Scottish Sanitary Survey Report

Sanitary Survey Report
Basta Voe Cove
SI-232 and SI-324
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Cefas

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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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Appendices

I. Executive Summary

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

The purpose of the sanitary survey is to demonstrate compliance with the requirements stated in Annex II (Chapter II Paragraph 6) of Regulation (EC) 854/2004. The sanitary survey results in recommendations on the location of RMPs, the frequency of sampling for microbiological monitoring, and the boundaries of the production areas deemed to be represented by the RMPs. A sanitary survey was undertaken on the classified mussel fishery at Basta Voe Cove on the basis recommended in the European Union Reference Laboratory publication: "Microbiological Monitoring of Bivalve Mollusc Harvesting Area Guide to Good Practice: Technical Application" (http://www.cefas.defra.gov.uk/nrl/information-centre/eu-good-practice-guide.aspx). This areas was selected for survey at this time based on a risk-based ranking amongst those Scottish production areas that had yet to receive a survey.

Basta Voe is located on the northeast side of Yell, one of the more northerly Shetland Islands. The area is very lightly populated, with individual farms and a pier and shore base on the west side, and small settlements along the east side.

The production area contains two long-line mussel farms, one of which is comprised of three separate sets of longlines along the west shore of the voe and the other of which is a single block of long lines near the east shore of the voe.

The main sources of contamination to the area are diffuse faecal contamination from livestock, mainly sheep, grazed along the northern shores of the voe and two small consented discharges of septic tank effluent to sea along the east shore of the voe.

The main pathway for contamination is via freshwater input from watercourses and runoff from land. Sheep have access to the shoreline, and direct deposition of droppings on the foreshore is likely to also be a significant source. Within the voe, wind direction will dictate the direction of particle transport and maximum transport distances are estimated to be 3.1 km. A bacteriological survey was undertaken, which showed highest results at the northern end of the northern set of lines on the west side of the voe.

It is recommended that the production area boundaries be amended to exclude the identified point source discharges on the east side and the head of the voe north of the road bridge, and that the RMP be moved to the HU 5171 9758, on the northernmost mussel farm site.

II. Sampling Plan

Production Area	Basta Voe Cove
Site Name	Inner-Site1-Thomason (Colvister)
SIN	SI 323-399-08
Species	Common mussels
Type of Fishery	Long-line aquaculture
NGR of RMP	HU 5171 9758
East	451710
North	1197580
Tolerance (m)	40
Depth (m)	1-3
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 Boundary	The area bounded by lines drawn between HU 5263 9620 and HU 5193 9578, HU 5196 9774 and HU 5215 9763, HU 5108 9878 and HU 5114 9881 and extending to MHWS

III. Report

1. General Description

Basta Voe is an inlet on the north-eastern coast of Yell, part of the Shetland Isles. The area is part of the Shetland Islands Council.

Basta Voe is approximately 5.2 km in length and is 2 km wide at its mouth, and has a south-easterly aspect. The voe is largely between 10 and 20 metres deep.

The area around Basta Voe is sparsely inhabited with the small settlements of Basta and Colvister on the south west coast and the settlements of Cunnister and Sellafirth on the North West coast.

A sanitary survey was undertaken on the classified fishery at Basta Voe Cove on the basis recommended in the European Union Reference Laboratory publication: "Microbiological Monitoring of Bivalve Mollusc Harvesting Area Guide to Good Practice: Technical Application" (http://www.cefas.defra.gov.uk/nrl/information-centre/eu-good-practice-guide.aspx). This production area was selected for survey at this time based on a risk-based ranking of the area amongst those in Scotland that have yet to receive sanitary surveys.

