Scottish Sanitary Survey Report

Sanitary Survey Report
Hamar Voe
SI-655-1404-08
April 2015

Report Title	Hamar Voe Sanitary Survey Report
Project Name	Scottish Sanitary Survey
Client/Customer	Food Standards Agency Scotland
Cefas Project Reference	C6316C
Document Number	C6316C_2014_20
Revision	V1.0
Date	10/04/2015

Revision History

Revision number	Date	Pages revised	Reason for revision
Id3	04/02/2015	-	Internal draft for review
v0.1	06/02/2015	all	Draft report for external consultation
V1.0	10/04/2015	i,ii,22,23-26, 28,29,32-42	Amended to correct table numbering, pagination, and typographic errors.

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Partner Organisations

The hydrographic assessment and the shoreline survey and its associated report were undertaken by Shetland Seafood Quality Control, Scalloway.

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I. Executive Summary

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

The purpose of the sanitary survey is to demonstrate compliance with the requirements stated in Annex II (Chapter II Paragraph 6) of Regulation (EC) 854/2004. The sanitary survey results in recommendations on the location of RMPs, the frequency of sampling for microbiological monitoring, and the boundaries of the production areas deemed to be represented by the RMPs. A sanitary survey was undertaken on the Hamar Voe classified production area on the basis recommended in the European Union Reference Laboratory publication: "Microbiological Monitoring of Bivalve Mollusc Harvesting Area Guide to Good Practice: Technical Application" (https://eurlcefas.org/media/13831/gpg_issue-5_final_all.pdf).

Hamar Voe is an inlet on the east coast of the Northmavine which is located on the northwest of mainland Shetland.

Hamar Voe is a common mussel (*Mytilus edulis*) fishery, comprised of a single long-line mussel farm located along the east shore of the main body of the voe.

The main sources of contamination to the mussel farm are:

- Diffuse agricultural sources, mainly sheep, grazed around the voe
- Diffuse wildlife sources particularly from seabirds present at or near the mussel farm

There is a potential for diffuse human source contamination arising from homes and a shore base along the voe to the north of the mussel farm.

Contamination is most likely to be carried to the fishery via fresh water runoff and watercourses, and may be more concentrated in fresher water near the surface. Surface currents assisted by wind forcing may produce particle transport distances of up to 1.5 km. Salinity profiles recorded during the shoreline survey showed evidence of freshwater influence in the surface waters at the fishery which were greater at the northern end than the southern end of the fishery.

The recommendations from the survey are to retain the production area boundaries as established. The RMP should be amended to HU 3070 7613, in order to reflect the location of the actual mussel farm. The RMP lies at the northeast corner of the farm in order to reflect contamination arising from sources nearer this end of the farm.

II. Sampling Plan

Production Area	Hamar Voe
Site Name	Northmavine
SIN	SI-655-1404-08
Species	Common mussels
Type of Fishery	Long-line
NGR of RMP	HU 3070 7613
East	430700
North	1176130
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 Anderson Gwen Williamson Vicki Smith
Production area boundaries	The area bounded by lines drawn from HU 3066 7638 to HU 3081 7631 and from HU 3015 7606 to HU 3015 7589 and extending to MHWS

III. Report

1. General Description

Hamar Voe is an inlet on the east coast of the Northmavine which is located on the northwest of mainland Shetland. The location is shown in Figure 1.1.

Hamar Voe is approximately 2 km in length and varies in width from 120 m at its narrowest to 550 m at its widest. It has a mean depth of 7.9 m with a maximum depth 23.1 m. The voe has an easterly aspect and opens to Ura Firth which in turn opens at its southern end to St Magnus Bay.

The area surrounding Hamar Voe is sparsely inhabited, with a few hamlets located around the shore: clockwise from the northwestern end of the voe these are South Lees, North Lees, Scarpy, Orbister and Hamar.

A sanitary survey was undertaken on the classified fishery for Hamar 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”. This production area was selected for survey at this time due to the submission of an application for classification of a common mussel fishery.

Figure 1.1 Location of Hamar Voe

2. Fishery

Hamar Voe is a common mussel (*Mytilus edulis*) fishery, comprised of a single long-line mussel farm. Details of the site as provided by FSAS are presented in Table 2.1. As it is a relatively new fishery, it does not appear in the 2014/15 classification list.

Table 2.1 Hamar Voe shellfish farms

Production area	Site	SIN	Species
Hamar Voe	Northmavine	SI-655-1404-08	Common Mussels *(Mytilus edulis)*

The shoreline survey, undertaken on 20th October 2014, identified six double-headed long-lines with 10 m droppers. The site is licensed for six 220 m double-headed long-lines. Harvesting is to be conducted as and when required, throughout the year.

A provisional RMP assessment was undertaken for Hamar Voe in September 2013. This comprised the first stage in the sanitary survey process. The boundaries for the provisional production area recommended in that assessment were: the area bounded by lines drawn from HU 3066 7638 to HU 3081 7631 and from HU 3015 7606 to HU 3015 7589 and extending to MHWS. The assessment recommended that a provisional RMP be located at HU 3071 7621 pending further review. That location was at the northern extent of the intended farm area identified at the time. The present farm extent is south of this and so the pRMP lies to the north of the actual mussel farm.

The mussel farm location, as recorded during the shoreline survey, is shown in Figure 2.1.

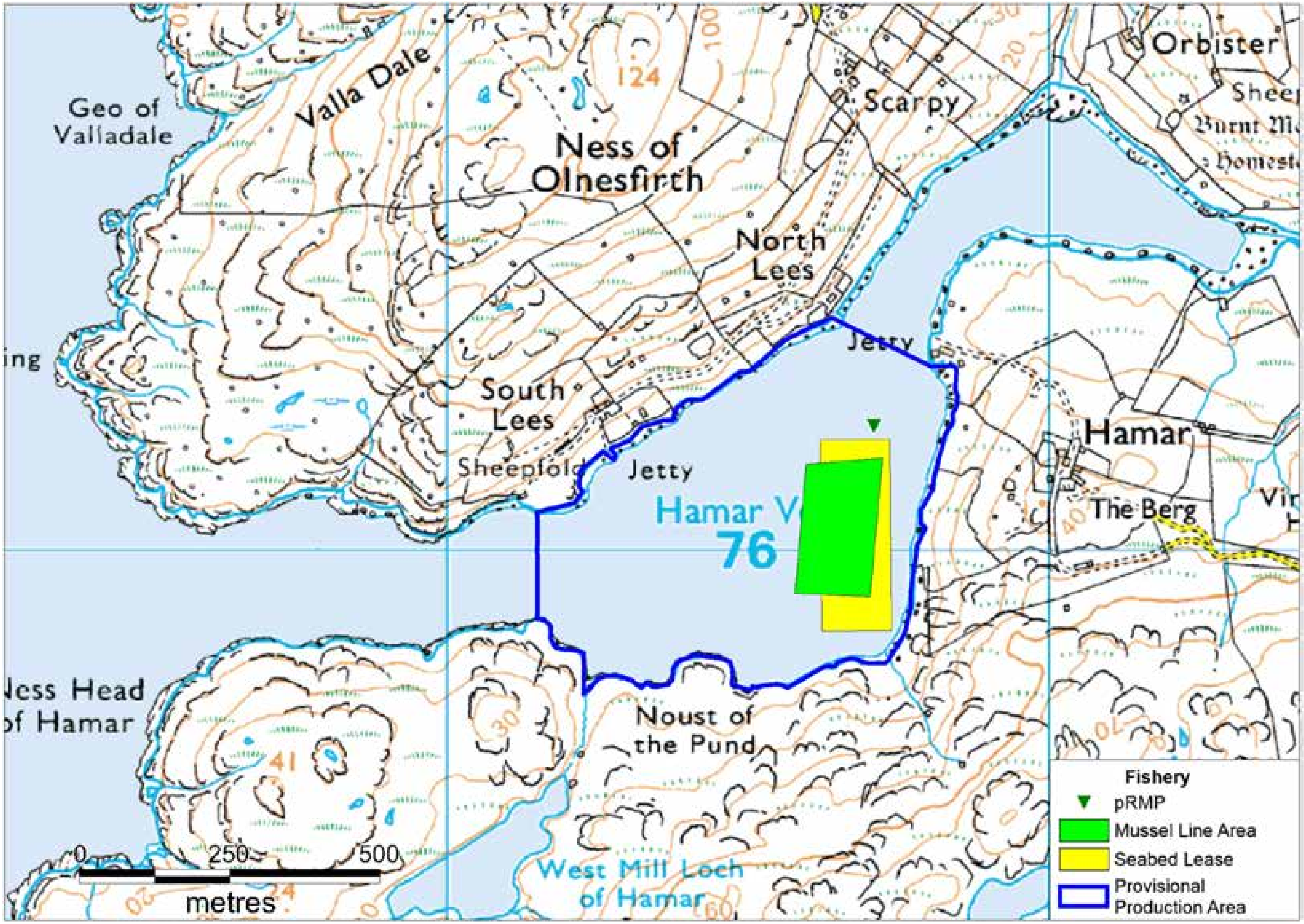


Figure 2.1 Hamar Voe Fishery

3. Human Population

Information was obtained on the population within the vicinity of the Hamar Voe production area from the General Register Office for Scotland. The last census was undertaken in 2011. The census output areas in the vicinity of Hamar Voe are shown thematically mapped by the 2011 population densities in Figure 3.1. Only the census output area S00057244 is directly adjacent to Hamar Voe. The population density in that output area is very low at just over 5 people per km^2. The population within output areas will not be evenly distributed.

Table 3.1 Census output area and population – Hamar Voe

Census Output Area ID	Population	Area (km^2)	Population density (people/ km^2)
S00057244	162	31	5.13
S00059471	148	38	3.85

The majority of the shoreline surrounding Hamar Voe is uninhabited and inaccessible by road. Individual homes are situated along the tracks on the north shore of the voe and at Hamar on the south shore. Five residential dwellings were recorded during the shoreline survey. No tourist accommodation is thought to be present in the survey area.

A shore base used for the salmon farm at the mouth of the voe is located at Hamar and during the shoreline survey there was one workboat present at the pier. An anchorage and moorings are located near the head of the voe (Clyde Cruising Club, 2007) and one small fishing boat was observed at this location at the time of the shoreline survey.

Overall, the local population surrounding the survey area is low and sparsely distributed however in relation to the shellfish farm, the northern end of the longlines are likely to be more impacted by human-related sources due to the presence nearby of dwellings at Hamar and North Lees and the activity at the shorebase and anchorage.

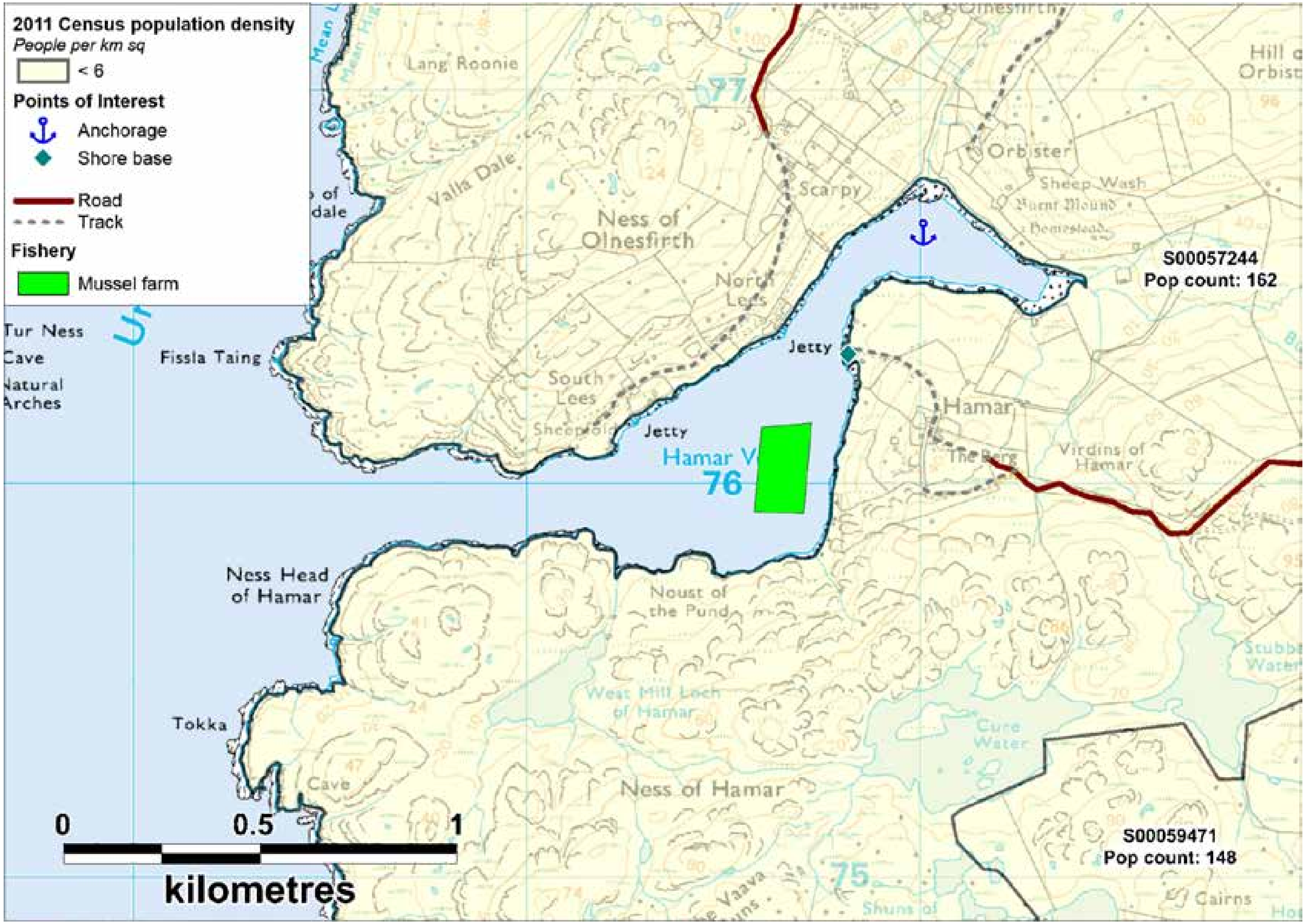


Figure 3.1 Population map for the area around Hamar Voe

4. Sewage Discharges

Information on sewage discharges within an area 3 km around the point HU 3071 7621 (the vicinity of the Hamar Voe mussel farm), was sought from Scottish Water and the Scottish Environment Protection Agency (SEPA). Data requested included the name, location, type, size (in either flow or population equivalent), level of treatment, sanitary or bacteriological data, spill frequency, discharge destination (to land, watercourse or sea), any available dispersion or dilution modelling studies, and whether improvements were in work or planned. No information was provided on sanitary or bacteriological data, any available dispersion or dilution modelling studies, and whether improvements were in work or planned. Spill frequency information was not relevant as no rainfall-dependent overflows (CSOs or storm tanks) were identified.

4.1 Community Discharges

Scottish Water and SEPA both provided information about community discharges within the area requested.

SEPA provided information of four community discharges; three continuous outflows and one Emergency Outflow (EO). Scottish Water provided information on three community discharges: two continuous discharges and an emergency overflow. A summary of these are given in Table 4.1.

Hillswick Public Conveniences (CAR/L/1002242) are public toilets maintained by Hillswick Animal Sanctuary (P. Nicolson 2014 pers. comms.) and do not use any Scottish Water assets.

The data for the two continuous discharges from the two providers matched by name but not licence number or location. The licence number provided for the WWPS EO was the same in both data sets.. However the asset name and location differed. Locations which plotted on land are assumed to be asset locations while those at or below mean high water are presumed to represent the outfall locations. The locations of discharges from both data providers are given in Figure 4.1. Information on locations where sewage sludge is applied to land had been requested from SEPA: it was identified that little data was held on this and that the data that was held could not be made available for assessment within the sanitary survey programme.

Table 4.1. Community discharges

Scottish Water					SEPA					
Discharge Name	**Licence number**	**Location**	**Treatment Level**	**PE**	**Discharge Name**	**Licence number**	**Location**	**Treatment Level**	**PE**	**DWF (m3/day)**
Valladale Urafirth ST	SD58	HU 302 784	septic tank	250	Urafirth Outfall, Valladale	CAR/L/1002283	HU 30065 78409	Primary	250	not given
Stucca Hillswick ST	WPC/N/70044	HU 2874 7710	septic tank	164 (MDF 47 m3/day)	Stucca WwTP, Hillswick	CAR/L/1002860	HU 28678 77146	Primary	164	not given
Hilswick WWPS EO	CAR/L/1004155	HU 2824 7693	6 mm screen	NA	East Ayre PS	CAR/L/1004155	HU 28285 77026	not given	NA	NA
					Hillswick Public Conveniences	CAR/L/1002242	HU 2820 7700	Untreated	not given	not given

DWF=Dry Weather Flow, EO=Emergency Overflow, MDF=Mean Daily Flow, NA=not applicable, PE=Population Equivalent, ST= Septic Tank, WWPS =Waste Water Pumping Station

4.2 Consented Private Discharges - SEPA

SEPA provided information regarding consented discharges within the request area identified. The full list of discharges assessed in the report are given in Appendix 6

SEPA provided information on 11 private sewage discharge consents around Hamar Voe. These discharges are mainly located around the shoreline at the head of Ura Firth north of Hamar Voe. They are listed in Table 4.1 below and the locations are shown in Figure 4.1.

Table 4.2 Private discharge consents within 2 km of the fishery

Licence Number	National Grid Reference	Discharge Type	Discharging to	PE
CAR/R/1027207	HU 29270 78050	Sewage (Private) Primary	Soakaway	7
CAR/R/1039925	HU 29080 77890	Sewage (Private) Primary	Soakaway	6
CAR/R/1051773	HU 30370 78900	Sewage (Private) Primary	Soakaway	8
CAR/R/1051794	HU 30440 78960	Sewage (Private) Primary	Soakaway	5
CAR/R/1071246	HU 30260 78510	Sewage (Private) Primary	Soakaway	20
CAR/R/1076630	HU 30580 73330	Sewage (Private) Primary	Soakaway	10
CAR/R/1102714	HU 30250 78550	Sewage (Private) Primary	Soakaway	9
CAR/R/1108420	HU 29340 78310	Sewage (Private) Primary	Soakaway	6
CAR/R/1109733	HU 29130 78020	Sewage (Private) Primary	Soakaway	5
CAR/R/1117496	HU 29540 78740	Sewage (Private) Primary	Land	5
CAR/R/1118409	HU 28760 77910	Sewage (Private) Primary	Soakaway	5

All of the assessed consents were for discharges to soakaway. The effectiveness of soakaway systems depends on location and maintenance, and SEPA have identified previously that in remote areas, consents originally registered as discharging to land may be diverted to sea or watercourses upon failure of the soakaway fields. A planning consent application that related to a property to which CAR/R/1108420 applies, mentioned the existence of another septic tank discharging to sea (Shetlands Island Council, 2014). A separate planning application for a new dwelling, 2010/432/PCD, detailed a septic tank discharging to soakaway located in Hamar. No corresponding consents were provided by SEPA. As all recent new builds are required to have their septic tanks registered, this may suggest additional private discharges have not been reported.

Registration is required for all new properties and upon sale of existing properties. Information provided by SEPA is considered to be correct at the time of writing; however there may be additional discharges that are not yet registered with SEPA.

SEPA provided information on seven marine cage fish farms (MCFF) within the area requested. Working facilities on these may have toilets , but no specific information regarding these was given. One large feeding barge was observed at a fish farm in the mouth of the loch, approximately 570 m west of the southwest corner of the mussel farm. No evidence was found of a marine cage fish farm at the consented location adjacent to the mussel farm.

4.3 Shoreline Survey Discharge Observations

One observation of a possible sewage related structure was observed during the shoreline survey. This is shown in Table 4.2 below.

Table 4.3 Discharge-associated observations made during the shoreline survey

No.	Date	NGR	Description
1	20/10/2014	HU 30356 76236	One dwelling house on hill above, possible septic tank within property boundary.

No corresponding licence information was provided by SEPA. The location of the observation is approximately 300 m from the mussel lines. No outfall pipe was recorded and so it may discharge to soakaway.

