAR/R/1040176	HU 42534 45409	Kingdom Hall & Meetint Hall, Tingwall	Kingdom Hall & Meeting Hall, Tingwall, Shetland, ZE2 9SH			5	
CAR/R/1040193	HU 35493 48557	Quoys, Sandsound, Bixter, Shetland	Quoys, Sandsound, Bixter, Shetland, ZE2 9LU			5	
CAR/R/1040347	HU 35840 48233	Shoreside, Bixter, Shetland	Shoreside, STE to soakaway, Sandsound, Tresta, Bixter, Shetland			5	Sewage (Private) Primary
CAR/R/1040740	HU 38760 44490	Kirkhouse, South Whiteness, Shetland	Kirkhouse, South Whiteness, Shetland, ZE2 9LL			5	
CAR/R/1040814	HU 35551 49665	Seaview Cottage, Sandsound, Bixter	Seaview Cottage, Sandsound, Bixter, Shetland, ZE2 9LU			5	
CAR/R/1042577	HU 38772 45118	Easthouse, Whiteness, Shetland, ZE2 9LL	Easthouse, Whiteness, Shetland, ZE2 9LL			10	
CAR/R/1042613	HU 38801 49918	Sandpipers, Weisdale	Sandpipers, Weisdale, ZE2 9LQ			5	
CAR/R/1042654	HU 38840 45210	Rocklea, South Whiteness, Shetland	Rocklea, STE to soakaway, South Whiteness, Shetland			5	Sewage (Private) Primary

Licence Number	NGR	Site Name	Location Description	MDF	DWF	DPE	Discharge Type
CAR/R/1045655	HU 35270 47770	New House, Foraness, Innersand, Sand, Shetlnd	New House adj to Foraness, Innersand, Sand, Bixter, Shetland, ZE2 9NQ			5	
CAR/R/1045739	HU 38104 49813	Leault, Cott, Weisdale, Shetland	Leault, STE to Weisdale Voe, Shetland			14	Sewage (Private) Primary
CAR/R/1046307	HU 36495 51089	Leabreck, Tresta, Shetland	Leabreck, Tresta, Shetland, ZE2 9LT			5	
CAR/R/1046389	HU 38774 45016	Taraheim, Whiteness, Shetland	Taraheim, STE to land, Whiteness, Shetland			6	Sewage (Private) Primary
CAR/R/1047530	HU 39108 49510	Stourabrekk, Weisdale, Shetland	Stourabrekk, Weisdale, Shetland, ZE2 9LQ			6	
CAR/R/1048436	HU 38726 50116	Kalli Brig, Weisdale, Shetland	Kalli Brig, Weisdale, Shetland, ZE2 9LQ			5	
CAR/R/1053809	HU 38618 43772	(Seator),Fitch.Shetland	(Seator), Fitch, STE to soakaway, Shetland			5	Sewage (Private) Primary
CAR/R/1057792	HU 38735 44367	Kirkhoose (Hunter), Shetland, ZE2 9LL	Kirkhoose, (Hunter), Shetland, ZE2 9LL			5	
CAR/R/1058189	HU 38680 44467	Breck, South Whiteness, Shetland	Breck, South Whiteness, Shetland, ZE2 9LL			7	
CAR/R/1058709	HU 39181 47671	Innvik, Whiteness, Shetland	Innvik, STE to soakaway, Shetland			15	Sewage (Private) Primary
CAR/R/1059021	HU 38745 45087	Easthouse Cottage, Whiteness, Shetland	Easthouse Cottage, Whiteness, Shetland, ZE2 9LL			5	
CAR/R/1059209	HU 38036 43261	Pund, South Whiteness, Shetland	Pund, South Whiteness, Shetland, ZE2 9LL			5	
CAR/R/1059555	HU 41890 45091	Tingwall Mains Renewal, Shetland	Tingwall Mains Renewal eng wks, pipeline crossing (8) on Burn of Rock @ Airport				Pipeline/Cable Crossing
CAR/R/1061077	HU 42775 44028	11 Veensgarth & Midleagarth,Tingwall Shetland	11 Veensgarth and Midleagarth, Gott, Shetland, ZE2 9SB			10	
CAR/R/1061647	HU 38735 44367	Syrandae, Finstown, Orkney	Kirkhoose, (Hunter), Shetland, ZE2 9LL			5	
CAR/R/1067615	HU 33670 48280	The Glebe, Sand, Bixter, Shetland	The Glebe, STE to land, Sand			7	Sewage (Private) Primary
CAR/R/1067619	HU 33617 48291	The Glebe, Sand, Bixter, Shetland	The Glebe, Sand, Bixter, Shetland, ZE2 9NQ			5	