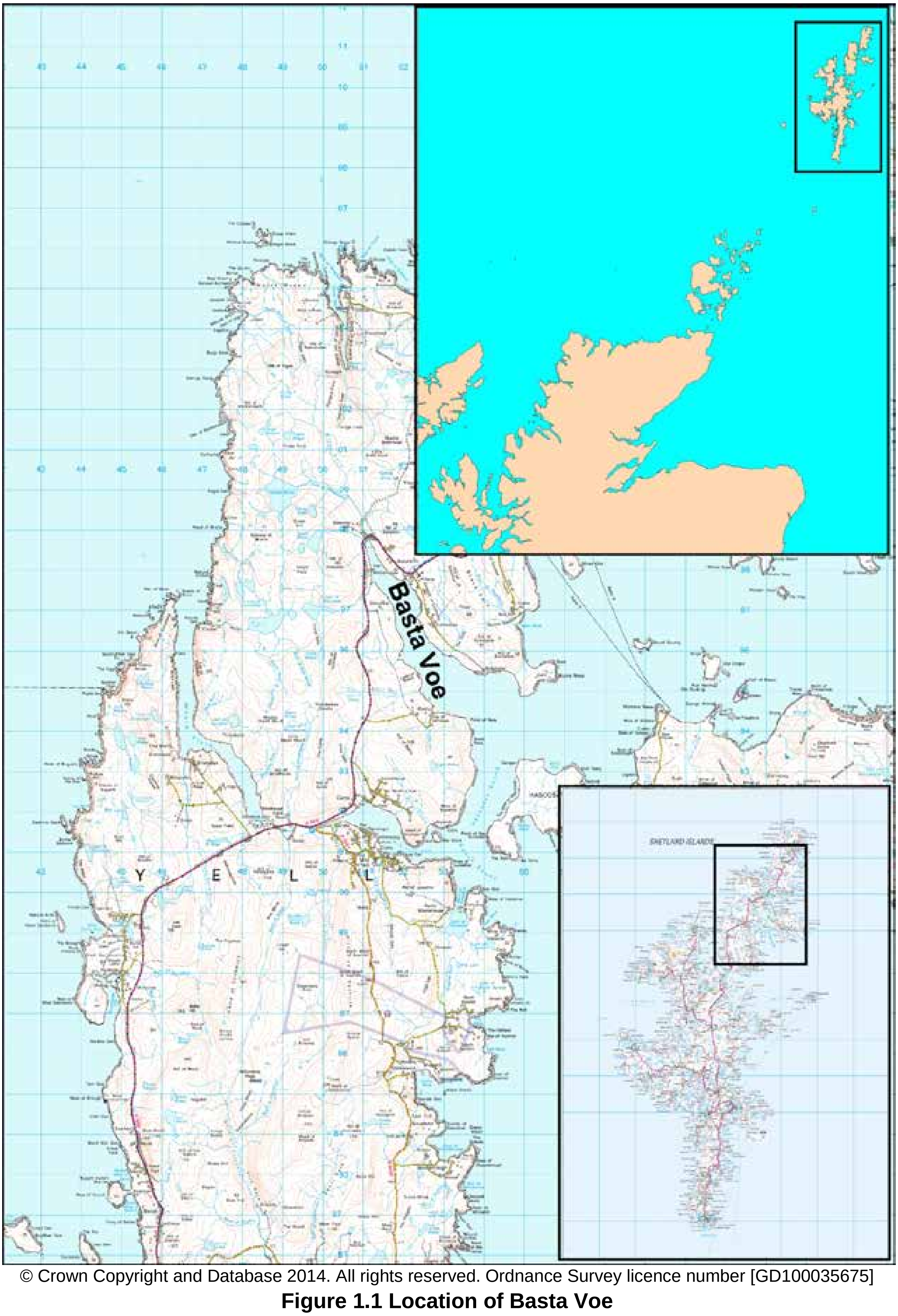

Figure 1.1 Location of Basta Voe

2. Fishery

The fishery at Basta Voe Cove is comprised of two long-line common mussel (*Mytilus edulis*) farms. Details of the sites as given in the 2014-2015 classification document are presented in Table 2.1.