Information obtained during the shoreline survey identified that there were sanitary facilities aboard a barge associated with the fish farm located west of the mussel farm but that there were plans for this to be upgraded to a chemical treatment system.

4.4 Summary

The majority of community and private discharges are located within Ura Firth with those at Hillswick being approximately 1.5 km from the mouth of Hamar Voe and nearly 3 km from the mussel farm. The discharges located nearer the head of Ura Firth are further from the fishery. Whether any of these will potentially impact at the mussel farm will depend on the maximum particle transport distance within the waterbody system. If so, the community discharges are likely to be a more important source of faecal contamination given their greater size and the fact that they discharge to the marine environment. Other, presently unlicensed, septic tank discharges may be located within the Hamar Voe area itself, serving the small number of dwellings that are located there. Any discharge from the barge associated with the fish farm located to the west of the mussel farm could affect the water quality in the immediate vicinity: however, the distance between the barge and the mussel farm is relatively great (over 500 m) given the likely loading that will be discharged.

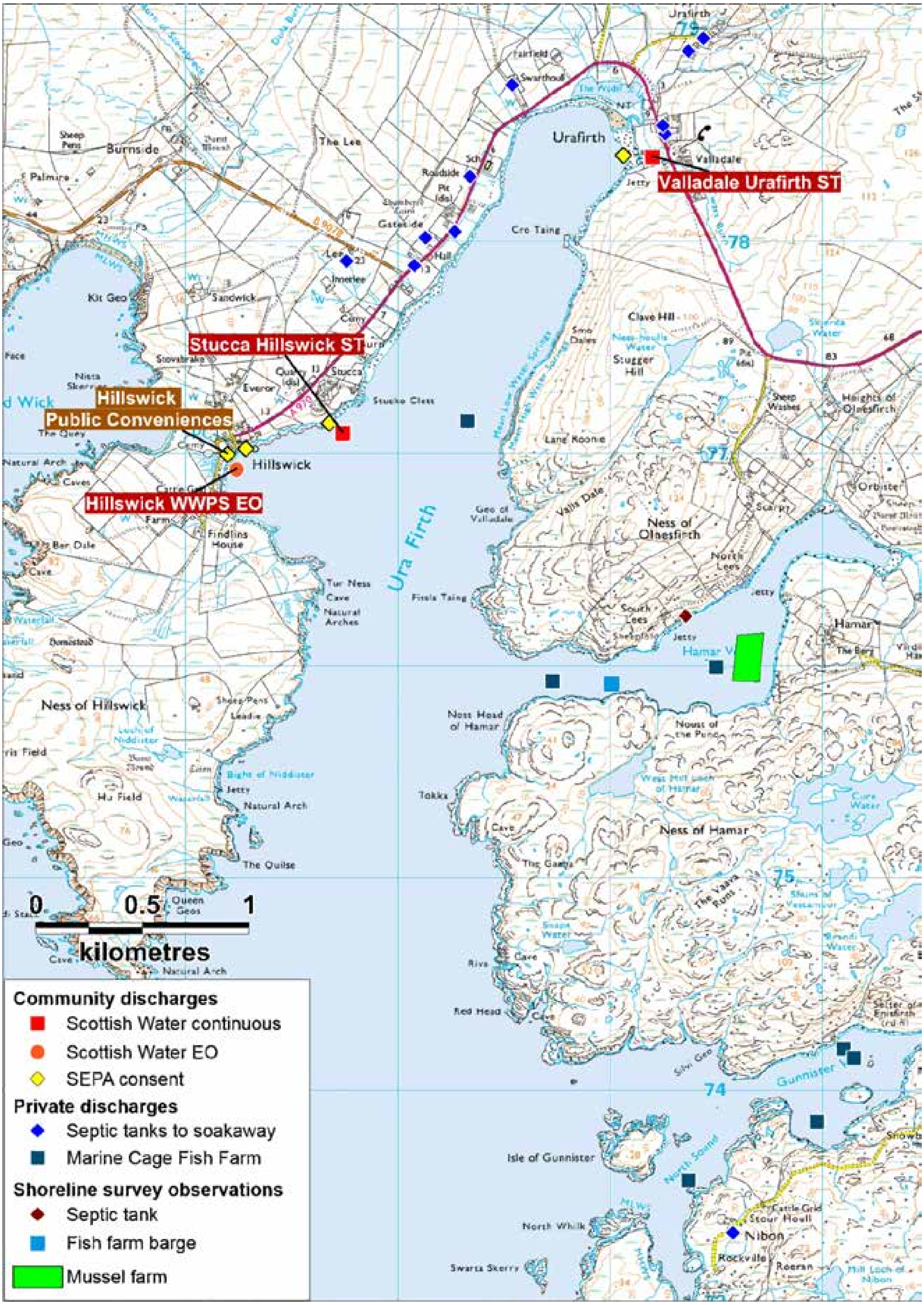


Figure 4.1 Sewage Discharges in the Vicinity of Hamar Voe

5. Agriculture

Information on the spatial distribution of animals on land adjacent to or near the shellfishery can provide an indication of the potential amount of organic pollution from livestock entering the shellfish farm area. Agricultural census data to parish level was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the Northmavine parish. Reported livestock populations for the parish in 2013 are listed in Table 5.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data. Any entries which relate to fewer than five holdings, or where two or fewer holdings account for 85% or more of the information, are replaced with an asterisk.

Table 5.1 Livestock numbers in the Northmavine agricultural parish

	Northmavine	
	204 km^2	
	Holdings	Numbers
Pigs	*	*
Poultry	27	514
Cattle	21	458
Sheep	110	36,312
Horses used in Agriculture	*	*
Other horses and ponies	13	54

* data withheld

The livestock census numbers for Northmavine relate to a large area, therefore it is not possible to determine the spatial distribution of the livestock on the shoreline adjacent to the survey area or to identify how many animals are likely to impact the catchment around the shellfish farm. Although the figures are of little use in assessing the potential impact of livestock contamination to the shellfishery they do give an idea of the total numbers of livestock over the broader area. Pig numbers and horses used in agriculture were not reported due to the small number of holdings present. Sheep were kept in moderate numbers while poultry and cattle were kept in small numbers .

A source of spatially relevant information on livestock population in the area was the shoreline survey (see Appendix 5) which only relates to the time of the site visit on the 20th October 2014. Observations made during the survey are dependent upon the viewpoint of the observer some animals may have been obscured by the terrain.

The majority of the land observed around the production area during the shoreline survey was either rough grazing or common grazing. Fields that had been used for silage production were noted on the west shore, east shore and at the head of the voe. In total, approximately 192 sheep were recorded during the survey with approximately 70 on the eastern shore and 82 on the western shore. The majority of the livestock observed at these locations had access to the shoreline and faeces were frequently recorded near the shoreline. Forty sheep were recorded at the eastern end of the voe in a fenced field with no access to the shoreline. Two cattle were recorded in an enclosed field inland on the south eastern side of the voe. No other livestock were observed during the shoreline survey.

The 1:25,000 Ordnance Survey map identified sheep washes on the northern and eastern sides of the voe.

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

Numbers of sheep are expected to be approximately double during the spring and summer months when lambs are present. Any contributions from livestock to faecal contamination at the mussel farm are expected to be greatest from sheep located on, or near, the shore immediately to the east of the mussel farm. Additional contamination may arise from the sheep located on the shores to the northwest and southwest of the mussel farm.

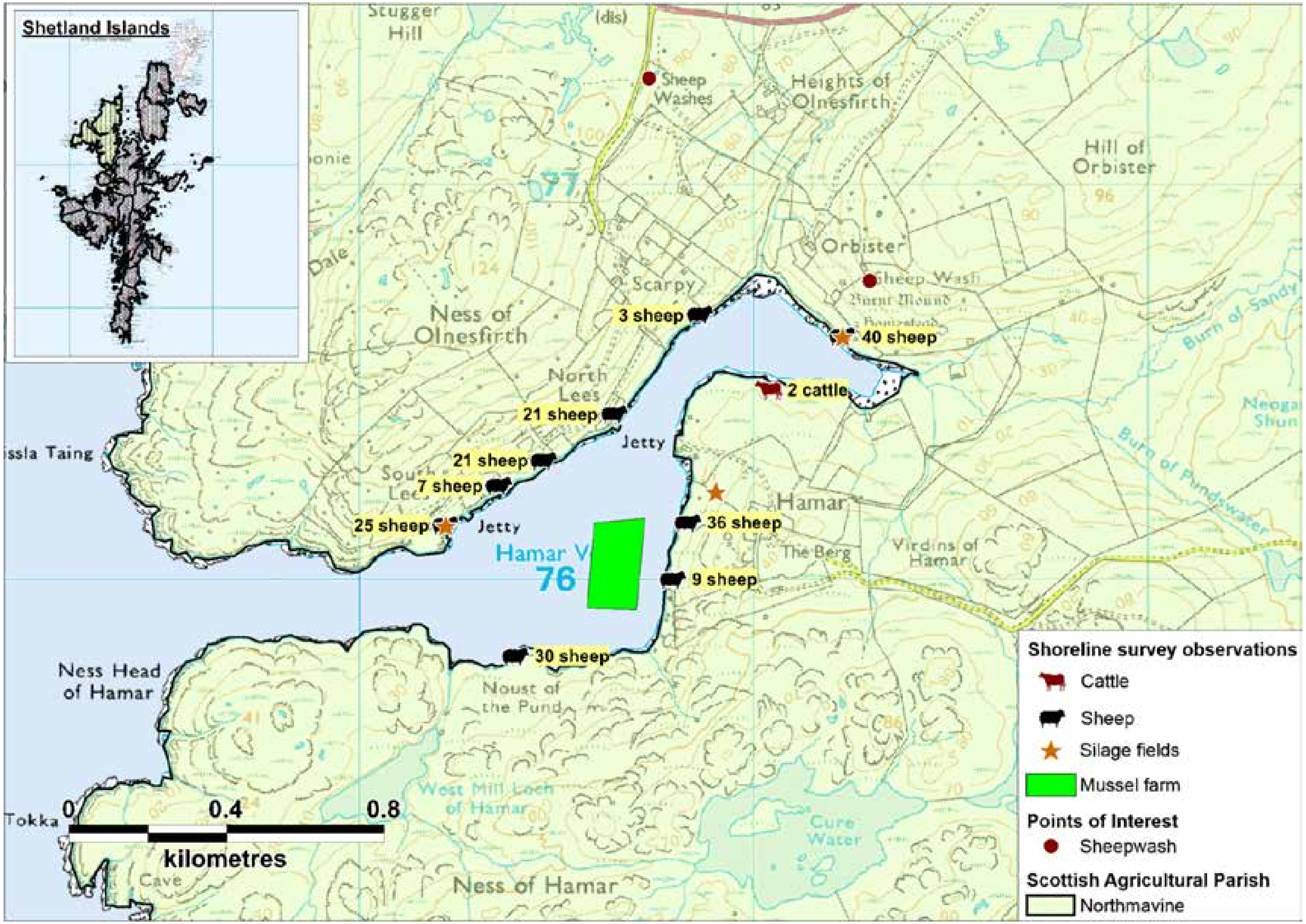


Figure 5.1 Livestock observations at Hamar Voe

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 (pinnipeds), whales (cetaceans) and some seabirds may deposit faecal wastes directly into the sea, whilst birds and mammals present on land will contribute a proportion of any faecal indicator loading carried in diffuse runoff or watercourses.

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

Pinnipeds

The Special Committee on Seals report (Special Committee on Seals, 2013) identified that the harbour seal population within Shetland decreased between 2000 and 2010 by 30%. No population estimates are available for grey seals, though pup production across Shetland and mainland Scotland appears stable. The Shetland Marine and Spatial Plan 2012 report indicates common seal habitat is present in Gunnister Voe, around Ness of Hillswick and further west of the Ness of Hillswick. No grey seal habitat was noted within the vicinity of Hamar Voe.

Two seals were observed during the shoreline survey; one southeast of the mussel farm and the other towards the head of the voe.

Cetaceans

There are no reports or anecdotal accounts of cetaceans within Hamar Voe. No cetaceans were observed during the shoreline survey.

Birds

Seabird data was downloaded from the collated JNCC dataset from the website (JNCC, 2014) in March 2014. Where entries were present for the same species and locations but different dates, the most recent entries were selected. It should be appreciated that the sources of this data are varied, with some recorded as unknown or estimated, whilst some come from reliable detailed surveys such as those carried out for the Seabird 2000 report by Mitchell *et al.*, (2004). Data applicable for the 5 km area around the fishery are listed in Table 6.1.

Table 6.1 JNCC seabird data from within 5 km of Hamar Voe

Common name	Species name	Count*	Qualifier	Accuracy
Arctic Skua	*Stercorarius parasiticus*	28	Occupied territory	Accurate
Great Skua	*Stercorarius skua*	88	Occupied territory	Accurate
Arctic Tern	*Sterna paradisaea*	166	Individuals on land and occupied nests	1 count estimate, 7 counts accurate
Common Tern	*Sterna hirundo*	4	Individuals on land and occupied nests	Accurate
Black Guillemot	*Cepphus grylle*	386	Individuals on land	Accurate
Shag	*Phalacrocorax aristotelis*	68	Occupied nests	Accurate
Great Cormorant	*Phalacrocorax carbo*	30	Occupied nests	Unknown
Herring Gull	*Larus argentatus*	68	Occupied territory, nests and individuals on land	Accurate
Black-Headed Gull	*Chroicocephalus ridibundus*	2	Occupied territory	Accurate
Lesser Black-Backed Gull	*Larus fuscus*	4	Occupied territory	Accurate
Great Black-Backed Gull	*Larus marinus*	92	Occupied territory, nests and individuals on land	Accurate
Common Gull	*Larus canus*	218	Occupied territory, nests and individuals on land	Accurate
Fulmar	*Fulmarus glacialis*	4966	Occupied sites	Accurate

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

The JNCC seabird data highlights that the Ness of Hillswick (situated approximately 2 km west of the Hamar Voe) is a significant breeding area for seabirds. Seabirds were also present in low numbers around Hamar Voe. The main breeding season takes place between May and September, during which contamination levels are expected to be highest.

Birds were the most common wildlife observed during the shoreline survey. Species included plover, sparrow, crow, snipe, curlew, geese and common gull. Common gulls were observed in high numbers close to the fishery, where bird faeces were also noted on the buoys. A potential bird feeding area was also present onshore, southwest of the voe.

Otters

The Eurasian otter (*Lutra lutra*) is common in Shetland, which holds approximately 12% of the UK population (Shetland Otters, 2014). Anecdotal accounts suggest otters are present within Hamar Voe as well as voes close by, as well as around Ness of Hillswick (Shetland Amenity Trust, 2010). No suitable otter habitat was noted around Hamar Voe or in its vicinity in the Marine and Spatial Plan for Shetland report (2012). No otters were observed during the shoreline survey.

Rabbits

Rabbit droppings were observed to the southwest of the voe. 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). Therefore, most of the time rabbits will not contribute significant amounts of *E. coli* to the area.

Overall

Seabirds particularly fulmars, are anticipated to be the main contributors to wildlife based faecal contamination. Gulls and geese will also contribute. Contamination from the fulmar colonies in the surrounding area is expected to be highest during the May to September breeding season. Seals and otters may also contribute low levels of contamination. There is no evidence on which to deduce spatial differences across the relatively small area covered by the mussel farm.

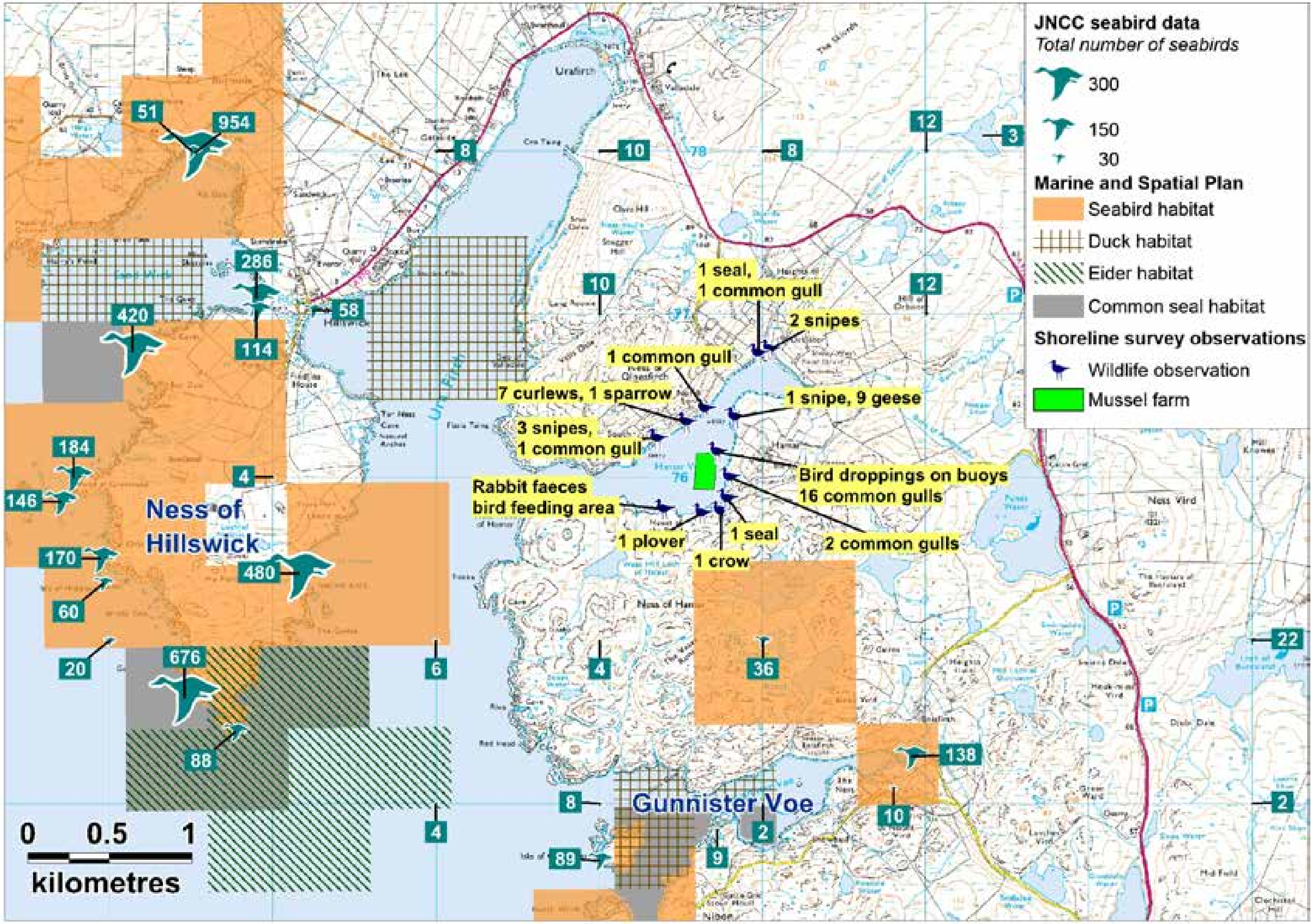


Figure 6.1 Map of wildlife around Hamar Voe

7. Land Cover

The Land Cover Map 2007 data for the area is shown in Figure 7.1. The land cover types adjacent to the shellfish farm are dwarf shrub heath and rough grassland. There is a small area of improved grassland and acid grassland inland of the northern coastline and small areas of littoral sediment on the eastern shoreline. There are no built up or urban areas represented.

Faecal indicator organism export coefficients for faecal coliform bacteria have been found to be approximately 8.3×10^8 cfu/km^2/hr for areas of improved grassland and approximately 2.5×10^8 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 mussel farm is from the areas of rough grassland (grazing) located on the shoreline to the east and north of the fishery. Any impact is likely to be greatest on the long lines situated closest to the shoreline. This contribution would be expected to increase after rainfall events.