Licence Number	NGR	Site Name	Location Description	MDF	DWF	DPE	Discharge Type
CAR/R/1070971	HU 44070 46360	New House, Califf, Tingwall	New House, STE to soakaway, Califf, Tingwall, Shetland			6	Sewage (Private) Primary
CAR/R/1072271	HU 38700 44230	Midfield, South Wuitness, Shetland	Midfield, STE to Soakaway, Whiteness, Shetland			11	Sewage (Private) Primary
CAR/R/1075597	HU 40703 51213	Boden, Stromfirth, Weisdale, Shetland	Boden, Stromfirth, Weisdale, Shetland, ZE2 9LH			5	
CAR/R/1075797	HU 39143 46838	Brugarth, Whiteness, Shetland	Brugarth, STE to Soakaway, Shetland			5	Sewage (Private) Primary
CAR/R/1077068	HU 39003 44777	Hamar, South Whiteness, Shetland	Hamar, South Whiteness, Shetland, ZE2 9LL			5	
CAR/R/1077071	HU 38684 44219	Hamelea, South Whiteness, Shetland	Hamelea, STE to soakaway, Shetland			5	Sewage (Private) Primary
CAR/R/1077993	HU 45017 46586	Norbreck, North Califf, Tingwall, Shetland	Norbreck, North Califf, Tingwall, Shetland, ZE2 9SF			5	
CAR/R/1077996	HU 44872 45630	South Califf, Tingwall, Shetland	South Califf, Tingwall, Shetland, ZE2 9SF			5	
CAR/R/1078068	HU 40760 51510	Serrang +1, Stromfirth, Weisdale, Shetland	Serrang & The Flat, STE to soakaway, Stromfirth			10	Sewage (Private) Primary
CAR/R/1078227	HU 38911 45134	Windy Heights + 2, South Whiteness, Shetland	Windy Heights, Ingerlea & Kinvarra, STE to soakaway, Shetland			15	Sewage (Private) Primary
CAR/R/1078318	HU 39218 45697	Mousaness, Hoove, South Whiteness, Shetland	Mousaness, Hoove, South Whiteness, Shetland, ZE2 9LL			5	
CAR/R/1078321	HU 39165 46802	Brugarth (Shop), Whiteness, Shetland	Brugarth (Shop), Whiteness, Shetland, ZE2 9GJ			15	
CAR/R/1078325	HU 39106 46826	Brugarth (Workshop), Whiteness, Shetland	Brugarth (Workshop), Whiteness, Shetland, ZE2 9GJ			15	
CAR/R/1078337	HU 41508 44183	Greenfield, Griesta, Gott, Shetland	Greenfield, Griesta, Gott, Shetland, ZE2 9SB			7	
CAR/R/1078447	HU 40902 51589	Jogar, Stromfirth, Weisdale, Shetland	Jogar, Stromfirth, STE to soakaway, Shetland			5	Sewage (Private) Primary
CAR/R/1078455	HU 38450 43630	Seaview, South Whiteness, Shetlands Isles	Seaview, STE to soakaway, Shetland			6	Sewage (Private) Primary