Table 2.1 Basta Voe Cove shellfish farms

Production area	Site	SIN	Species	RMP
Basta Voe Cove	Inner-Site 2-Nisbet	SI-324-400-08	Common mussels	HU 5223 9724
Basta Voe Outer	Inner-Site 1-Thomason	SI 323-399-08	Common mussels	*

* Currently classified under Basta Voe Outer production area, which has its RMP at HU 5294 9568

The Basta Voe Outer production area was subject to a sanitary survey in 2012. Both Inner-Site 1-Thomason and Inner-Site 2-Nesbit were found to straddle the two production areas, so agreement was obtained from FSAS to consider only the sites identified as Outer and Basta Ness in the Basta Voe Outer sanitary survey, as these were the only sites wholly located within the Basta Voe Outer production area at that time (Cefas/FSAS, 2012). The other two sites were to be considered under a survey of the Basta Voe Cove production area. The recommendations arising from that sanitary survey established the basis for the Basta Voe Outer production area boundaries as they are currently defined. The Basta Voe Cove production area boundaries were then modified by FSAS to abut the new northern boundary for Basta Voe Outer. Inner-Site 1-Thomason had not yet been moved into the Basta Voe Cove production area, however this is anticipated to occur on completion of this survey. The Basta Voe Cove production area is currently defined as the area bounded by lines between HU 5263 9620 and HU5193 9578 extending to MHWS.

At the time of the 2014 shoreline survey, Inner Site 1 (Thomason) was comprised of three discrete farm areas running parallel to the west shore of the voe; these have been designated as North, Mid and South for ease of reference. This site is known to the harvester as Colvister. Inner Site 2 (Nisbet) is a single block of lines on the east side of the voe. Both sites had 8 metre droppers. Table 2.2 shows the equipment present on each farm site.

Table 2.2 Aquaculture equipment at Basta Voe Cove shellfish farms

Site	Equipment
Site 1 Thomason (N)	2 double-headed long-lines
Site 1 Thomason (mid)	4 quad-headed long-lines
Site 1 Thomason (S)	1 double-headed long-lines, 4 quad-headed long-lines
Site 2 Nisbet	9 double-headed long-lines

Locations of the mussel farms, production areas and RMPs are shown in Figure 2.1. Due to weather conditions and poor manoeuvrability of the work boat used, it was not possible for surveyor to pass very close to the some of the ends of the mussel farms, and in these cases the point locations were estimated by the surveyor (details of the points affected can be found in Appendix 5.) No location was taken for the south-east corner of Site 1 Thomason (S) so this point was estimated using the satellite image overlay in MapInfo.