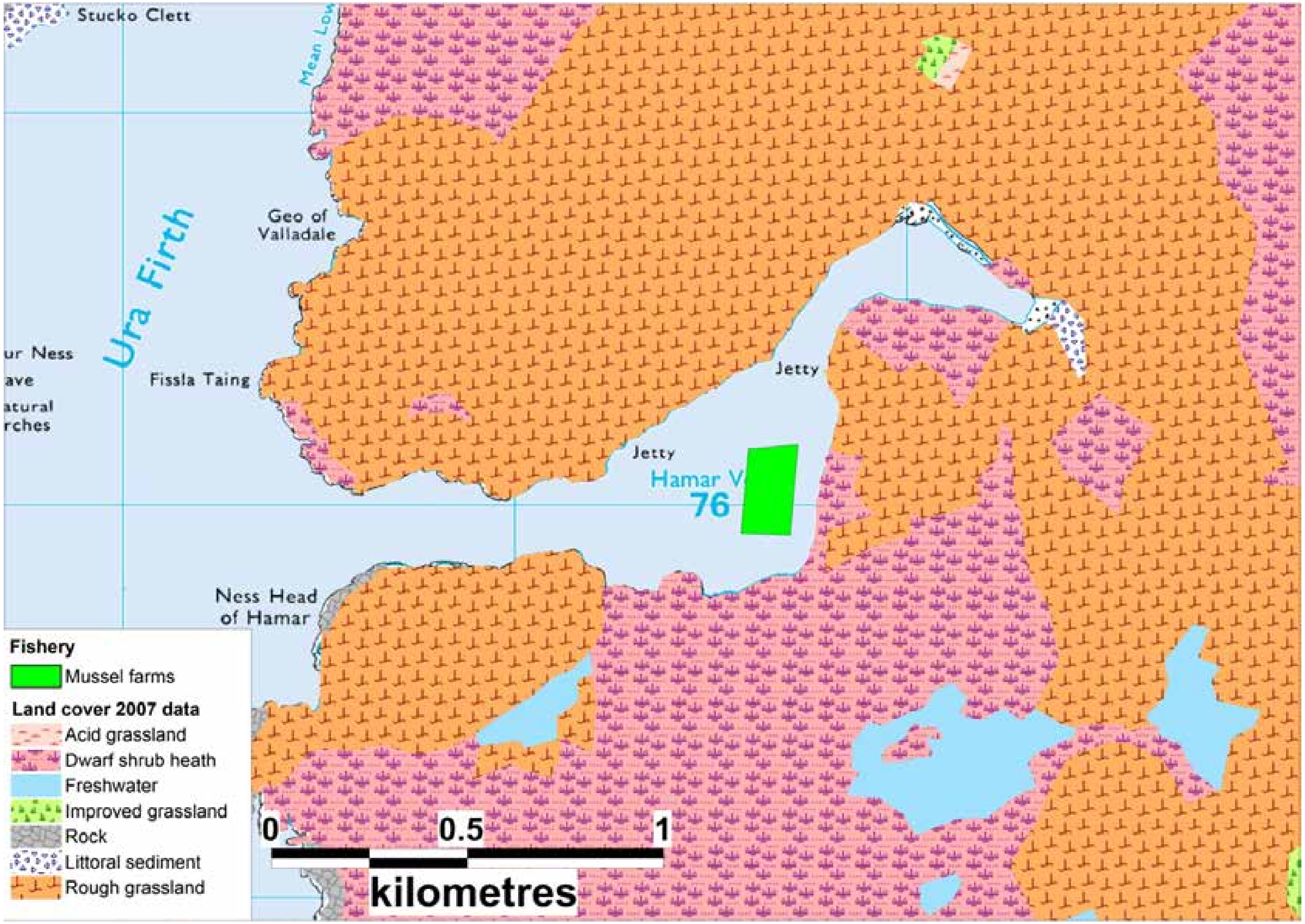


Figure 7.1 LCM2007 land cover data for the area around Hamar Voe

8. Watercourses

There are no gauging stations on watercourses entering Hamar Voe. Spot measurements of flow and microbial content were obtained during the shoreline survey conducted on the 20th October 2014. Rain showers were recorded in the 48 hrs prior to the survey. The watercourses listed in Table 8.1 are those recorded during the shoreline survey. Three areas of land drainage were observed south and east of the mussel farm. The locations and loadings of measured watercourses are shown in Figure 8.1.

Table 8.1 Watercourses entering Hamar Voe

No.	Eastings	Northings	Description	Width (m)	Depth (m)	Flow (m^3/d)	Loading (*E. coli* per day)
1	430356	1176236	Watercourse	0.15	0.05	183	Not determined*
2	430773	1176581	Watercourse	0.20	0.10	240	Not determined*
3	431021	1176805	Burn of Eelawater	2.00	0.35	23950	1.2×10^{10}
4	431436	1176522	Watercourse	0.25	0.06	332	Not determined*
5	431439	1176482	Burn of Sandy Lochs/Burn of Pundswater	1.80[1] 0.20[2]	0.15[1] 0.20[2]	13134[1] 2219[2]	7.7×10^{9}
6	431277	1176420	Watercourse	0.40	0.06	156	6.2×10^{7}
7	430855	1176187	Watercourse	0.20	0.07	87	Not determined*
8	430784	1175870	Watercourse	0.12	0.05	40	2.0×10^{7}
9	430743	1175795	Watercourse	0.40	0.15	498	3.5×10^{8}
10	430734	1175798	Watercourse	0.12	0.05	255	1.8×10^{7}
11	430242	1175737	Mill Burn	0.30	0.27	4500	5.8×10^{9}

*Not sampled [1] Watercourse 1 [2] Watercourse 2. Loadings for each watercourse were estimated separately and then combined to give the overall loading

In total, eleven watercourses were observed along the coastline surrounding Hamar Voe. Not all of these watercourses were sampled and it was therefore only possible to calculate loadings for seven of these watercourses (see Table 8.1). The largest watercourses discharging into Hamar Voe are the Burn of Eelawater (watercourse no, 3) and the Burn of Sandy Lochs/Burn of Pundswater which merge and flow into the voe as one watercourse (watercourse no, 5). These watercourses are located at the north eastern end of the loch < 1 km from the mussel farm. These watercourses had moderate estimated *E. coli* loadings Watercourses 8, 9 and 10 had relatively low estimated loadings at the time of the shoreline survey but lie <200 m from the eastern and southern extents of the mussel farm and therefore have a greater potential to impact directly at the site.

Overall, freshwater inputs would be expected to provide moderate levels of contamination to the production area at Hamar Voe, with the highest impact expected from the watercourses that discharge on the eastern and southern sides of the mussel farm.

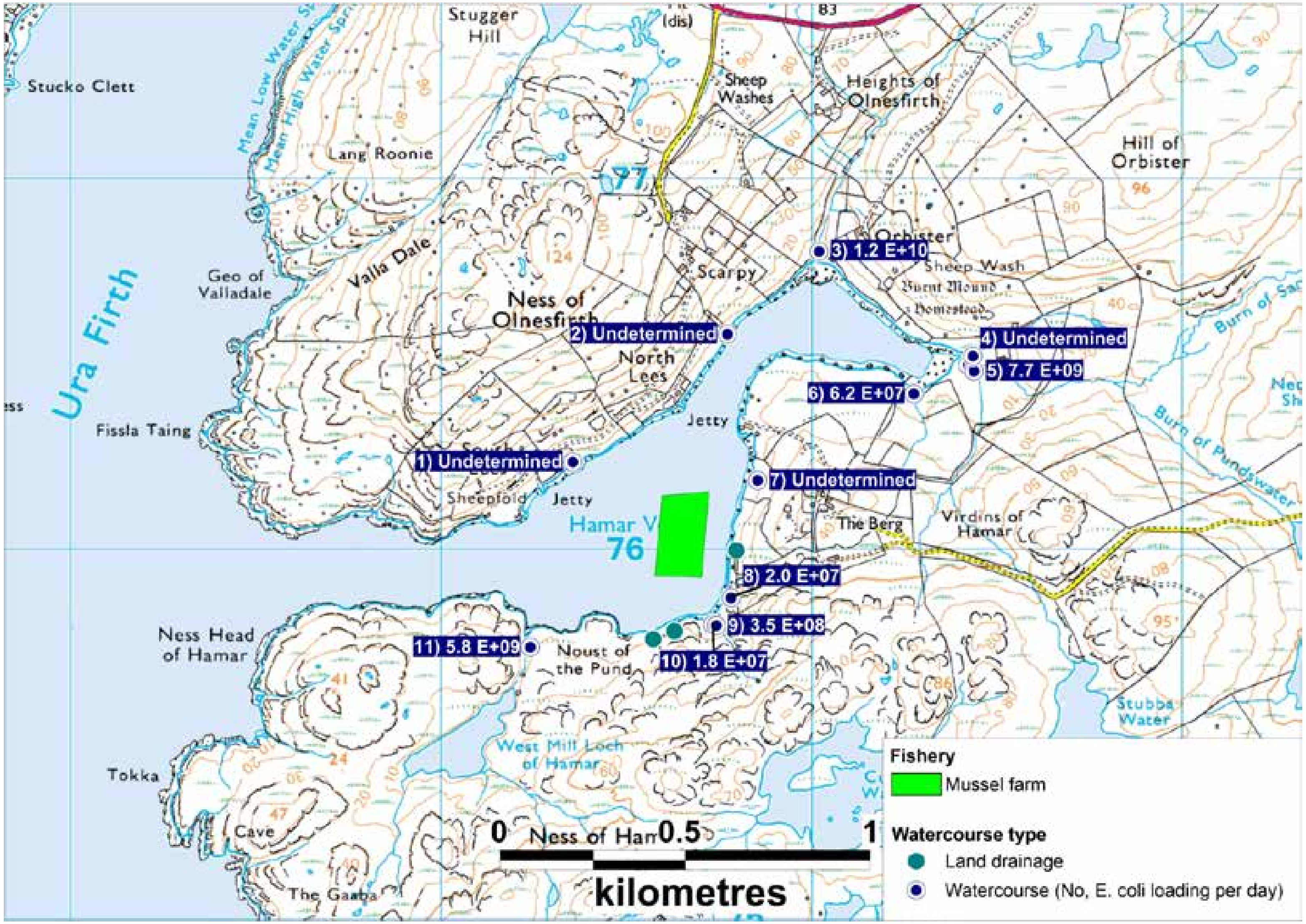


Figure 8.1 Map of watercourse loadings at Hamar Voe

9. Meteorological Data

The nearest weather station for which a near complete rainfall data set was available is located at Lerwick, situated approximately 39 km south-southeast of the production area. Rainfall data was available for January 2008 – December 2013. The nearest wind station is also at Lerwick. Conditions may differ between this station and the fisheries due to the distances between them. However, this data is still shown as it can be useful in identifying seasonal variation in wind patterns.

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

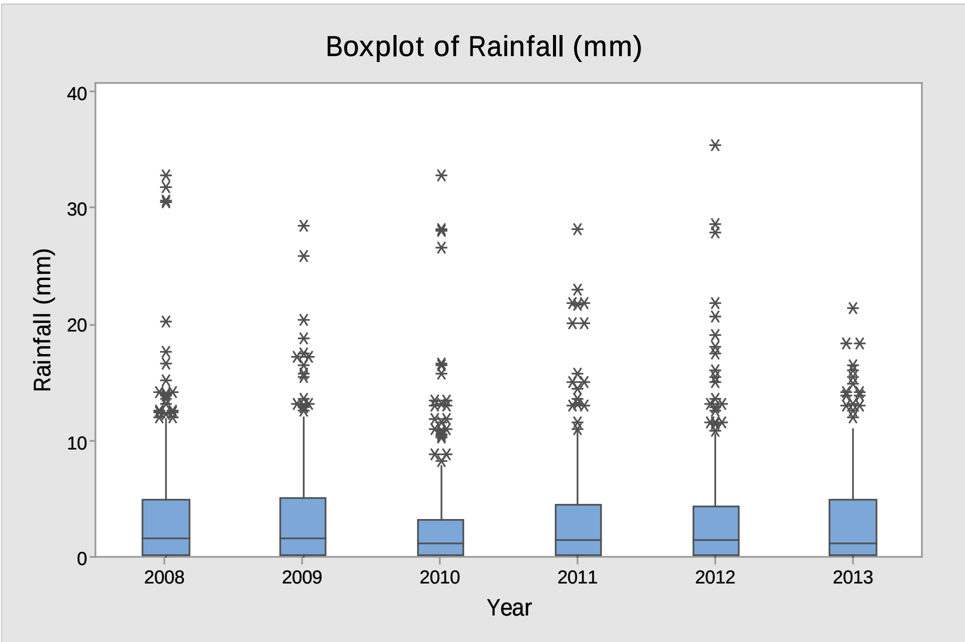


Figure 9.1 Box plot of daily rainfall values by year at Lerwick (2008 – 2013)

Total annual rainfall varied from year to year, with 2010 being the driest year (866 mm) and 2008 the wettest (1250 mm). High rainfall values of more than 30 mm/d were recorded in 2008, 2010 and 2012.

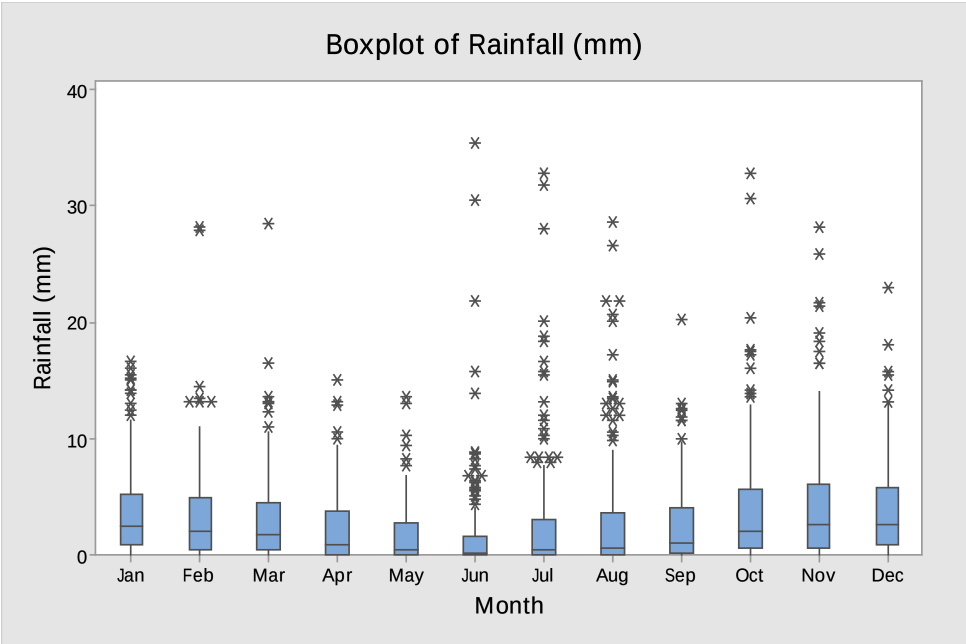


Figure 9.2 Box plot of daily rainfall values by month at Lerwick (2008 – 2013)

Daily rainfall values were higher during the autumn and winter. Total rainfall was greatest in November (745 mm) and least in April (304 mm). Rainfall values exceeding 30 mm/d occurred in June, July and October.

For the period considered here (2008 – 2013) 47 % of days received daily rainfall of less than 1 mm and 7 % of days received daily rainfall of over 10 mm.

It is therefore expected that run-off due to rainfall will be higher during the autumn and winter months. However, extreme rainfall events leading to episodes of high runoff can occur in most months and when these occur during generally drier periods in late spring and summer, they are likely to carry higher loadings of faecal material that has accumulated on pastures when greater numbers of livestock were present.

9.2 Wind

Wind data was collected from Lerwick and summarised in seasonal wind roses in Figure 9.3 and annually in Figure 9.4.

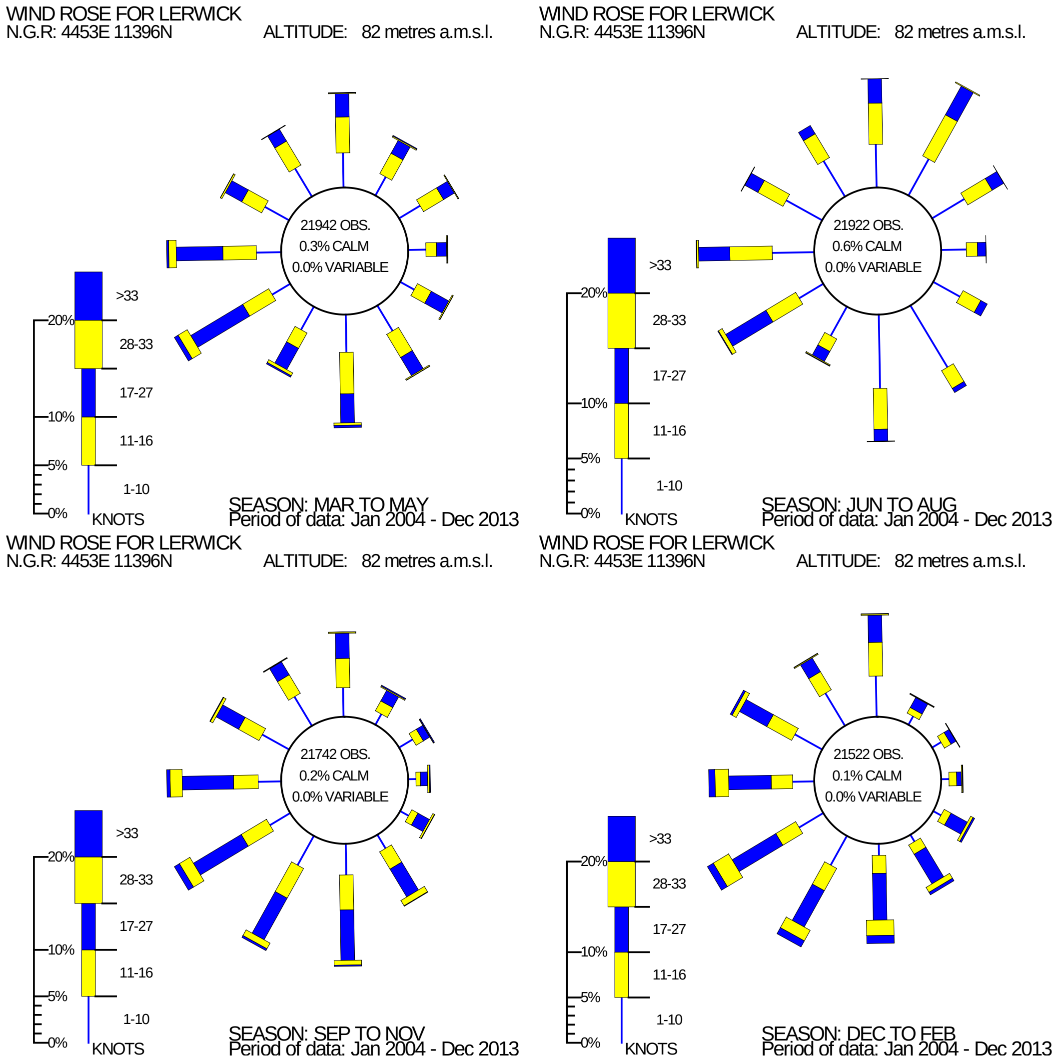


Figure 9.3 Seasonal wind roses for Lerwick

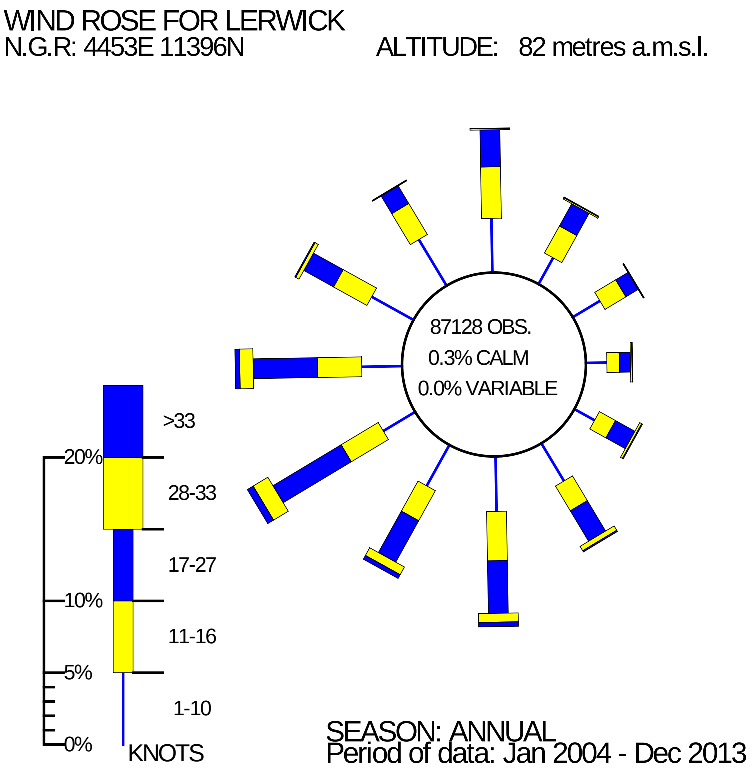


Figure reproduced under license from Meteorological Office. Crown Copyright 2013.