Licence Number	NGR	Site Name	Location Description	MDF	DWF	DPE	Discharge Type
CAR/R/1078483	HU 35610 51510	Ansonville, Tresta, Bixter, Shetland	Ansonville, STE to soakaway, Shetland			5	Sewage (Private) Primary
CAR/R/1078669	HU 38590 48070	The Rock, Whiteness, Shetland	The Rock, STE to Soakaway, Whiteness, Shetland			7	Sewage (Private) Primary
CAR/R/1079709	HU 39220 46790	Brugarth & Raldihus, Whiteness, Shetland	Brugarth & Raldihus, STE to Loch of Strom, Shetland			11	Sewage (Private) Primary
CAR/R/1080194	HU 38690 44290	Kirkhouse (Leask), South Whiteness, Shetland	Kirkhouse (Leask), STE to Soakaway, Shetland			5	Sewage (Private) Primary
CAR/R/1084768	HU 39550 53090	Kergord Hatchery, Weisdale, Shetland	Kergord Hatchery, Weisdale, Shetland, ZE2 9LW			50	
CAR/R/1086363	HU 41900 45170	Tingwall Airport, Tingwall, Gott, Shetland	Tingwall Airport, Tingwall, Gott, Shetland, ZE2 9XJ			14	
CAR/R/1086787	HU 38445 43091	Erdisland, Whiteness, Shetland	Erdisland, Whiteness, Shetland, ZE2 9LL			6	
CAR/R/1089611	HU 39130 47750	Hubrake, Whiteness, Shetland	Hubrake, STE to soakaway, Whiteness, Shetland			10	Sewage (Private) Primary
CAR/R/1091085	HU 38280 50290	Oversound, Weisdale, Shetland	Oversound, STE to soakaway, Weisdale, Shetland			6	Sewage (Private) Primary
CAR/R/1095290	HU 35710 48358	Fine View, Sand Sound, Shetland	Fine View, Sand Sound, Shetland, ZE2 9LU			9	
CAR/R/1097194	HU 39450 53060	Bonhoga Gallery & Mill House, Weisdale	Bonhoga Gallery & Mill House, STE to soakaway, Shetland			50	Sewage (Private) Primary
CAR/R/1098359	HU 38286 43244	Lidice, South Ustaness, Shetland	Lidice, South Ustaness, Whiteness, Shetland, ZE2 9LL			9	
CAR/R/1098470	HU 43388 49535	Chapel View, Grista, Shetland	Chapel View, Grista, Shetland, ZE2 9SQ			5	
CAR/R/1098919	HU 41252 43019	Holmview, Scalloway, Shetland	Holview, Scalloway, Shetland, ZE1 0UQ			7	
CAR/R/1101532	HU 43250 48050	Vatster Quarry, Gott, Shetland	Vatster Quarry, STE to soakaway, Gott, Shetland			20	Sewage (Private) Primary
CAR/R/1101986	HU 39100 47180	Westerhouse, Olligarth, Shetland	Westerhouse, STE to River Whiteness Voe, Olligarth, Shetland			6	Sewage (Private) Primary

Licence Number	NGR	Site Name	Location Description	MDF	DWF	DPE	Discharge Type
CAR/R/1105765	HU 38570 50720	Djuba, Weisdale, Shetland	Djuba, STE to soakaway, Weisdale, Shetland			5	Sewage (Private) Primary
CAR/R/1106846	HU 43060 50570	Girlsta Hatchery (Office), Girlsta, Shetland	Girlsta Hatchery (Office), Girlsta, Shetland, ZE2 9SQ			10	
CAR/R/1110186	HU 35833 50193	Vivilea, Tresta, Shetland	Vivilea, Tresta, Shetland, ZE2 9LT			6	
CAR/R/1110553	HU 42960 48790	Scalloway to Tingwall MR, Vatster, Girlsta	Scalloway to Tingwall MR, Pipe/cable crossing (3) Loch of Vatster				Pipeline / Cable Crossing
CAR/R/1112305	HU 39680 52870	(Tulloch), Gardie, Shetland	(Tulloch), Gardie, STE to land via soakaway, Shetland			6	Sewage (Private) Primary
CAR/S/1085670	HU 41900 45170	Tingwall Airport, Tingwall, Shetland	Tingwall Airport, Tingwall, Gott, Shetland, ZE2 9XJ				
CAR/S/1089897	HU 43160 46250	Strand Loch Bridge Refurbishment, Shetland	Strand Loch Bridge, Tingwall, Shetland				
PPC/A/1023330	HU 43278 48135	TWMA Vatster, Gott, Shetland	Vatster Depot, TE to U/T of Loch Vatster, Gott				
WML/N/0050099	HU 43000 50500	Old Lime Quarry, Girilsta (WML/N/50099)	Old Lime Quarry, Girlsta, Shetland				
WML/XC/1086833	HU 42150 44470	No 1 Veensgarth, Tingwall, Shetland	Land adjacent to 1 Veensgarth, Tingwall, Shetland				