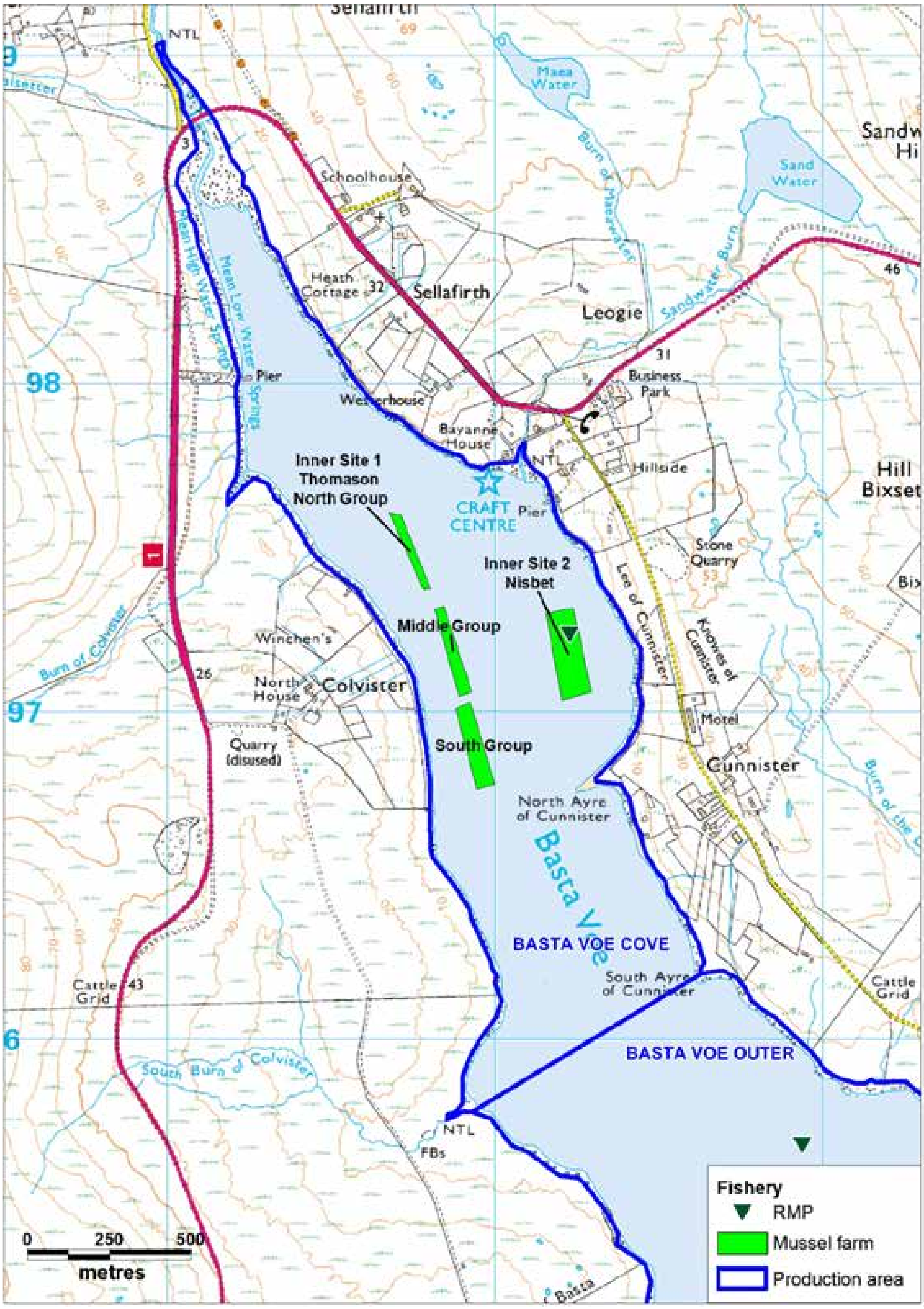

Figure 2.1 Basta Voe Cove fishery

3. Human Population

Information was obtained on the population within the vicinity of Basta Voe Cove production area from the General Register Office for Scotland. The last census was undertaken in 2011. The census output areas surrounding the Basta Voe Cove production area are listed in Table 3.1 They are shown thematically mapped by population density in Figure 3.1.

Table 3.1 Census output areas and population – Basta Voe Cove

Census Output Area ID	Population	Area (km^2)	Density (persons/km^2)
S00059433	111	65	1.7
S00059508	195	30	6.5

Only one output area actually adjoins the voe, and this has a population density of 1.7 persons/km^2. The main transport link for the island, the A968, passes within 1 km of the west side of the voe, skirting close to the head of Basta Voe before continuing eastward toward the ferry terminal at Gutcher. There are only a small number of individual dwelling along the west side of the voe at Basta and Colvister. The majority of the population around the voe live along the east side of the voe, around Sellafirth and Cunnister, however even on this side of the voe there are only small numbers of homes around each settlement. There is no known tourist accommodation in any of the settlements adjacent to Basta Voe. There are two piers at the northern end of the voe. One is used as a shore base for the mussel farm operators and four workboats were present at the time of the shoreline survey. An anchorage is located at the northern end of the voe, north of Inner-Site 2-Nisbet (Clyde Cruising Club, 2005)

Overall, the local population surrounding the voe is low and sparsely distributed. The mussel lines closest to the shoreline are likely to be more impacted by human-related sources due to the presence nearby of dwellings at Colvister, Cunnister, and Sellafirth. The anchorage adjacent to the Nisbet site would be a potential source to the northern end of the mussel farm when occupied. There is unlikely to be much seasonal variation in population in the area.