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. The strongest winds tended to come to from the southwest quarter although winds from the north occurred relatively frequently. During the summer, winds were also often seen from the north-northeast. Winds were strongest during the winter and were weakest during the summer.

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

Hamar Voe is a new production area for common mussels (*Mytilus edulis*). The site has been given an A classification for the period from July 2014 to March 2015 inclusive.

11. Historical *E. coli* Data

11.1 Validation of historical data

Results for all samples assigned against the Hamar Voe production area for the period 01/01/2009 to the 07/01/2015 were extracted from the FSAS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. The data was extracted on 07/01/2015. All *E. coli* results were reported as most probable number (MPN) per 100 g of shellfish flesh and intravalvular fluid.

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

One sampled was omitted from the the data analysis as the reported sampling location lay >6 km outside of the production area boundaries. The remaining 16 sampling results were reported as valid, were received at the laboratory within 48 hours of collection and had box temperatures of <8^{o}C.

11.2 Summary of microbiological results

A summary of sampling and results at Hamar Voe is displayed in Table 11.1.

Table 11.1 Summary of historical sampling and results

Sampling Summary	
Production area	Hamar Voe
Site	Hamar Voe
Species	Common mussels
SIN	SI-655-1404-08
Location	HU 3071 7613 and HU 3071 7614
Total no of samples	16
No. 2013	5
No. 2014	11
No. 2015	0
Results Summary	
Minimum	<18
Maximum	1300
Median	30
Geometric mean	35
90 percentile	-
95 percentile	-
No. exceeding 230/100g	1
No. exceeding 1000/100g	1
No. exceeding 4600/100g	0
No. exceeding 18000/100g	0

The 90 and 95 percentile values have not been included due to the small number of results available. All but one of the samples taken to date have yielded results <230 *E. coli* MPN/100 g.

11.3 Overall geographical pattern of results

The geographical locations of all sample results assigned to Hamar Voe are shown in Figure 11.1. The NGR of one sample had a typographical error, which was corrected for mapping purposes. The sizes of the symbols are proportional to the magnitude of the *E. coli* results.

All reported sampling locations were within 10 m of one another and plot at the northeast corner of the current mussel farm boundaries. The current RMP lies approximately 58 m north of the mussel farm location as recorded during the shoreline survey.

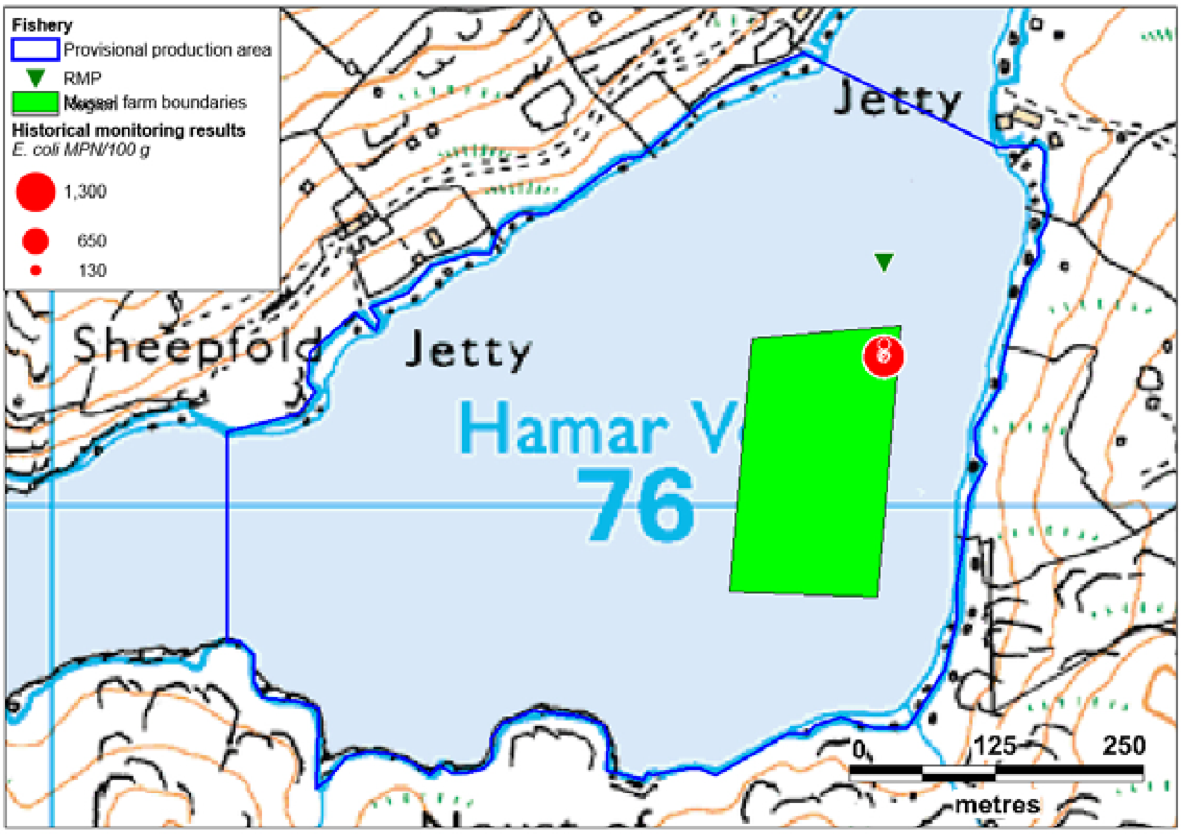


Figure 11.1 Map of reported sampling locations for common mussels at Hamar Voe

11.4 Overall temporal pattern of results

A scatterplot of *E. coli* results against date for Hamar Voe is presented in Figure 11.2. Due to the limited data available, a trend line has not been superimposed.

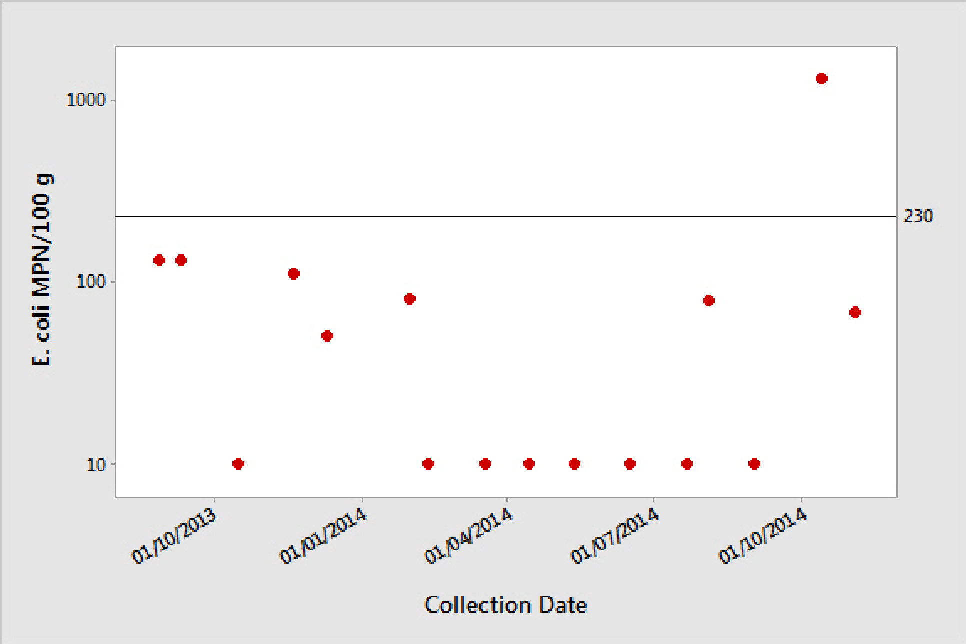


Figure 11.2 Scatterplot of *E. coli* results by collection date at Hamar Voe, fitted with a lowess line

The highest result was from a sample taken in November 2014. The results from samples taken from February to June 2014 were all below the limit of detection.

11.5 Summary and conclusions

Sampling at Hamar Voe began in August 2013. Reported sampling locations have been within 10 m of one another at the northeast corner of the surveyed mussel farm location. The RMP lies approximately 60 m north of the current fishery location. Most of the results have been <230 *E. coli* MPN/100 g.

12. Designated Waters Data

Shellfish Water Protected Areas

There are no designated shellfish water protected areas covering Hamar Voe.

Bathing Waters

There are no designated bathing waters within Hamar Voe.

13. Bathymetry and Hydrodynamics

13.1 Introduction

The study area comprises all waters east of a line drawn between HU 295 761 (Ness of Olnesfirth) and HU 295 757 (Ness Head of Hamar), namely Hamar Voe. The voe is located on the eastern shore of Ura Firth, which is a broad inlet on the northern coast of St. Magnus bay on the west Shetland Mainland. The voe is orientated roughly east-west and is characterised by narrow approaches that broaden to the main body of the voe, with a second constriction leading to shallow headwaters in a dogleg to the north-east.

13.2 Bathymetry

An extract from Admiralty chart BA3295 (1:25,000) annotated with the limits of the study area, production area, mussel farm mooring containment area and the location of two hydrographic surveys conducted in the voe is given in Figure 13.1.

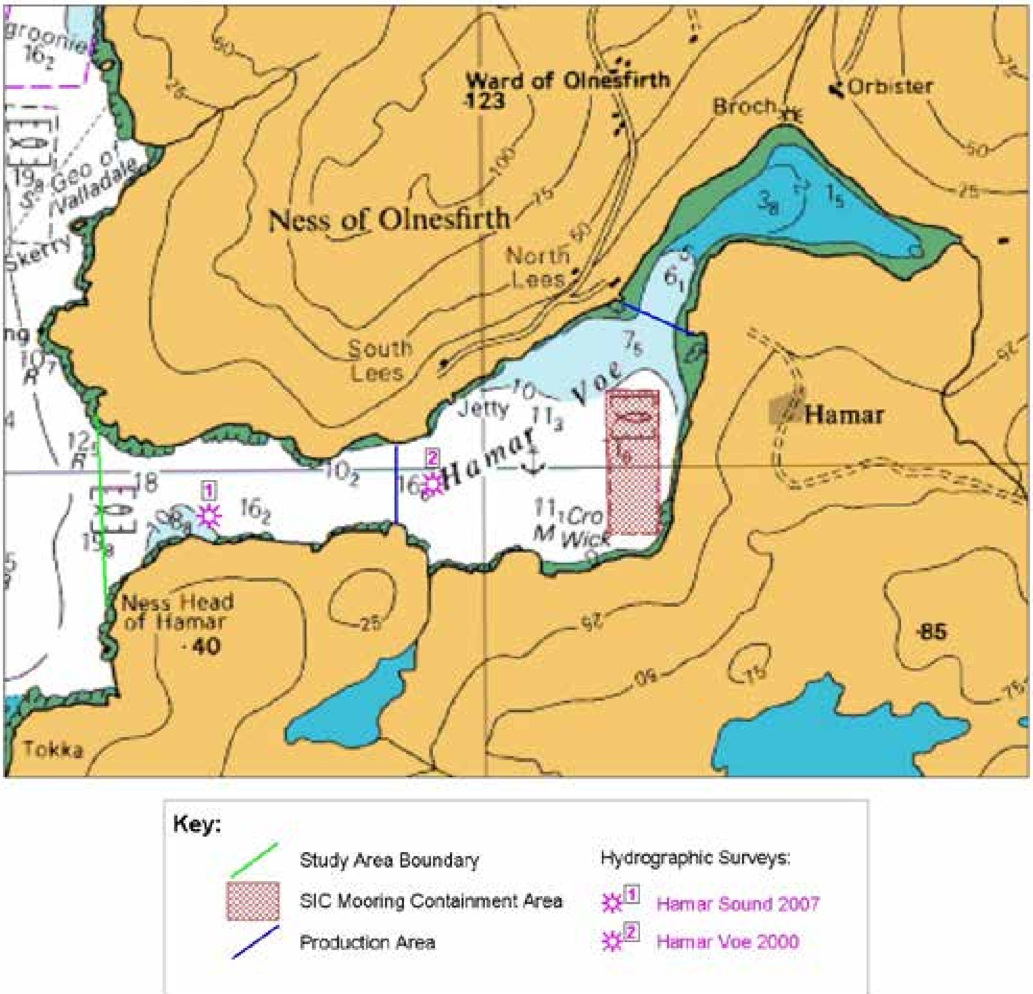
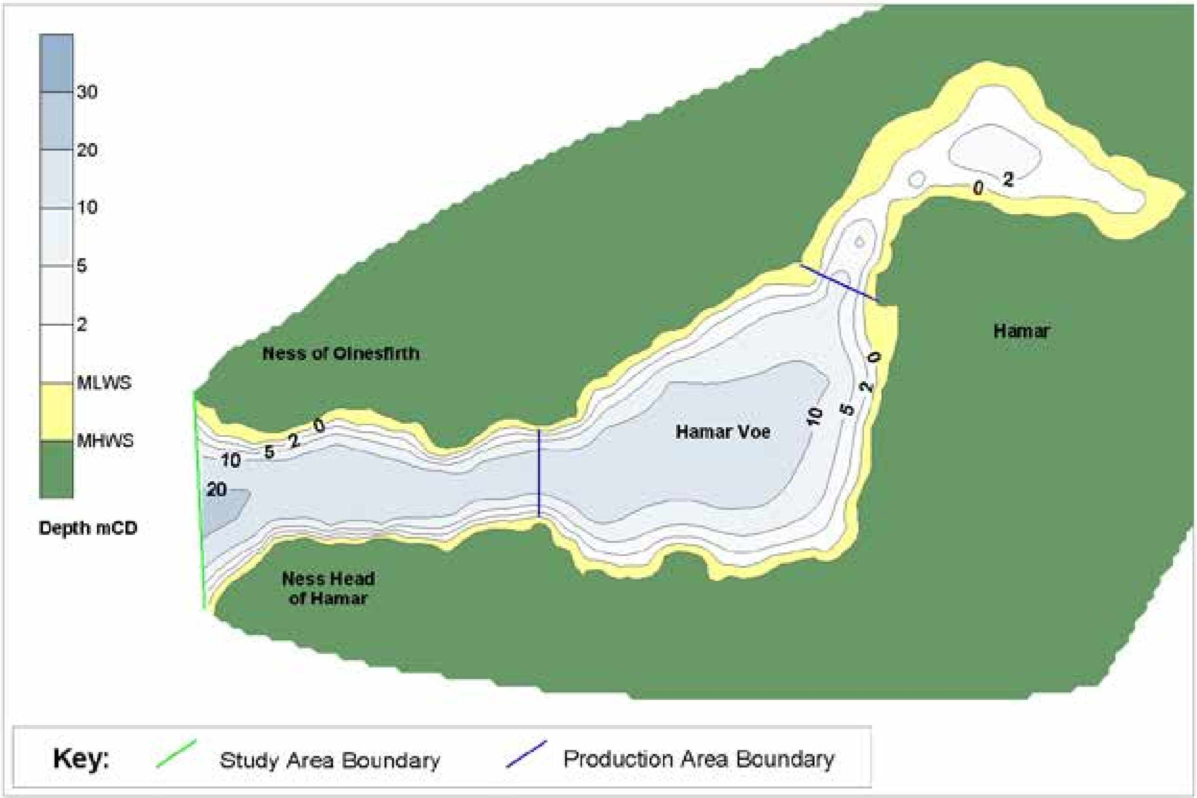


Figure 13.1 Admiralty chart extract

Vector data from an electronic version of this chart was extracted and contoured using Golden Software Surfer 8 (Figure 13.2). As part of the Hamar Sound 2007 hydrographic survey it was noted that the depth observed did not correspond well with the apparent charted depth which warranted the collection of 20 spot depths around the survey location. During the shoreline survey work undertaken in October 2014 a further 16 spot depths were collected for the remainder of the voe. This additional survey data is included to improve the accuracy of the contour plot. In both cases soundings were corrected to chart datum (CD) by subtracting the local tide height extracted from the Admiralty prediction for Hillswick, the closest port to the area.



Depths given as metres chart datum.

Figure 13.2 Bathymetry of Hamar Voe

The contour plot illustrates:

- The depth at the mouth of the voe exceeds 20 metres.
- At the narrower part of the voe near the mouth depth increases rapidly from both shores, while gentle gradients are present at the inner parts of the voe.
- A depth of 10 to 20 metres is present for the majority of the length of the voe.
- There are no sill or basin features within the voe. The apparent minor sill present at the narrowest part of the voe prior to the headwaters is likely to be an artefact of the contouring process as none of the additional spot depths corroborated this feature.

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 using Surfer

Parameter*	Production Area	Study Area (Hamar Voe)
Area (km^2)	0.26	0.47
Volume (Mm^3)	2.11	3.73
Mean depth (m)	8.1	7.9
Maximum depth (m)†	16.7	23.1

* All values at chart datum. †derived from the spot depths collected

Hamar Voe is not included in the *Scottish Sea Lochs Catalogue* (Edwards and Sharples, 1986) and while it is listed in the *Catalogue of Voes, Firths and Sounds in Shetland* (Dixon, 1987) comparison with the values given in Table 13.2 is not possible as the corresponding parameters are not calculated in this instance.

13.3 Tidal Information

Information pertaining to predicted tide height is derived from the UKHO TotalTide prediction for Hillswick, the nearest secondary port which is located 1.5 km north-west from the study area in Ura Firth. Figures 13.3 and 13.4 show tidal curves for a fifteen day period starting on the 20 October 2014 which the date of the shoreline survey.