Scottish Water discharges:

Licence No.	NGR	Site Name	Discharge Type	Treatment Level	PE	Dry Mean Daily Flow (m^3/d)
	HU 3981 4583	NESBISTER WWPS 1999 HU398458				
CAR/L/1002230	HU 4264 4462	VEENSGARTH WWPS 1992 HU427446	EO	10mm screen		
CAR/L/1002229	HU 4351 4644	STRAND WWPS 1992 HU434463	EO			
SD13	HU 388 484	CLACH-NA-STROM SEP 1968 HU390482	FE	septic tank	250	
SD59	HU 191 579	KALLINESS EAST SEP 1965 HU388502	FE	septic tank	250	
T/B21/062/98	HU 3959 4470	WORMADALE SEP 1985 HU397450	FE	septic tank		max 60m3/day
WPC/N/72207	HU 388 499	KALLINESS WEST SEP 2001 HU386498	FE	septic tank	70	15
WPC/N/48943	HU 357 514	WESTERFIELD TRESTA SEP HU492414	FE	septic tank	10	2.5
S8X	HU 4429 4703	TRONAFIRTH SEP 1975 HU443470	FE	septic tank		max 95m3/day

2. Bathymetry and Hydrodynamic Assessment Appendices

Appendix 1: Hydrographic survey details

Sitename	NGR	Survey Period	Equipment
Binna Ness	HU 37700 42500	12/02/99 – 01/03/99	Sensordata A/S SD6000
Binna Ness	HU 37720 42604	04/09/00 – 20/09/00	Nortek 500 kHz ADCP
Whiteness shore base pontoon	HU 38088 43476	16/07/13 – 06/08/13	Star-Oddi DST CDT no. 5885
Burra Holm fishery	HU 38570 45560	16/07/13 – 06/08/13	Star-Oddi DST CDT no. 5884

In the table above green shading denotes the surveys that are considered of particular interest to this study. Where two sets of data are present for a given site the deployment with the greatest precision is used.

Appendix 2: Hydrographic survey summary statistics

Parameter	Units		Binna Ness 2000
		Near-surface	
		Mid-depth	
		Near-bottom	
Mean speed	m/s		0.051
			0.043
			0.046
Maximum Speed	m/s		0.215
			0.199
			0.282
Tidal major axis	°Grid		020
			020
			030
Amplitude anisotropy	-		1.29
			1.20
			1.24
Residual speed	m/s		0.0084
			0.0031
			0.0056
Residual direction	°Grid		042
			031
			358
Vector averaged residual	-		0.005 m/s at 25 °Grid
Tidal excursion	km		0.94
			0.77
			0.83

The tidal major axis is the long axis of the predominant tidal direction. Amplitude anisotropy is a measure of the relative scale of the currents along the tidal major axis relative to those across it. Residual speed and direction represent the net transport away from survey position during the fifteen-day assessment period and this is resolved over the three layers in the value reported as vector averaged residual. Finally the tidal excursion is an estimate based on the amplitude of tidal current s along the tidal major axis.