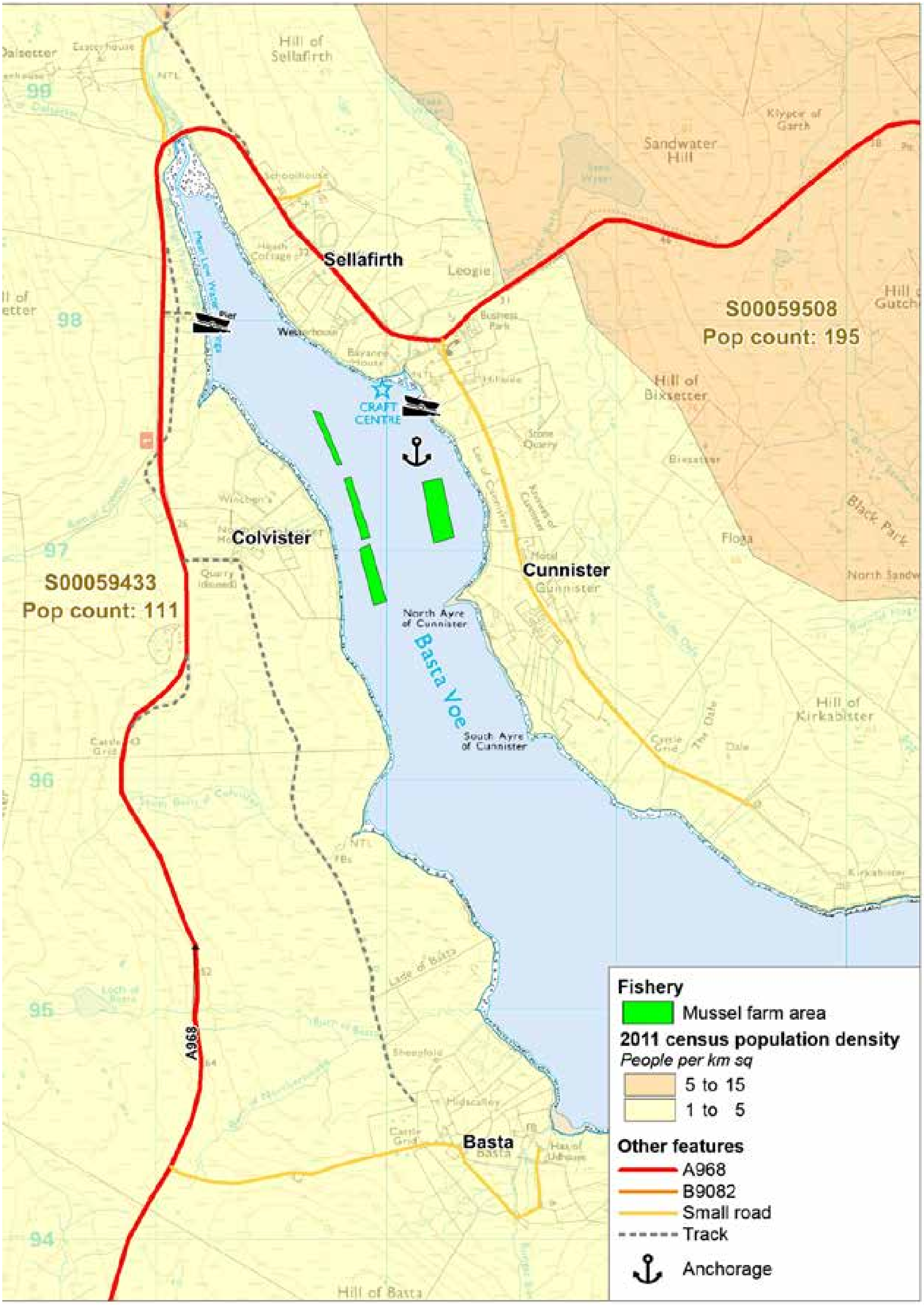

Figure 3.1 Population map for the area around Basta Voe Cove

4. Sewage Discharges

Information on sewage discharges within an area 5 km around the point HU 5223 9724, which lies on the Nisbet site, 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 data was provided regarding sanitary or bacteriological data, spill frequency, dispersion or dilution modelling studies or planned improvements for any of the consented discharges identified.

Community Discharges

SEPA and Scottish Water reported no community discharges in the requested area.

Consented Sewage Discharges

SEPA provided information regarding a number of consented discharges within the request area identified. Discharges relating to abstraction or engineering works were excluded from assessment, as they should not contribute any faecal input to the area. Three consents related to Colvister Quarry transfer station, which accepts materials, including waste oil and vehicles, for recycling. These were also excluded from assessment as they should not be related to faecal contamination.