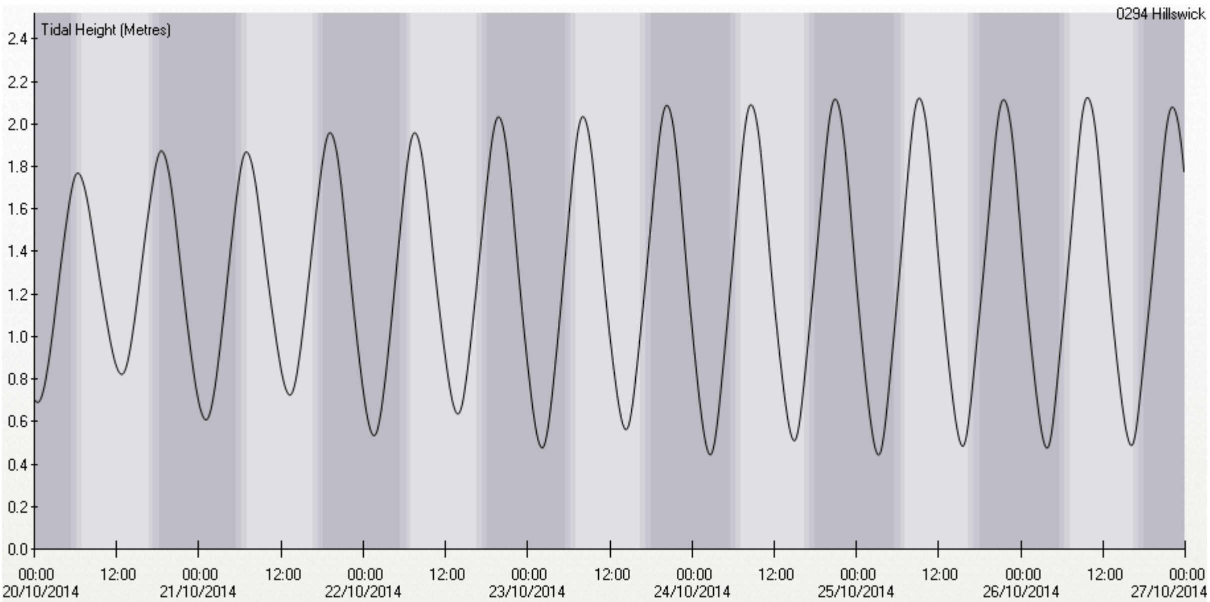


Figure 13.3 Tidal Curve Hillswick 20 to 27 October 2014

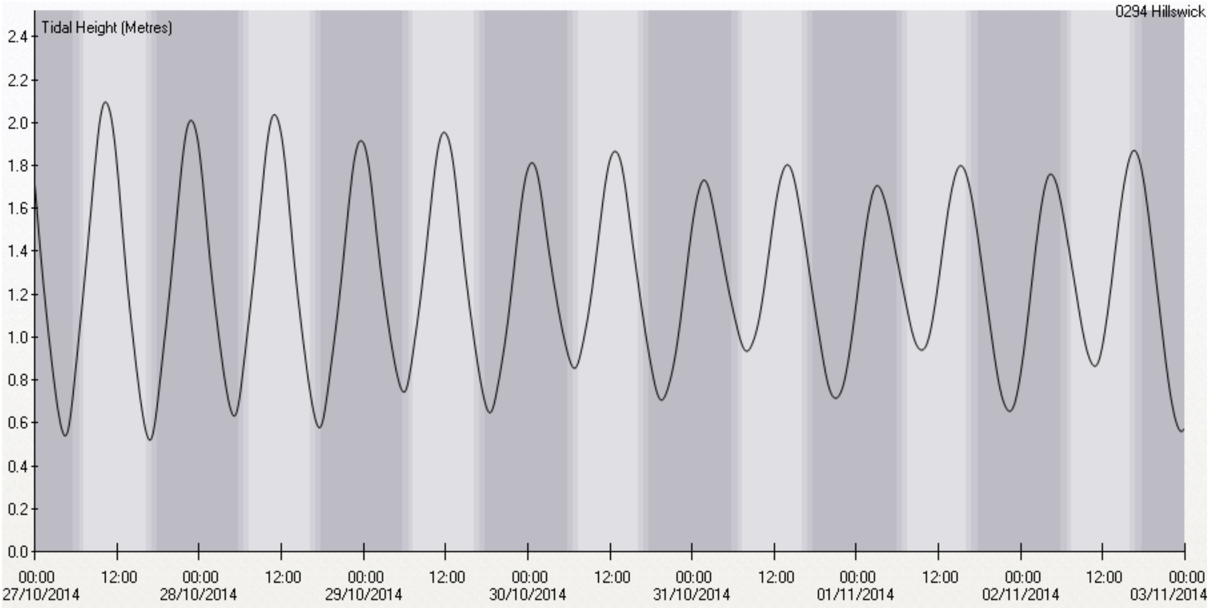


Figure 13.4 Tidal Curve Hillswick 27 October to 3 November 2014

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

0294 Hillswick is a Secondary Non-Harmonic port.

The tide type is Semi-Diurnal.

HAT	2.4 m
MHWS	2.0 m
MHWN	1.6 m
MLWN	0.8 m
MLWS	0.4 m
LAT	-0.1 m

Based on the above Hillswick would be classified as micro-tidal with a low tidal range of 1.6 m for springs and 0.8 m for neaps. Comparable conditions are likely to be found within the study area 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 Section 4.

13.3.1 Timing

Pressure data were recorded by a current meter deployed in 2007 at Hamar Sound 0.2 km east of the study area boundary. No pressure data was collected during the survey conducted in 2000. The 2007 data were compared to the Hillswick TotalTide prediction for the equivalent survey period. The timing of high and low water at the survey location was found to be very similar to the prediction, with a tendency for high or low water to occur at Hamar Voe fractionally (less than 20 minutes) after the predicted time at Hillswick.

13.3.2 Range

The range of three tides around the spring tide and three tides around the neap tide for the 2007 deployment in Hamar Sound were compared to that predicted for the corresponding tides at Hillswick. The observed tidal range during both spring and neap tides is comparable to the prediction. For springs this is an observed range of 1.57 dBar against a predicted range 1.50 m while for neaps the observed range is 0.97 dBar compared to a predicted range 0.93 m. Atmospheric pressure is not accounted for in the survey data.

13.3.3 Tidal Volume

The volume of water entering and leaving a given area 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 study area. Based on this method estimates of flushing time (T_f) and flushing rate (Q) for both the study and production areas are given below in Table 13.2.

Table 13.2 Estimate of flushing rate and tidal volume for the study area (Hamar Voe) and the production area using the tidal prism method

Input:		Production Area	Study Area
Volume* (V)	Mm^3	2.22	3.92
Area* (A)	Km^2	0.27	0.49
Tidal range (R)	m	1.6	
Output:			
Flushing Time (T_f)	days	3.86	3.68
Flushing Rate (Q)	Mm^3/year	210	389
Flushing Rate (Q)	Mm^3/day	0.57	1.06
Flushing Rate (Q)	Mm^3/tidal cycle	0.30	0.55

*Calculated for MLWS.

The tidal prism method indicates that 14.1 % of the low water volume of the study area is exchanged during each tidal cycle, a figure which decreases to 13.5 % for the production area alone. Total exchange for both areas would take just under four days.

The second method again utilises Surfer grid computations to estimate the volume of each area at different tidal states by defining the “z” surface according to the tidal level and subtracting low water from high water (Table 13.3).

Table 13.3 Estimate of flushing rate and tidal volume of the study area (Hamar Voe) and the production area using Surfer grid volume calculation

Tide	Z (m)	Production Area Volume (Mm^3)	Study Area Volume (Mm^3)
MLWS	0.4	2.22	3.92
MHWS	2.0	2.67	4.79
Difference (spring tide)		0.46	0.88
MLWN	0.8	2.33	4.12
MHWN	1.6	2.56	4.56
Difference (Neap tide)		0.23	0.44
Average Difference		0.34	0.66

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. While Hamar Voe may be considered typical of a semi-enclosed water body for which the tidal prism calculation is suited the fact that the entrance to the voe is narrower than the main body of the voe may serve to restrict exchange to a certain extent. Such interactions are beyond the scope of simple box modelling techniques.

13.4 Currents

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

13.4.1 Field Data

Historically there have been two field studies which give an insight into the current flow patterns of the study area. Summary information of the deployments is given in Appendix 4, Table 1 while their locations are included at Figure 13.1. Data from these hydrographic studies were provided to Cefas by SEPA which archive information concerning fish farm licencing on their Public Register. Survey data 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. The quality of the data collected is assessed to determine if each survey suitably represents the hydrographic conditions at each location. The survey in 2000 was conducted with an array of three instruments which have a measuring threshold of 0.014 m/s, above which the measuring rotor will begin to rotate reliably. With 68 % of the observations within a range of 0 to 0.014 m/s and a mean speed of 0.023 m/s the effectiveness of this type of instrument to suitably represent the low current speeds recorded at the site must be questioned. The survey conducted in 2007 produced data that is considered acceptable to the standards defined in Attachment VII. However, while velocity precision was predicted to be 0.019 m/s, below the 0.020 m/s threshold required by these standards, this still represents a predicted standard deviation which is 41 % of the observed mean speed. Once again, reliability of the data will be affected to a certain extent, although overall these data are considered to be reliable.

13.4.2 Survey Data Assessment

An assessment of the hydrographic data collected at Hamar Voe and Hamar Sound was undertaken with detailed summary statistics tabulated in Appendix 4, Table 2. Figure 13.5 illustrates the frequency of currents by vector and the pertinent summary statistics for near-surface waters.

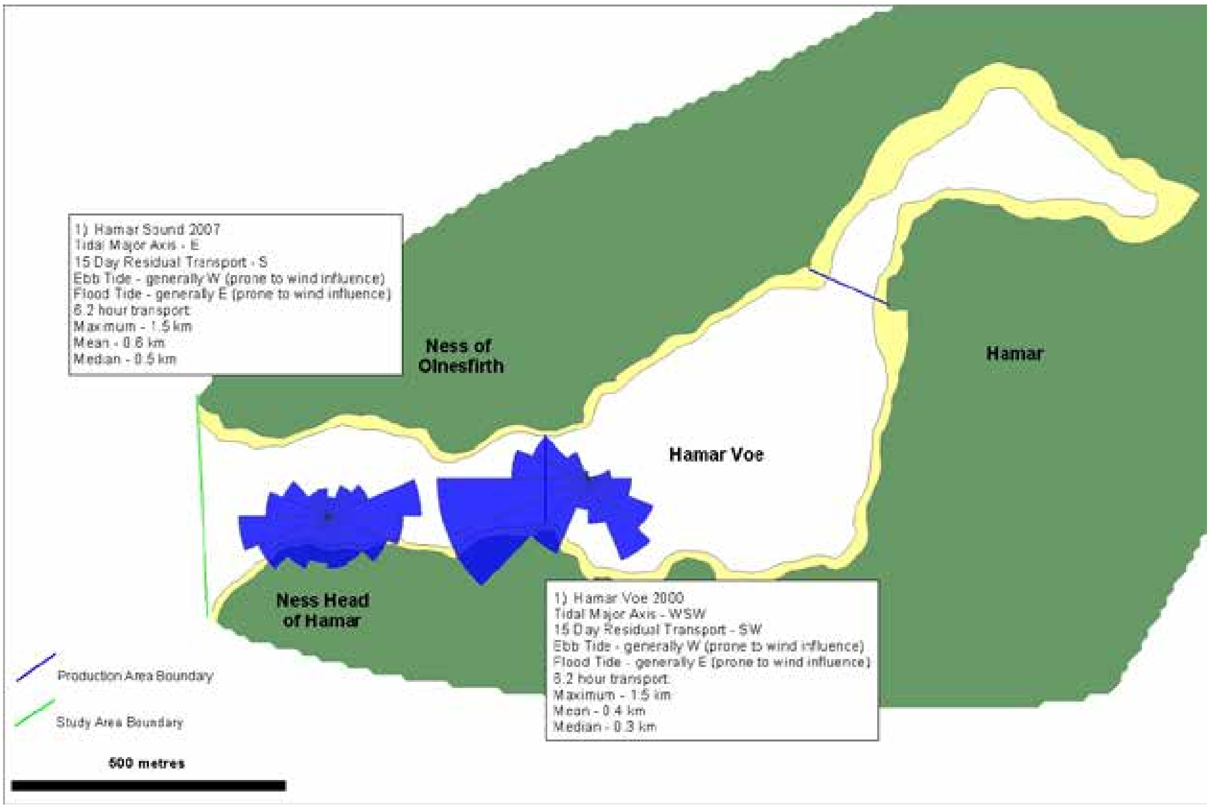


Figure 13.5 Near-surface current direction frequency (bin size 22.5°) for the two surveys at Hamar Voe including a summary of residual and tidal transport at each location

A detailed assessment of the hydrographic data collected at Hamar Voe in 2000 is compounded by the poor quality of the data. In all three layers there are periods of no current flow recorded indicating that velocity was insufficient to enable the measuring rotor to turn.

The hydrographic data indicates that the influence from tidal currents is relatively low, however they are aligned along a weak axis orientated east-west corresponding to the shoreline topography. Residual transport indicates that near-surface waters are transported out of the voe while near-seabed waters show a net flow into the voe. Current velocities are greater at the seabed than they are in the near-surface layer.

There is limited evidence of a tidal signature; peak velocities are recurrent from just after low water through the early part of the flood tide and at mid depth, for a few days during a spring tide, current direction alternates between generally easterly on the flood tide to generally westerly on the ebb tide. However this pattern does not persist throughout the survey period, nor does it occur elsewhere in the water column.

It is apparent through assessment of the near-surface record that wind forcing has an influence on the currents observed during the 15 day period analysed. The survey period was not particularly windy with peak velocity reaching Beaufort Force 5 or F6 on two occasions, both from the north. In both instances there is a corresponding increase in current flow sustained over adjacent tidal cycles. This is most pronounced in the near-seabed layer where the velocity is more than double that recorded at the near-surface layer, and is flowing consistently to the east towards the head of the voe. At the same time near-surface currents are flowing to the south-west. Throughout the survey, periods of elevated velocity in the near-surface record correspond with periods of elevated wind speeds and generally the data suggests that currents in the near-seabed layer are flowing in the opposite direction to the currents present at the near-surface layer at the time.

The survey location is relatively sheltered with fetches of 1.1 km to the north-east, and 1.6 km to the west. The Hamar Voe 2000 survey location is closest to the fishery which is exposed to a greater fetch to the west of approximately 2.0 km. In the near-surface layer periods of greatest transport during a 6.2 hour period (up to 1.5 km) mostly occur in a single cluster during a strong wind forcing event, and were coincidental with an ebb tide and transport to the west.

The data collected during the survey at Hamar Sound in 2007 demonstrate more activity than that present further east into the voe. Mean current velocity is largely consistent throughout the water column with currents aligned on an east-west axis, again corresponding to the topography of the voe at this point. In the near-surface layer residual flow to the south is indicative of relatively balanced distribution of currents along this axis while a residual flow to the west south-west in the near-seabed layer illustrates a dominance of currents flowing out of the voe to the west.

With regard to the tidal cycle, in terms of velocity there is very little variation between the two tidal streams. There is a periodic increase in velocity associated with the ebb tide or at low water, although this is not always the case. There is no evidence of the spring-neap tidal cycle in the velocity record. Current direction would appear to conform to the expected pattern with the flood tide entering the voe from west to east with opposite true for the ebb tide. However there is substantial variation during any given tide, from one tide to the next and in some cases the flow present will persist for over 24 hours.

South-westerly winds dominated the first two thirds of the survey period followed by more a variable airflow present in the remainder of the record. Wind speed was mostly consistent at F5, briefly reaching F7 for a short period towards the end of the survey. This location is again relatively sheltered with fetches of 1.1 km to the east and from 1.0 km to 1.7 km between the south-west and north-west. Near-surface waters do not appear to be particularly responsive to elevated wind speeds encountered during the survey period, while close to the seabed the most energetic conditions are coincidental with the highest wind speeds. These periods are largely associated with a relatively consistent flow out of the voe from east to west which continues over adjacent ideal cycles, although the strongest flow during these periods occurs during the ebb tide. The data imply that while the survey location may have been sheltered from the effects of a south-westerly airflow, further east the orientation of the voe is such that these winds would be blowing along the long axis of the voe. As data collected here indicates that there is some potential for wind generated currents to form a net movement towards the head of the voe may be present. The pattern observed in the near-seabed layer at Hamar Sound may therefore be evidence of a counter flow which can overpower the flood tide or enhance the velocity of the ebb tide.

In near-surface waters periods of greatest transport during a 6.2 hour period (up to 1.5 km) occurred in two clusters associated with wind forcing events. The first with south-westerly winds producing an easterly current flow during the flood tide, the second occurred during a calm period following F5 south-westerly winds producing an atypically strong ebb tide flowing west. There is also a periodicity in the level of excursion that matches the tidal cycle, although there is no particular bias for this to occur either the flood or the ebb tide.

In summary tidal currents in the study area are weak and subject to influence from even moderate wind forcing. In some cases this can generate currents which dominate the tidal regime while in others this can serve to augment a given flow when the direction of tidal and wind generated currents are coincidental.

13.5 Stratification

Salinity and temperature profiles were collected at two locations within the production area during the shoreline survey in October 2014. These locations corresponded to the northern and southern ends of the easternmost line of the fishery. In both profiles a marked reduction in salinity was recorded at the surface compared to readings taken at 3 metres depth with values at the northern end of the site showing the greatest reduction. Here the surface value was 11.5 ppt below that at 3 metres, while at the southern end of the fishery the surface reading was 6.6 ppt below that observed at 3 metres. It was not possible to collect a full profile at the latter due to depth restrictions although comparable readings were recorded in each profile at 3 metres and 5 metres at both locations. The surface seawater samples collected at each of these locations showed the same pattern in the salinity levels. An additional seawater sample was collected from a location north of the fishery at the jetty where the voe narrows prior to the broader part at the head of the voe. Here surface salinity was considerably lower at 10.54 PSU. These measurements correspond to the observation during the boat work where a brown discolouration was present in the surface waters around the fishery noted as the vessel moved through the water.

A total of twelve watercourses were recorded draining into Hamar Voe during the shoreline survey, the largest of which discharge into the headwaters of the voe (the Burn of Eelawater and the combined Burns of Sandy Lochs and Pundswater). While meteorological data illustrates that there were rainfall events in the preceding two days prior to the survey the amount was not recorded in the available data. There was no evidence of recent significant flow events recorded (i.e. debris and flattened grass on the banks of the watercourses). It is apparent that reduced salinity in near surface waters is occurring due to fresh water input, and therefore annual rainfall patterns will have an effect on surface salinity throughout the year. Figure 13.6 illustrates the monthly total rainfall and the 24 hour average rainfall from the Lerwick Meteorological Office from 2007 to 2012.

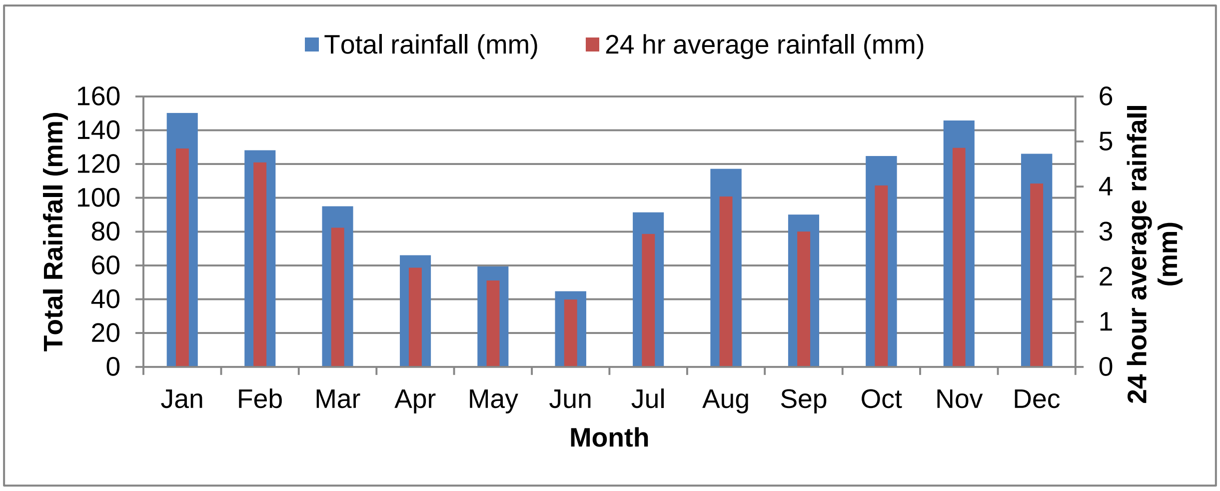


Figure 13.6 Total monthly and mean 24 hour rainfall for the period 2007 to 2012

The two temperature profiles showed only minor variation with depth with surface values 0.1°C lower than those recorded lower in the profile. During the summer months there is the potential that thermal stratification may occur. With a layer of warmer water above cold dense water the potential also exists for the formation of density driven currents. However the timing of the fieldwork precluded any study of this phenomenon. Complete salinity and temperature profile data and water sample analysis are available in the shoreline survey report.

Various parameters pertaining to freshwater input are described by Dixon, 1987 although not all of these are given. These figures have been updated and where required completed using digital mapping techniques and modern rainfall totals in Table 13.4 below.