As there is no community sewerage in the area, all dwellings and businesses are presumed to be connected to private septic tanks. SEPA reported a total of 27 consented septic tanks in the request area. Eleven of these were associated with discharges over 6 km from the fishery; these were considered highly unlikely to affect the fishery and so are not assessed here. The remaining 16 consented discharges are shown in Figure 4.1. A summary of all reported consents can be found Appendix 6.

Most of the consented septic tank discharges were reported in the two main settlements of Sellafirth and Cunnister, and at Basta. The majority were located along the east shore of the voe. However, it should be noted that no consents were received for the dwelling and shore base at Colvister, and it there are likely to be further homes along the east shore for which no consents were received. Most of the consents are for discharge to land or soakaway, however two consents are for discharges (CAR/R/1046278 and CAR/R/1097197) to the voe. One consent related to septic tank discharge to soakaway from the Yell Water Treatment Works (WTW) near the head of the voe, presumably associated with toilet facilities for staff. The consented PE for this discharge is 5, which is equivalent to consents for septic tanks serving single homes.

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 have been diverted to sea or watercourses upon failure of the soakaway fields.

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 have not yet been registered with SEPA.

Shoreline Survey Discharge Observations

Four observations of sewage effluent or infrastructure were recorded during the shoreline survey.

Table 4.1 Discharge-associated observations made during the shoreline survey

No.	NGR	Associated Photograph (Appendix 5)	Description
1	HU 52020 97765	Figure 8	Concrete septic tank associated with property closest to shore with outfall to shore.
2	HU 52025 97746	Figure 9	Location of outfall. Grey discharge dripping from end.
3	HU 52426 97089	Figure 10	Discharge pipe to sea, end not visible underwater. Appears to originate from the septic tank associated with the former North Isles Motel which has been unoccupied for 20 years or so.
4	HU 52539 97091		Large concrete septic tank associated with the disused motel.

Observations 1 and 2 relate to a septic tank and outfall pipe. A slight grey discharge was noted from the end of the outfall pipe. No sample was taken. This outfall plots close to, and probably represents, CAR/R/1046278 which has a PE of 5.

Observations 3 and 4 relate to a septic tank and outfall pipe associated with a disused motel. The surveyor stated that the motel has been unoccupied for approximately 20 years so is unlikely to contribute to any faecal pollution. CAR/R/1097197 plots in practically the same location as the observation and has a PE of 5. The registry office advised that this consent was applied for in 2011. Given the recent date and small PE it may serve a small dwelling associated with the motel which could still be discharging.

Summary

As there are no community discharges to the area the primary inputs come from small private septic tanks. Only two discharges are recorded as discharging to Basta Voe with all other discharges discharging to soakaway. Of the two consented discharges to sea, one is associated with an abandoned hotel and is not in use. The other was found to be active during the shoreline survey and discharges approximately 300 m east of the northernmost end of the Thomason (N) site and approximately 500 m north of the Nesbit site.

List of Acronyms

MDF=	Mean daily flow	DWF=	Dry weather flow
PE=	Population Equivalent	ST=	Septic Tank
WWTW=	Wastewater Treatment Work	CSO=	Combined Sewer Overflow