Table 13.4 Comparing freshwater runoff parameters

Parameter	Units	Dixon 1987	SSQC 2014
Watershed	km^2	8.9	13.8
Annual Rainfall	(mm)	1,100	1,223*
Runoff	(Mm^3/yr)	7.6	13.4
Fresh/tide, per thousand	-	Not given	31.7
Salinity reduction	ppt	Not given	1.1
Runoff/width	m^2/d	Not given	147

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

It can be seen that values described by Dixon are smaller than those derived for the purpose of this report. Notably the watershed is estimated to be 56 % larger than the figure presented in the publication which leads to a corresponding increase in the prediction for freshwater runoff. The predicted salinity reduction is lower than that observed during the fieldwork however the figure is calculated for the whole water body and is the average value for a whole year. These parameters confirm that freshwater input has the potential to have an influence on the production area although they must be considered in the context of seasonal variations in runoff and the likely salinity gradient relating to the sources of the freshwater input. When compared to other voes collated in the *Catalogue of Voes, Firths and Sounds in Shetland* (Dixon, 1987), Hamar Voe would rank second in the list of locations listed in order of greatest freshwater to tidal water supply ratio and resultant salinity reduction. This is a reflection of the fact that the voe has a relatively large watershed for a small body of water.

13.6 Summary

- The tidal prediction for Hillswick is applicable to the study area in terms of timing and range.
- Figures for tidal exchange derived from the two methods indicate that between 13.5 % to 15.4 % of the low water volume of the production area is exchanged during the tidal cycle leading to a flushing time of approximately 3.9 days.
- The production area represents only the broad centre part of Hamar Voe (approximately or 57 % of the total volume). Tidal exchange figures for the whole voe that between 14.1 % to 16.7 % of the low water volume is exchanged during the tidal cycle leading to a flushing time of approximately 3.7 days.
- Field observations indicate that tidal currents are relatively weak and variable in the voe, although they appear to be more clearly defined at the mouth of the voe where the topography constricts the flow into a channel which is

narrower than the body of the voe. Tide appears to conform to this topography flowing east on the flood and west on the ebb, although during the survey periods these currents were often dominated by those attributed to wind forcing.

- Wind forcing can generate surface water transport which leads to a counter flow present near the seabed. The latter can dominate a given tidal stream, or serve to enhance the flow if the direction of this and the tide are coincidental. The fishery is exposed to 2.0 km fetch to the west.
- Close to the surface the greatest transport events during a 6.2 hour (tidal) period of up to 1.5 km are associated with elevated wind forcing which has the effect of producing an atypically strong tidal flow for a given flood or ebb tide.
- Salinity profiles collected during the October 2014 shoreline survey showed evidence of freshwater influence in the surface waters at the fishery which appeared to be greater at the northern end than the southern end of the fishery. A salinity measurement closer to the head of the voe showed an even greater reduction in salinity which implies that the largest watercourses draining into the inner basin here have a substantial effect on the headwaters themselves.
- Freshwater runoff calculations based on the watershed and bathymetric properties of Hamar Voe would suggest that there is potential for a high degree salinity reduction in the order of 1.1 ppt for the whole voe over a whole year. There will be season fluctuations in runoff as well as localised salinity reduction in surface waters near to the source of a given freshwater discharge.

14. Shoreline Survey Overview

The shoreline survey was conducted on 20th October 2014. Light rain was reported in the 48 hours prior to the survey. The survey day was dry with sunny spells, with a moderate westerly F3-F4 turning lighter and south-westerly in the afternoon.

Dwellings were noted towards the head of the voe and were predominantly set back from the shore. Six dwellings were observed, one of which was derelict. A possible septic tank was noted at some distance back from the shoreline at South Lees. No guest house accommodation was observed.

The fishery consisted of a common mussel farm with six 220 m twin-headed long-lines and 10 m droppers. It was located along the eastern side of Hamar Voe and was stocked at the time of the survey. Harvest was said to be demand dependent.

Mussel samples were taken from droppers at the northeastern and southeastern corners of the mussel farm. Results from samples taken at the tops of the droppers were much higher than those taken at the bottom. The highest result, 3500 *E. coli* MPN/100 g, was from a sample taken at the top at the northeastern corner of the farm. A seawater sample taken at that location yielded a result (70 *E. coli* cfu/100 ml) that was slightly higher than that obtained from a seawater sample taken at the southeastern corner of the farm (50 *E. coli* cfu/100 ml).

A salmon farming shore base (Grieg Seafood Hjaltland UK Ltd) was located on the eastern shoreline, but no discharges were observed within its vicinity. A seawater sample taken adjacent to the shore base returned a result of 400 *E. coli* cfu/100 ml. A fish farm with a barge was also noted to the west of the fishery. A member of staff from the shore base reported sanitary facilities aboard the barge were due to be upgraded to a chemical disinfection system in the near future.

Boat traffic was largely associated with aquaculture farms in the voe and creel fishing. The Grieg Seafood Hjaltland UK Ltd shore base contained a pier and slipway where one workboat was present. A small fishing boat was anchored at the head of the voe, where several other moorings were also present.

One hundred and ninety-two sheep were observed in total around the voe. Shore access was possible in most areas, except where steep escarpments made it treacherous and at the head of the voe where fields were fenced. Sheep faeces were frequently recorded near the shoreline and were noted on six occasions where no animals were present. Two cows were noted in an enclosed field inland at the head of the voe.

Rough and common grazing dominated the surrounding coastline. The eastern coastline also contained patches of heather on higher ground and grassland became more common on the low lying ground close to the head of the voe. Three recently cut silage fields were noted; one on the east shore, one on the west shore and one at the head of the voe. Boggy areas were also noted at the head of the voe.

Seven watercourses were measured and sampled. Freshwater samples returned low levels of contamination, varying between 1 and 130 *E. coli* cfu/100 ml.

Birds were the most common wildlife observed. Species included curlews, snipes, common gulls, geese, plover, sparrow and crow. A suspected bird feeding area was noted on the southeast shoreline and bird faeces were seen on the buoys to the northeast of the fishery. Two seals were noted in the voe and rabbit droppings were reported on onshore southwest of the voe.

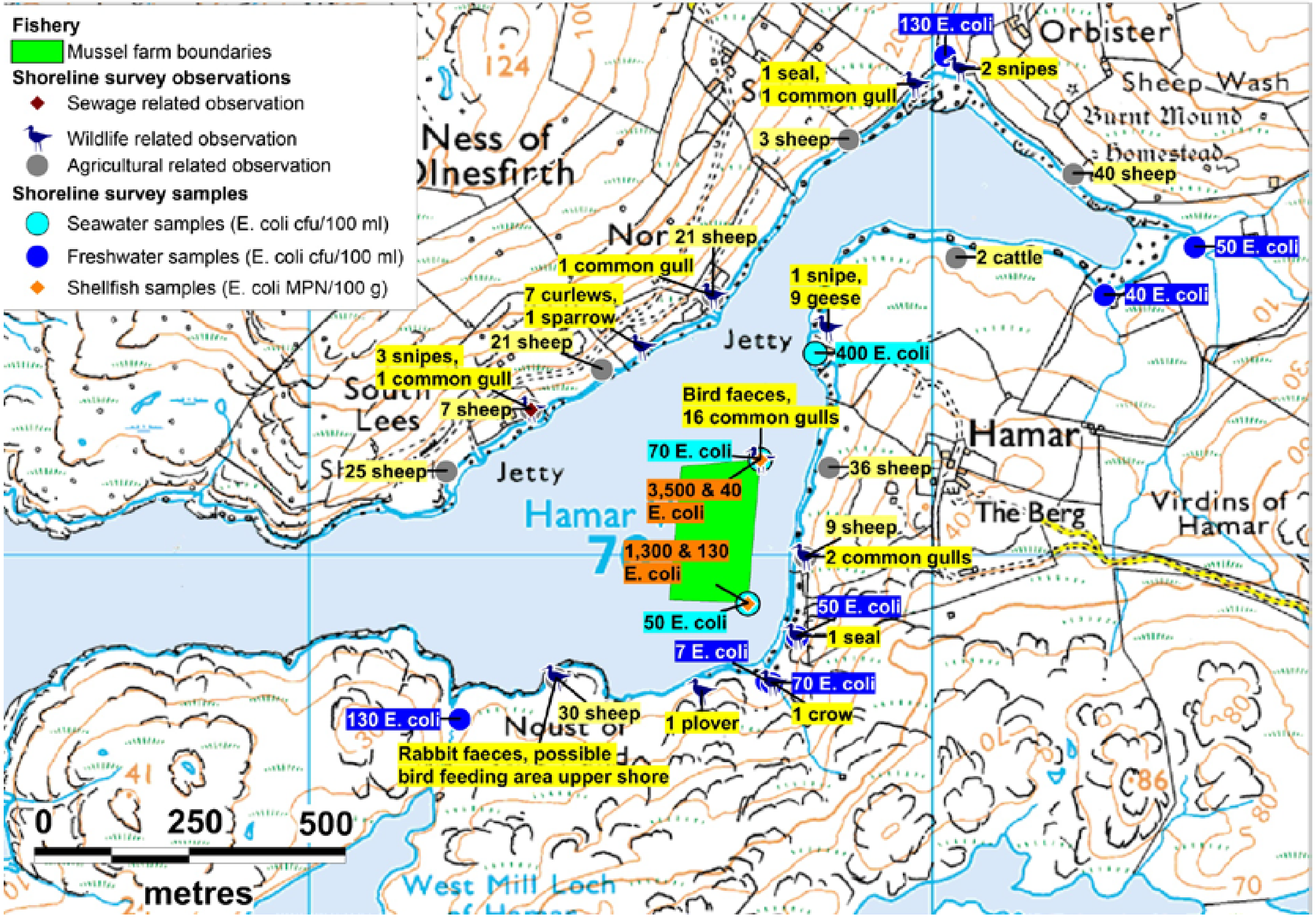


Figure 14.1 Map of shoreline survey observations at Hamar Voe

15. Bacteriological Survey

No bacteriological survey was undertaken at Hamar Voe due to the relatively simple nature of the area.

16. Overall Assessment

Human sewage impacts

Population around Hamar Voe itself is sparse and is mainly distributed along the northern shoreline and at Hamar, inland to the east of the fishery. Population is greater at Hillswick and Urafirth in the part of Ura Firth north of Hamar Voe and this is where most of the reported community and private sewage discharges are located. However, it is expected that dwellings located around Hamar Voe will have private septic tanks and these may impact water quality within the voe, either directly, or via watercourses. It is not expected that the discharge from the fish farm barge recorded during the shoreline survey will impact at the mussel farm unless it operates closer to the mussel farm than the location recorded during the survey.

Agricultural impacts

Faecal contamination from livestock sources is expected to be greatest from sheep located on, or near, the shore immediately to the east of the mussel farm. Additional contamination may arise from the sheep located on the shores to the northwest and southwest of the mussel farm.

Wildlife impacts

Seabirds are expected to be the main source of faecal contamination from wildlife sources and there may be additional contributions from geese. There may also be some contribution from seals and otters. No evidence is available to determine whether there will be any differences in faecal contamination from wildlife sources across the mussel farm.

Seasonal variation

No marked seasonal variation is expected in the human population around the voe. Farm animal populations are expected to be highest during the spring and summer. Contamination from seabirds is expected to be highest during the May to September breeding season. Rainfall will be greatest in autumn, winter and early spring although high rainfall events occurring during the drier months may wash accumulated faeces off the hillsides.

Watercourses

Freshwater inputs are be expected to provide moderate levels of contamination to the mussel farm at Hamar Voe, with the greatest effects seen during and after heavy rainfall from the watercourses that discharge on the eastern and southern sides of the mussel farm. However, the watercourses located towards the head of the voe will contribute to *E. coli* levels in the inner voe.

Movement of contaminants

Tidal currents in the voe are relatively weak and variable. The currents flow east on the flood tide and west on the ebb although this general pattern will be affected by winds. Strong winds from the west will enhance the flood current. Surface currents assisted by wind forcing may produce particle transport distances of up to 1.5 km. Salinity profiles recorded during the shoreline survey showed evidence of freshwater influence in the surface waters at the fishery which were greater at the northern end than the southern end of the fishery. A salinity measurement made closer to the head of the voe showed a greater reduction in salinity than seen at the mussel farm. This is thought to be due to the effect of the larger watercourses entering the voe in that vicinity.

Temporal and geographical patterns of sampling results

All of the routine mussel samples have been reported to have been taken in the same area located at the northeastern extent of the mussel lines and therefore no assessment can be undertaken of the spatial variation from the *E. coli* results of those samples. Of the four mussel samples taken during the shoreline survey, higher results were seen at the northeastern end of the lines than the southeastern end and the results from the samples taken at the surface were much higher than those taken at depth. A seawater sample taken at the northeastern end of the lines showed a slightly higher result than one taken at the southeastern end of the lines. A much higher result was obtained from a seawater sample taken adjacent to the fish farm base located to the northeast of the mussel farm.

There is limited temporal monitoring data for the mussel farm. To date, a run of very low results was seen from February to July 2014 and the highest result occurred in October 2014. The high surface mussel *E. coli* results from the shoreline survey were also taken in that month.

Conclusions

The predicted particle transport distance means that it is unlikely that there will be significant contamination arising at the mussel farm from sewage sources located outside of Hamar Voe. There are few identified sources of contamination within Hamar Voe. Although contamination sources associated with farm animals and watercourses indicate that the eastern and southern sides of the mussel farm may be impacted to the greatest extent, other data shows that sources located closer to the head of the voe may be more important and may have a more significant effect on water quality at the fishery.

17. Recommendations

Production area

It is recommended that the production area boundaries be maintained as those given in the pRMP assessment. That is, the area bounded by lines drawn from HU 3066 7638 to HU 3081 7631 and from HU 3015 7606 to HU 3015 7589 and extending to MHWS.

RMP

It is recommended that the RMP be moved to the northeastern corner of the present mussel lines, in the vicinity of the recent reported sampling locations, in order to reflect contamination arising to the northeast of the mussel farm. The recommended location is: HU 3070 7613. The actual location of sampling should be recorded on each occasion using a GPS.

Tolerance

It is recommended that a tolerance of 40 m be applied in order to allow for drift of the lines.

Depth of sampling

It is recommended that sampling be undertaken from the top 1 m of the lines in order to reflect the anticipated effect of freshwater inputs and the results seen in the shoreline survey.

Frequency

It is recommended that sampling be undertaken monthly.

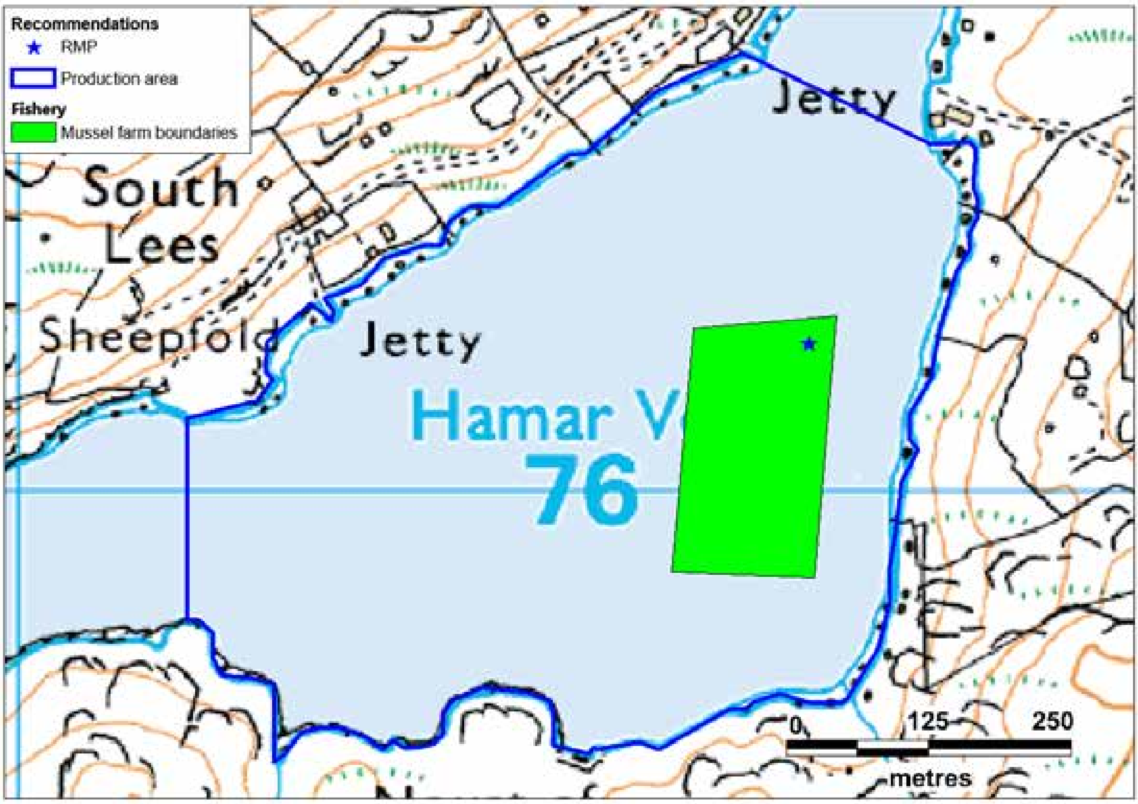


Figure 17.1 Map of recommendations at Hamar Voe

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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.

Otter

The European Otter (*Lutra lutra*) is present around Scotland with some areas hosting populations of international significance. Coastal otters tend to be more active during the day, feeding on bottom-dwelling fish and crustaceans among the seaweed found on rocky inshore areas. An otter will occupy a home range extending along 4-5km of coastline, though these ranges may sometimes overlap (Scottish National Heritage, n.d.). Otters primarily forage within the 10 m depth contour and feed on a variety of fish, crustaceans and shellfish (Paul Harvey, Shetland Sea Mammal Group, personal communication).

Otters leave faeces (also known as spraint) along the shoreline or along streams, which may be washed into the water during periods of rain.

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2. Tables of Typical Faecal Bacteria Concentrations

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

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

comparing base- and high-flow GMs for each group and type.

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

Table 3 – Geometric mean (GM) and 95% confidence intervals (CIs) of the GM faecal indicator organism (FIO) concentrations (cfu/100ml) under base- and high-flow conditions at the 205 sampling points and for various subsets, and results of paired t-tests to establish whether there are significant elevations at high flow compared with base flow

FIO	*n*	Base Flow			High Flow		
Subcatchment land use		Geometric mean	Lower 95% CI	Upper 95% CI	Geometric mean[a]	Lower 95% CI	Upper 95% CI
Total coliforms							
All subcatchments	205	5.8×10^{3}	4.5×10^{3}	7.4×10^{3}	7.3×10^{4}**	5.9×10^{4}	9.1×10^{4}
Degree of urbanisation							
Urban	20	3.0×10^{4}	1.4×10^{4}	6.4×10^{4}	3.2×10^{5}**	1.7×10^{5}	5.9×10^{5}
Semi-urban	60	1.6×10^{4}	1.1×10^{4}	2.2×10^{4}	1.4×10^{5}**	1.0×10^{5}	2.0×10^{5}
Rural	125	2.8×10^{3}	2.1×10^{3}	3.7×10^{3}	4.2×10^{4}**	3.2×10^{4}	5.4×10^{4}
Rural subcatchments with different dominant land uses							
≥75% Imp pasture	15	6.6×10^{3}	3.7×10^{3}	1.2×10^{4}	1.3×10^{5}**	1.0×10^{5}	1.7×10^{5}
≥75% Rough Grazing	13	1.0×10^{3}	4.8×10^{2}	2.1×10^{3}	1.8×10^{4}**	1.1×10^{4}	3.1×10^{4}
≥75% Woodland	6	5.8×10^{2}	2.2×10^{2}	1.5×10^{3}	6.3×10^{3}*	4.0×10^{3}	9.9×10^{3}
Faecal coliform							
All subcatchments	205	1.8×10^{3}	1.4×10^{3}	2.3×10^{3}	2.8×10^{4}**	2.2×10^{4}	3.4×10^{4}
Degree of urbanisation							
Urban	20	9.7×10^{3}	4.6×10^{3}	2.0×10^{4}	1.0×10^{5}**	5.3×10^{4}	2.0×10^{5}
Semi-urban	60	4.4×10^{3}	3.2×10^{3}	6.1×10^{3}	4.5×10^{4}**	3.2×10^{4}	6.3×10^{4}
Rural	125	8.7×10^{2}	6.3×10^{2}	1.2×10^{3}	1.8×10^{4}**	1.3×10^{4}	2.3×10^{4}
Rural subcatchments with different dominant land uses							
≥75% Imp pasture	15	1.9×10^{3}	1.1×10^{3}	3.2×10^{3}	5.7×10^{4}**	4.1×10^{4}	7.9×10^{4}
≥75% Rough Grazing	13	3.6×10^{2}	1.6×10^{2}	7.8×10^{2}	8.6×10^{3}**	5.0×10^{3}	1.5×10^{4}
≥75% Woodland	6	3.7×10	1.2×10	1.2×10^{2}	1.5×10^{3}**	6.3×10^{2}	3.4×10^{3}
Enterococci							
All subcatchments	205	2.7×10^{2}	2.2×10^{2}	3.3×10^{2}	5.5×10^{3}**	4.4×10^{3}	6.8×10^{3}
Degree of urbanisation							
Urban	20	1.4×10^{3}	9.1×10^{2}	2.1×10^{3}	2.1×10^{4}**	1.3×10^{4}	3.3×10^{4}
Semi-urban	60	5.5×10^{2}	4.1×10^{2}	7.3×10^{2}	1.0×10^{4}**	7.6×10^{3}	1.4×10^{4}
Rural	125	1.5×10^{2}	1.1×10^{2}	1.9×10^{2}	3.3×10^{3}**	2.4×10^{3}	4.3×10^{3}
Rural subcatchments with different dominant land uses							
≥75% Imp. pasture	15	2.2×10^{2}	1.4×10^{2}	3.5×10^{2}	1.0×10^{4}**	7.9×10^{3}	1.4×10^{4}
≥75% Rough Grazing	13	4.7×10	1.7×10	1.3×10^{2}	1.2×10^{3}**	5.8×10^{2}	2.7×10^{3}
≥75% Woodland	6	1.6×10	7.4	3.5×10	1.7×10^{2}**	5.5×10	5.2×10^{2}

[a] Significant elevations in concentrations at high flow are indicated: **po0.001, *po0.05.

[b] Degree of urbanisation categorised according to percentage built-up land: 'Urban' (X10.0%), 'Semi-urban' (2.5–9.9%) and 'Rural' (o2.5%).

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

Table 4 - Comparison of faecal indicator concentrations (average numbers/g wet weight) excreted in the faeces of warm-blooded animals

Animal	**Faecal coliforms (FC) number**	**Excretion (g/day)**	**FC Load (numbers/day)**
Chicken	1,300,000	182	2.3×10^{8}
Cow	230,000	23,600	5.4×10^{9}
Duck	33,000,000	336	1.1×10^{10}
Horse	12,600	20,000	2.5×10^{8}
Pig	3,300,000	2,700	8.9×10^{8}
Sheep	16,000,000	1,130	1.8×10^{10}
Turkey	290,000	448	1.3×10^{8}
Human	13,000,000	150	1.9×10^{9}

Source: (Gauthier & Bedard, 1986)

References

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

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

Kay, D. et al., 2008b. Faecal indicator organism in concentration sewage and treated effluents. *Water Research,* 42(1/2), pp. 442-454.

3. Hydrographic Assessment Glossary

The following technical terms may appear in the hydrographic assessment.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4. Hydrographic Section Appendix

Table 1: Hydrographic survey details

Site Name	NGR	Survey Period	Equipment
Hamar Voe	HU 30232 75977	04/04/00 – 20/04/00	Sensordata SD6000
Hamar Sound	HU 29733 75906	16/12/06 – 17/01/07	Nortek 500 kHz ADCP

Table 2: Hydrographic survey summary statistics

Parameter	Units	Near-surface / Mid-depth / Near-bottom	Hamar Voe 2000	Hamar Sound 2007
Mean speed	**m/s**	Near-surface	0.019	0.046
		Mid-depth	0.014	0.046
		Near-bottom	0.036	0.048
Tidal major axis	**°Grid**	Near-surface	255	085
		Mid-depth	095	265
		Near-bottom	090	265
Amplitude anisotropy	**-**	Near-surface	1.98	1.60
		Mid-depth	2.08	1.57
		Near-bottom	6.79	1.62
Residual speed	**m/s**	Near-surface	0.011	0.008
		Mid-depth	0.009	0.004
		Near-bottom	0.033	0.008
Residual direction	**°Grid**	Near-surface	230	171
		Mid-depth	117	191
		Near-bottom	078	245
Vector averaged residual	**-**		0.011 m/s at 098° Grid	0.005 m/s at 204° Grid
Tidal excursion	**km**	Near-surface	0.40	0.89
		Mid-depth	0.31	0.90
		Near-bottom	0.84	0.94

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 currents along the tidal major axis.

5. Shoreline Survey Report

Shoreline Survey Report

Production Area: Hamar Voe
Site Name & SIN: Hamar Voe SI-655-1404-08
Harvesters: **Blueshell Mussels:** Michael Laurenson
Local Authority: Shetland Islands Council
Status: Existing area
Date surveyed: 20 October 2014
Surveyed by: Sean Williamson (Hall Mark Meat Hygiene Ltd.)
Alan Harpin (SSQC Ltd.)
Helena Mackay (SSQC Ltd.)
We are grateful to Blueshell Mussels for providing assistance during the marine survey work.
Provisional RMP: HU 3071 7621 *(E.coli)*
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 4-14.

Weather

Monday 20 October 2014

A moderate westerly F3-F4 breeze persisted throughout the period of the shoreline survey with freshening south westerly winds during the boat work. Scattered cloud with sunny spells continued throughout the day.

Preceding the shoreline survey, Sunday 19 October was overcast with some light rain showers with southerly F3-F4 winds occasionally increasing F5 and veering westerly by evening. Saturday 18 October started with mainly southerly winds gusting up to F7 overnight before easing to F3-F4 later in the day. Conditions remained overcast with some rain throughout the day.

Fishery

The location of the mussel lines for the Northmavine fishery is mapped in Figure 1. The fishery had stocked mussel lines on site. Harvesting at this site is carried out as and when required in conjunction with further sites to maintain Blueshell Mussels' supply.

The Northmavine fishery consisted of 6 x 220m long mussel lines positioned adjacent to the Hamar shoreline on the eastern coast of Hamar Voe (Figures 4 & 5). All lines were double-headed longlines with 10m droppers. The site is licenced for six 220 metre twin-headline longlines. Mussel samples were collected from two locations on the fishery; one from the south east corner and the other from the north east corner (RMP) as specified on the plan.

Sewage/Faecal Sources

Hamar Voe is sparsely populated with a few properties scattered towards the head of the voe and in the majority of cases these are located away from the shore. Six dwellings were recorded during the shoreline walk, one of which was abandoned. One possible septic tank, within the property boundary of a dwelling house some distance from the shore, was noted near the end of the shoreline walk at South Lees. No other septic tanks were observed during the survey.

Shore base facilities associated with aquaculture sites, operated by Grieg Seafood Hjaltland UK Ltd, are located on the eastern shore of Hamar Voe (Figures 6&7). No discharges were identified in the vicinity although there is believed to be an associated septic tank to service these work buildings which was not observed during the survey. A barge was situated on a site populated with Polarcirkel fish cages to the west of the Northmavine fishery (Figure 8). A member of staff at the shorebase reported that sanitary facilities aboard the barge were due to be upgraded with a chemical system in the near future.

Sample analysis

Seven freshwater samples were obtained from watercourses around the Hamar Voe production area, five on the eastern shore and two from the head of the voe. Five sampling points were outlined in the survey plan and all of these were collected. Two additional freshwater samples were collected; the first from a small unnamed watercourse in close proximity to a planned sample point (second in Table 3 of plan) before the two watercourses merged prior to entering the sea (Figure 9) and the second from a nearby watercourse flowing onto a pebbled beach in close proximity to the mussel lines (Figure 10). All watercourses sampled were found to have *E.coli* levels between 7-130 cfu/100 ml.

A total of three seawater samples were collected all of which were indicated in the sampling plan. Two samples were obtained from the Northmavine fishery; one from the south east corner and the other from the north east corner. A third sample was collected from the jetty in front of Grieg Seafood Hjlatland UK Ltd on the eastern shore of Hamar Voe. *E.coli* levels were between 50 to 400 cfu/100ml at all locations.

Four mussel samples were obtained from the fishery, again from the south east and north east corners, the latter having been designated as the provisional RMP for the site (Figure 11). Two samples were collected at each location, one from the top of a mussel dropper and one from the bottom of the dropper. The sample from the south east corner of the fishery returned results of 1,300 *E.coli* MPN/100g and 130 *E.coli* MPN/100g for the top and bottom samples respectively. At the north east corner levels were 3,500 *E.coli* MPN/100g and 40 *E.coli* MPN/100g for the top and bottom samples respectively.

Salinity profiles were obtained at the two locations described above. In both cases observed variation in salinity measurements with depth exceeded the accuracy value of the probe used (± 0.35 ppt) with a difference of between 8.21 ppt and 14.93 ppt present between the surface reading and the deepest measurement recorded. Surface salinity ranged from 20.09 ppt at the north east corner of the fishery to 26.72 ppt at the south east corner. The water was too shallow to collect a salinity measurement at a 10 metre depth from the south east corner.

Temperature profiles were also obtained from these locations. Both profiles showed little variation with depth (+/- 0.2°C). Surface temperature ranged from 11.2°C to 11.3°C. The water was too shallow to collect a temperature measurement at a 10 metre depth from the south east corner.

Salinities of the seawater samples analysed at the laboratory showed salinities ranging from 10.54 PSU present at the jetty in front of Grieg Seafood Hjlatland Ltd's shorebase, to 23.89 PSU present at the south east corner of the fishery.

Seasonal population

There is no guest house accommodation adjacent to, or in the vicinity of, the Northmavine fishery in Hamar Voe.

Boats/Shipping

Boat traffic within the Hamar Voe production area is largely associated with the fishery, salmon farming and creel fishing. The shore base operated by Grieg Seafood Hjaltland UK Ltd includes a pier and slipway where one workboat was present. One small fishing boat was at anchor near the head of the voe and further moorings were observed in this area (Figure 12).

Farming and Livestock

The majority of the land observed during the survey around the production area was either rough grazing or common grazing with some heathland. A total of approximately 192 sheep were observed during the shoreline walk with around 70 being recorded on the eastern shore and 82 on the western shore. Much of this livestock had access to the shore and faeces were frequently recorded near the shoreline. Forty sheep were noted at the head of the voe in a fenced field with no access to the shoreline. A sheep carcass was recorded in close proximity to a watercourse near the head of the voe (Figure 13). Faeces were noted 6 times where no animals were present. Access to some parts of the shoreline on both the eastern and western coastline may have been restricted through steep escarpments. Two cows were noted some distance from the shore nearing the head of the voe in an enclosed field. No other livestock were observed during the shoreline survey.

Land Use and Land Cover

Rough and common grazing dominates the coastline around Hamar Voe. The eastern shoreline is characterised by bedrock interspersed with rocky and pebbled beaches with high embankments limiting access to the shore in several places. Above the shoreline lies fenced grazing fields and open hill land with heather patches on higher ground. Low level grassland becomes more common approaching the head of the voe with some boggy areas noted. The head of the voe is again rough grazing with fenced fields providing limited access to a rocky shoreline. The western shoreline is made up of bedrock and rocky outcrops with a high coastline preventing access in places. Lower terrain consists of more accessible pebbled beaches though enclosed grazing fields were common in this area. Three fields which had been cut for silage were recorded during the shoreline walk; one each on the eastern and western coastlines and one at the head of the voe.

Watercourses

Seven watercourses were sampled during the shoreline survey, five of which were outlined on the sample plan. Two additional freshwater samples were collected; one from a small watercourse running onto the beach alongside a planned sample collection point, the other from a small watercourse entering the sea in close proximity to the fishery. Flow rates were recorded at each point sampled; flow rates for the watercourse identified as Burn of Sandy Lochs/Burn of Pundswater were measured before these two watercourses merged (Figure 14). Flow rates were also recorded from an additional 4 watercourses; 1 on the eastern shore, 1 at the head of the voe and 2 on the western shoreline of Hamar Voe.

Wildlife/Birds

Birds were observed throughout the survey. Snipes, common gulls, a plover and a crow were recorded on the eastern coastline of Hamar Voe and 9 geese in flight were sighted on the opposite side of the voe. A possible bird feeding site was identified near the beginning of the shoreline walk. Two snipes were noted at the head of the voe. On the western coastline, 3 common gulls, 7 curlews and 1 sparrow were sighted with 3 snipes being disturbed from a beach.

Rabbit faeces were noted on the eastern coastline.

Sixteen common gulls were recorded at the fishery and some bird faeces were observed on the mussel line buoys.

One seal was noted in the water on the eastern coastline and another was noted 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.

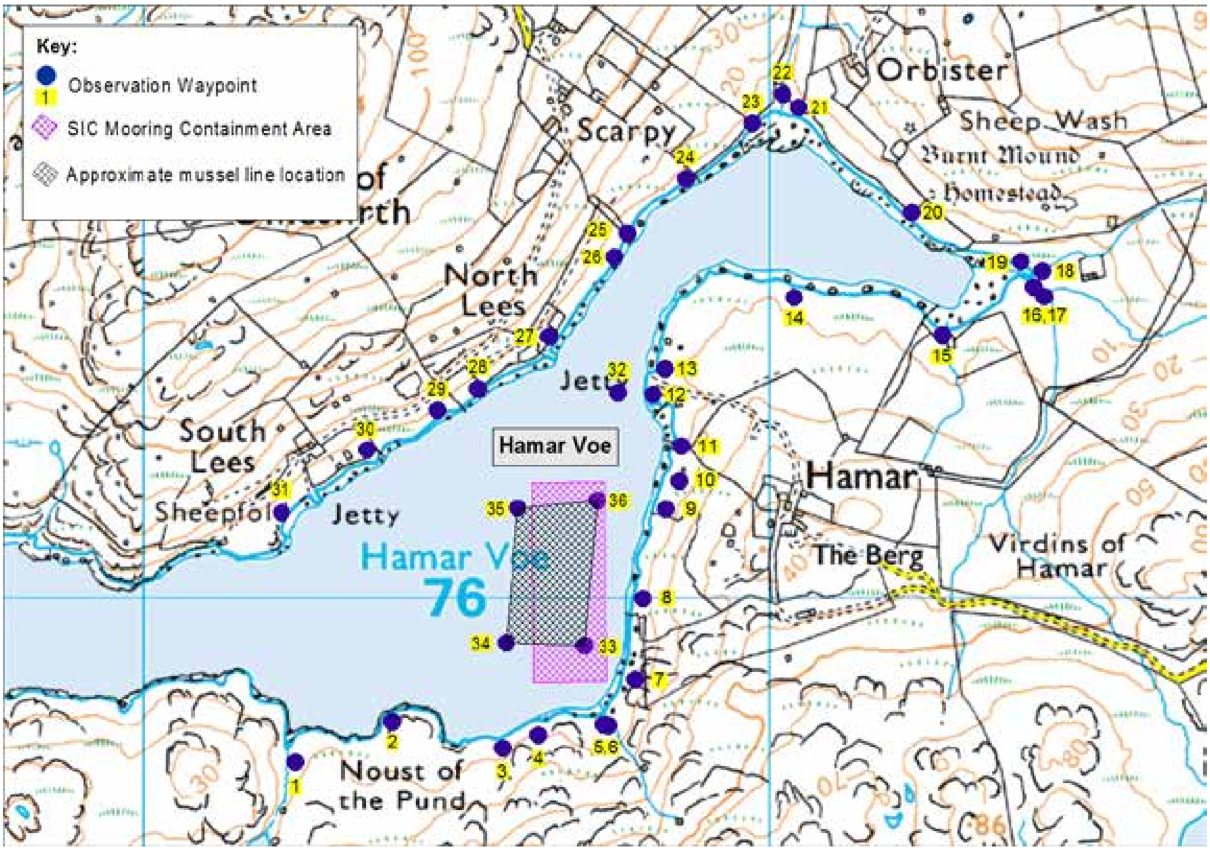

Figure 1 Map of shoreline observations Hamar Voe.

Table 1 Shoreline Observations

No.	Date/Time (UT)	NGR	Easting	Northing	Associated Figure	Associated Sample	Description
1	20/10/14 07:54:12	HU 30242 75737	430242	1175737		HAM-FW-01	Hamar Voe shoreline survey; start of shoreline walk. Weather: scattered clouds with some sunshine, F3-F4 moderate W breeze. Land cover beyond survey area was rough grazing with some heather patches on hills. Walk started at Mill Burn on the south east side of Hamar Voe. Planned freshwater sampled collected (first in Table 3 of plan) from Mill Burn which flows into Hamar Voe. Flow measurements recorded; 30cm wide, 27cm deep, flow 0.643cm/s, and SD 0.082cm/s. Sheep faeces present but limited access to shore at this point due to high cliff ledge.
2	20/10/14 08:03:34	HU 30397 75803	430397	1175803	Figure 4		Boggy area down at shore level. Sheep and rabbit faeces present. Access to stony beach possible. Some shell debris present higher up, possible bird feeding area. Approximately 30 sheep noted opposite on north side of the voe. 2 photos taken, 1 of fishery, 1 of barge associated with salmon farm.
3	20/10/14 08:09:38	HU 30573 75759	430573	1175759			Small boggy area with small flow of water onto rocky beach, flow too light to obtain measurements. Sheep faeces present above shoreline.
4	20/10/14 08:12:19	HU 30630 75781	430630	1175781	Figure 5		Land cover contains more heather and some moss. Some hill water run-off to shore. 1 plover noted. Photo taken looking

							north towards fishery.
5	20/10/14 08:15:20	HU 30734 75798	430734	1175798		HAM-FW-02	Unnamed small watercourse running down onto rocky beach. Freshwater sample collected, not on plan. Flow measurements recorded; 12cm wide, 5cm deep, flow 0.492cm/s and SD 0.022cm/s.
6	20/10/14 08:19:38	HU 30743 75795	430743	1175795	Figure 9	HAM-FW-03	Unnamed watercourse running down onto rocky beach in vicinity of planned sample (second in Table 3 of plan). Flow measurements recorded; 40cm wide, 15cm deep, flow 0.096cm/s and SD 0.012cm/s. Photo taken of this burn, also showing other unnamed watercourse (noted in observation no 5) in close proximity. Open hill land. 1 crow noted.
7	20/10/14 08:25:25	HU 30784 75870	430784	1175870	Figure 10	HAM-FW-04	Coastline becoming more accessible, rock and pebbled beaches. Fenced field above. Small watercourse running onto beach in close proximity to fishery (photo taken), freshwater sample collected (not on plan). Flow measurements recorded; 12cm wide, 5cm deep, flow 0.077cm/s and SD 0.024cm/s. 1 seal observed at sea.
8	20/10/14 08:32:49	HU 30797 75998	430797	1175998			Unfenced area with access to rocky beach. Sheep faeces present above shoreline. Some small boggy patches. 9 sheep and 2 common gulls noted.
9	20/10/14 08:35:56	HU 30835 76142	430835	1176142			36 sheep recorded with access to beach.

10	20/10/14 08:38:55	HU 30855 76187	430855	1176187			Some hill run-off through watercourse with thick vegetation. Flow measurements recorded; 20cm wide, 7cm deep, flow 0.072cm/s and SD 0.006cm/s. Sheep faeces present near shore.
11	20/10/14 08:40:03	HU 30858 76243	430858	1176243			Fenced grazing field. Field directly above cut for silage. Sheep prints present along narrow track between fence and shoreline.
12	20/10/14 08:43:08	HU 30813 76326	430813	1176326	Figures 6 & 7	HAM-SW-01	Shorebase and pier with buildings and equipment associated with salmon farm. No septic tank or discharges observed. 1 workboat. Planned seawater sample collected (as marked on map provided in plan). 3 photos taken of shorebase, pier and buildings, indicating proximity of fishery.
13	20/10/14 08:51:26	HU 30833 76366	430833	1176366			Rough grazing with easily accessible shoreline. Some heather patches. Sheep faeces present. 1 snipe recorded. 9 geese in flight on opposite side of voe.
14	20/10/14 08:58:53	HU 31039 76480	431039	1176480	Figure 12		Shoreline dominated by stony beach with low level grassland above. 3 houses on hill above some distance from the shore. 2 cattle noted in field near dwelling houses. 1 small fishing boat at anchor in voe and several more moorings were observed (photo taken). Sheep faeces present near shoreline.

15	20/10/14 09:07:19	HU 31277 76420	431277	1176420		HAM-FW-05	Small unnamed watercourse running into sea, planned freshwater sample collected from here (third in Table 3 of plan). Flow measurements recorded; 40cm wide, 6cm deep, flow 0.075cm/s and SD 0.016cm/s. Low level grass cover and shingle beach beyond with fenced field above. Some boggy areas.
16	20/10/14 09:15:13	HU 31422 76497	431422	1176497		HAM-FW-06	Larger burn running into sea at head of voe (from 2 tributaries further up - Burn of Sandy Lochs/Burn of Pundswater). Planned freshwater sample collected (fourth in Table 3 of plan). Photo taken of watercourse entering sea.
17	20/10/14 09:19:15	HU 31439 76482	431439	1176482	Figure 14		Flow measurements recorded from points before 2 watercourses joined. Larger flow - 180cm wide, 15cm deep, flow 0.563cm/s and SD 0.044cm/s. Smaller flow - 20cm wide, 20cm deep, flow 0.642cm/s and SD 0.015cm /s.
18	20/10/14 09:21:28	HU 31436 76522	431436	1176522	Figure 13		Ditched watercourse running to sea. Sheep carcass in close proximity to bank. Flow measurements recorded; 25cm wide, 6cm deep, flow 0.256cm/s and SD 0.016cm/s.
19	20/10/14 09:24:05	HU 31401 76537	431401	1176537			Pebbled beach with rough grazing above. Boggy area with Iris growing near shoreline. Some sheep faeces present.
20	20/10/14 09:28:22	HU 31227 76615	431227	1176615			Fenced silage field above shore, no access to beach. Approximately 40 sheep in field. 1 house on hill above.

21	20/10/14 09:35:30	HU 31046 76783	431046	1176783			Pebbled beach at NE end of voe. Rough grazing above with limited access to shore. 2 snipes noted. Photo of Burn of Eelawater entering sea.
22	20/10/14 09:40:49	HU 31021 76805	431021	1176805		HAM-FW-07	Burn of Eelawater, position of planned freshwater sample collected (fifth in Table 3 of plan). Flow measurements recorded; 200cm wide, 35cm deep, flow 0.396cm/s and SD 0.032cm/s
23	20/10/14 09:45:44	HU 30973 76758	430973	1176758			Fenced field above shoreline, sheep faeces present, no access to shore. Seal noted in sea. 1 common gull.
24	20/10/14 09:49:14	HU 30866 76670	430866	1176670			Field open to shore, high coastline so limited access. Bracken abundant. 3 sheep recorded.
25	20/10/14 09:54:39	HU 30773 76581	430773	1176581			Small watercourse running into sea. Flow measurements recorded; 20cm wide, 10cm deep, flow 0.139cm/s and SD 0.009cm/s.
26	20/10/14 09:57:42	HU 30752 76545	430752	1176545			Rocky beach with limited access to shore. Sheep faeces above shoreline.
27	20/10/14 10:00:56	HU 30648 76418	430648	1176418			Abandoned house near shoreline. 21 sheep on hill above. 1 common gull. 1 photo looking E across voe to shorebase; 1 photo looking SE to fishery.
28	20/10/14 10:11:16	HU 30534 76335	430534	1176335			Grazing area walled by dyke at 3 sides, access to shoreline, sheep faeces present. 7 curlews noted. 1 sparrow.
29	20/10/14 10:14:35	HU 30470 76300	430470	1176300			Rough grazing area with sheep faeces present above shoreline. 21 sheep counted with access to stony beach.

30	20/10/14 10:18:25	HU 30356 76236	430356	1176236			Rough grazing field. 1 dwelling house on hill above, possible septic tank within property boundary. 7 sheep with access to shoreline. Small stream running onto beach (photo taken). Flow measurements recorded; 15cm wide, 5cm deep, flow 0.283cm/s and SD 0.036cm/s. 3 snipes disturbed from beach. 1 common gull.
31	20/10/14 10:23:51	HU 30220 76136	430220	1176136	Figure 8		Area of field cut for silage. Sheep faeces present, access to pebbled beach. 25 sheep with shore access noted across on east side of voe. Photo looking SW to barge and salmon cages within Hamar Voe. End of shoreline walk. Weather increasingly sunny.
32	20/10/14 11:39:30	HU 30758 76328	430758	1176328			Start of boat work from jetty on east coast of Hamar Voe. Weather overcast. Wind freshening F4 from south west. Peaty discolouration in water appearance.
33	20/10/14 11:41:25	HU 30704 75923	430704	1175923		HAM-MUSS-01 (top) & HAM-MUSS-02 (Bottom), HAM-SW-02	SE corner of Hamar Voe fishery. Fishery consists of 6 double headed long lines positioned adjacent to the Hamar shoreline, running N-S. 2 mussel samples collected; surface sample collected from the top of a dropper, bottom sample collected from the bottom of a dropper. Seawater sample collected. Salinity Profile 1 collected (ppt/°C): 10m no reading taken - not enough depth, 5m 34.93/11.4, 3m 34.68/11.40, surface 26.72/11.30.
34	20/10/14 11:53:00	HU 30578 75928	430578	1175928			SW corner of fishery
35	20/10/14 11:56:05	HU 30597 76143	430597	1176143			NW corner of fishery

36	20/10/14 11:58:17	HU 30724 76155	430724	1176154	Figure 11	HAM-MUSS-03 (top) & HAM-MUSS-04 (bottom), HAM-SW-03	NE corner of fishery. 2 mussel samples collected; surface sample collected from the top of a dropper, bottom sample collected from the bottom of a dropper. Seawater sample collected. Salinity Profile 2 collected (ppt/°C): 10m 35.02/11.3, 5m 34.92/11.3, 3m 34.63/11.40, surface 20.09/11.20. Some bird faeces on buoys at the fishery. 16 common gulls noted. Photo taken looking SW across fishery. End of boat work.

Sampling

Water and shellfish samples were collected at the locations indicated in Figures 2 and 3. All five of the freshwater samples detailed in the survey plan were obtained, as well as two additional samples taken from watercourses running into Hamar Voe from the eastern coastline. 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	HAM-FW-01	20/10/14 07:54:12	HU 30242 75737	FW	130	-
2	HAM-FW-02	20/10/14 08:15:20	HU 30734 75798	FW	7	-
3	HAM-FW-03	20/10/14 08:19:38	HU 30743 75795	FW	70	-
4	HAM-FW-04	20/10/14 08:25:25	HU 30784 75870	FW	50	-
5	HAM-SW-01	20/10/14 08:43:08	HU 30813 76326	SW	400	10.54
6	HAM-FW-05	20/10/14 09:07:19	HU 31277 76420	FW	40	-
7	HAM-FW-06	20/10/14 09:15:13	HU 31422 76497	FW	50	-
8	HAM-FW-07	20/10/14 09:40:49	HU 31021 76805	FW	130	-
9	HAM-SW-02	20/10/14 11:41:25	HU 30704 75923	SW	50	23.89
10	HAM-SW-03	20/10/14 11:58:17	HU 30724 76155	SW	70	20.2

*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	HAM-MUSS-01	20/10/14 11:41:25	HU 30704 75923	Common Mussel	Top	1300
2	HAM-MUSS-02	20/10/14 11:41:25	HU 30704 75923	Common Mussel	Bottom	130
3	HAM-MUSS-03	20/10/14 11:58:17	HU 30724 76155	Common Mussel	Top	3500
4	HAM-MUSS-04	20/10/14 11:58:17	HU 30724 76155	Common Mussel	Bottom	40

Table 4 Salinity profiles

Profile	Date/Time (UT)	Position	Depth (m)	Salinity (ppt) (± 0.35 ppt)	Temperature (°C)
1	20/10/14 11:41:25	HU 30704 75923	Surface	26.72	11.3
			3	34.68	11.4
			5	34.93	11.4
			10	n/a	n/a
2	20/10/14 11:58:17	HU 30724 76155	Surface	20.09	11.2
			3	34.63	11.4
			5	34.92	11.3
			10	35.02	11.3

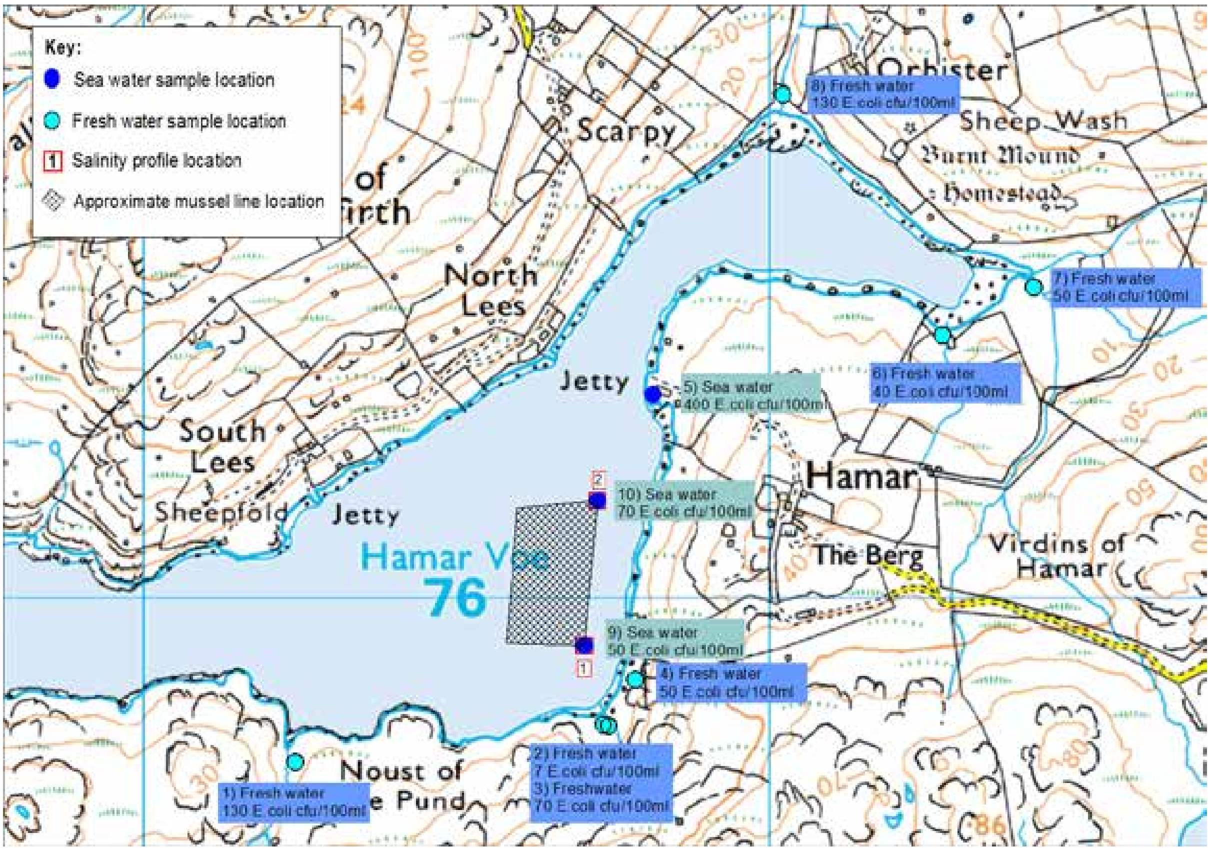

Figure 2 Map of water sample results and salinity profile locations Hamar Voe.

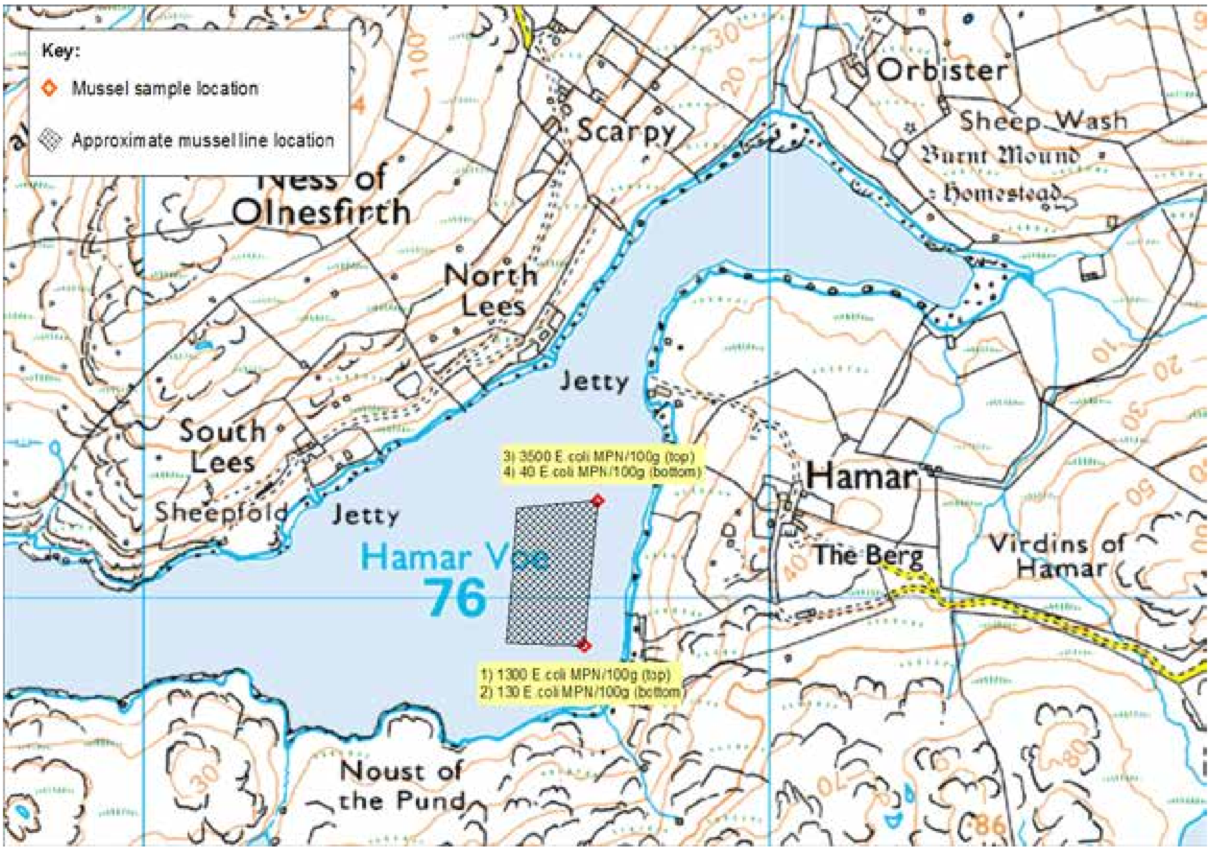

Figure 3 Map of shellfish sample results Hamar Voe.

Photographs

Figure 4 – Mussel lines at the Hamar Voe fishery, looking north-east

Figure 5 – Mussel lines at the Hamar Voe fishery

Figure 6 – Grieg Seafood Hjaltland UK Ltd’s shorebase at Hamar Voe

Figure 7 – Pier associated with Grieg Seafood Hjaltland UK Ltd’s shorebase

Figure 8 – Barge associated with salmon farm, looking south-west

Figure 9 – Unnamed watercourses flowing onto beach on eastern coastline

Figure 10 – Small watercourse running onto beach in close proximity to fishery

Figure 11 – Photo from RMP at north-east corner of fishery

Figure 12 – Small fishing boat and numerous moorings nearing head of Hamar Voe

Figure 13 – Sheep carcass in close proximity to watercourse near head of voe


Figure 14 – Confluence of the Burn of Sandylochs and the Burn of Pundswater

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6. SEPA Discharge Consents

Licence Number	National Grid Reference	Site Name	Location Description	Treatment Tyoe	Discharges to	PE
CAR/L/1002242	HU 2820 7700	Hillswick Public Conveniences, Hillswick	Hillswick Public Conveniences, Hillswick, Hillswick	Sewage (Public) Untreated		
CAR/L/1002283	HU 30065 78409	Urafirth Outfall, Valladale, Urafirth	Urafirth STW, FE to Ura Firth, Valladale, Shetland	Sewage (Public) Primary	Ura Firth	250
CAR/L/1002860	HU 28678 77146	Stucca WwTP, Hillswick	Stucca STW, FE to Ura Firth, Hillswick, Shetland	Sewage (Public) Primary	Ura Firth	164
CAR/L/1004029	HU 3110 7420	Gunnister	MCFF at Gunnister Voe, Shetland	Fish Farm Marine Cage		
CAR/L/1004030	HU 30500 76000	Hamar Voe MCFF, Ollaberry	Hamar MCFF, Hamar Voe, Hamar, Shetland	Fish Farm Marine Cage		
CAR/L/1004155	HU 28285 77026	East Ayre PS, EO to Hills Wick, Ura Firth	East Ayre PS, EO to Hills Wick, Ura Firth, Shetland	Sewage (Public) Emergency Overflow (EO)	Hills Wick	
CAR/L/1015710	HU 31150 74154	Gunnister Voe North MCFF, Ollaberry	Gunnister Voe North MCFF, Gunnister Voe, Hamar, Shetland	Fish Farm Marine Cage		
CAR/L/1015760	HU 30978 73854	Gunnister Voe South MCFF, Ollaberry	Gunnister Voe South MCFF, Gunnister Voe, Hamar, Shetland	Fish Farm Marine Cage		
CAR/L/1025498	HU 30370 73580	Gunnister Voe, Nibon, Northmavine	Gunnister Voe North Sound MCFF, Nibon, Shetland	Fish Farm Marine Cage		
CAR/L/1025503	HU 29730 75930	Hamar Sound, Hamar, Northmavine	Hamar Sound MCFF, Hamar Voe, Shetland	Fish Farm Marine Cage		
CAR/L/1025504	HU 29330 77160	Geo of Valladale, Ura Firth, Hillswick	Geo of Valladale MCFF, Ura Firth, Shetland	Fish Farm Marine Cage		
CAR/R/1027207	HU 29270 78050	Sjovik, Hillswick, Shetland	Sjovik, STE to soakaway, Hillswick, Shetland	Sewage (Private) Primary	Soakaway	7

Licence Number	National Grid Reference	Site Name	Location Description	Treatment Tyoe	Discharges to	PE
CAR/R/1039925	HU 29080 77890	Hillswick Shetland	STE to soakaway, Hillswick, Shetland	Sewage (Private) Primary	Soakaway	6
CAR/R/1051773	HU 30370 78900	Upper Urafirth, Shetland	STE to Soakaway, Upper Urafirth	Sewage (Private) Primary	Soakaway	8
CAR/R/1051794	HU 30440 78960	Upper Urafirth, Shetland	STE to soakaway, Upper Urafirth, Shetland	Sewage (Private) Primary	Soakaway	5
CAR/R/1071246	HU 30260 78510	Four properties Shetland	STE to soakaway, Shetland	Sewage (Private) Primary	Soakaway	20
CAR/R/1076630	HU 30580 73330	Two cottages Hamar, Shetland	STE to soakaway, Hamar	Sewage (Private) Primary	Soakaway	10
CAR/R/1102714	HU 30250 78550	Urafirth, Shetland	STE to soakaway, Urafirth, Shetland	Sewage (Private) Primary	Soakaway	9
CAR/R/1108420	HU 29340 78310	Hillswick, Shetland	STE to soakaway, Hillswick	Sewage (Private) Primary	Soakaway	6
CAR/R/1109733	HU 29130 78020	Hillwick, Shetland	Hillwick, Shetland - STE to soakaway	Sewage (Private) Primary	Soakaway	5
CAR/R/1117496	HU 29540 78740	Swarthoull, Shetland	Swarthoull, STE to Land, Heylor,	Sewage (Private) Primary	Land	5
CAR/R/1118409	HU 28760 77910	Hillswick, Shetland	STE to Soakaway, Hillswick, Shetland	Sewage (Private) Primary	Soakaway	5