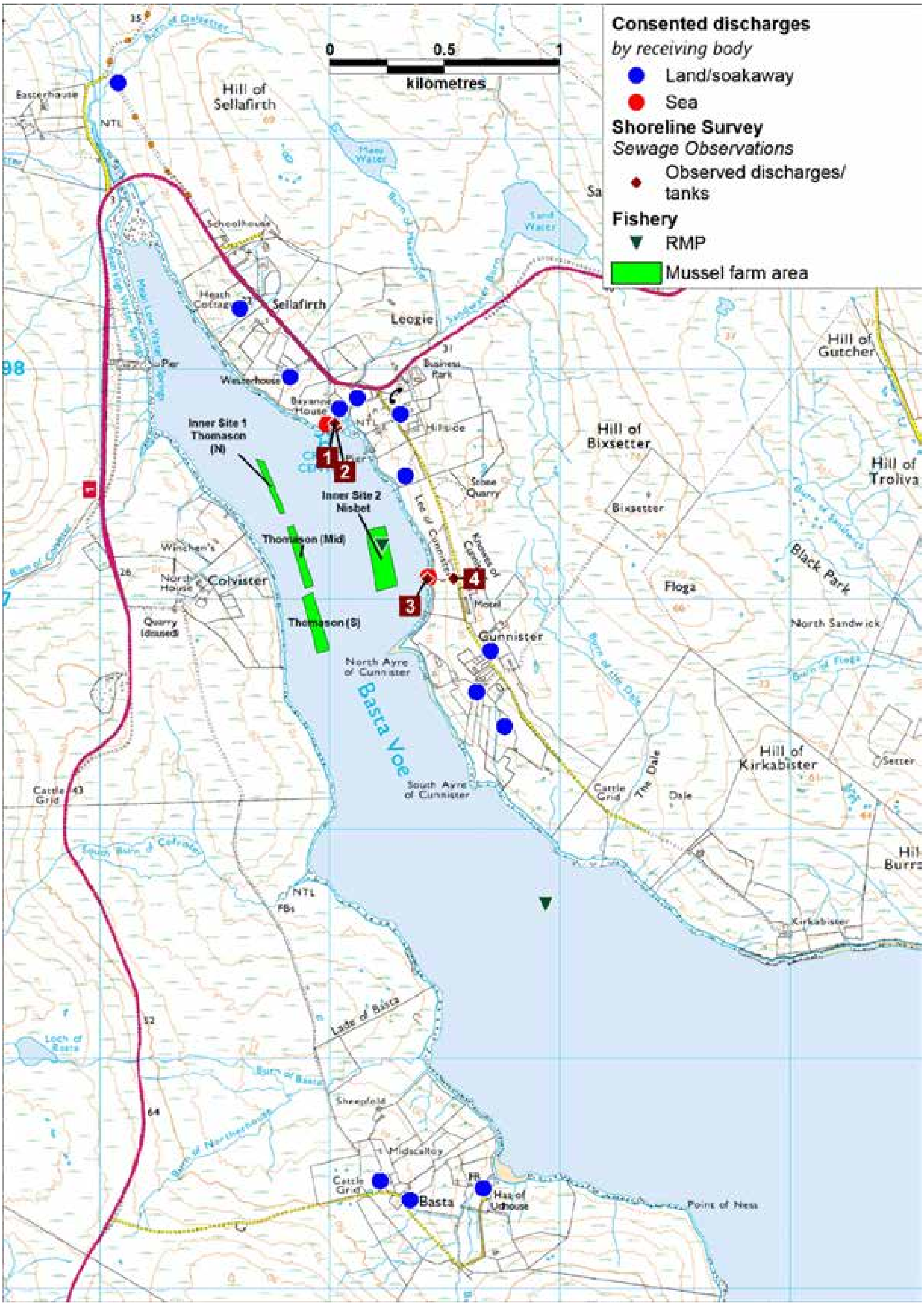

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Figure 4.1 Map of discharges for Basta Voe Cove

5. Agriculture

Information on the spatial distribution of animals on land adjacent to or near the fishery can provide an indication of the potential amount of organic pollution from livestock entering the shellfish farm area. Parish level agricultural census data was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the Yell 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 Yell agricultural parish 2013

	Yell	
	218 km^2	
	Holdings	Numbers
Pigs	*	*
Poultry	37	625
Cattle	14	187
Sheep	131	25,023
Horses used in Agriculture	0	-
Other horses and ponies	26	237

* data withheld

The Yell parish encompasses the entire island of Yell, as well as some of the smaller islands around it. Therefore, the livestock census date is not useful for determining the spatial distribution of the livestock on the shoreline adjacent to the voe or identifying how many animals are likely to impact the catchment around the shellfish farms. However, the census data does give an idea of the total numbers of livestock over the broader area. Sheep were reported in large numbers whilst poultry, cattle and horses were reported in small numbers. No pigs were reported for the parish due the small number of holdings.

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 19th August 2014. Observations made during the survey are dependent upon the viewpoint of the observer some animals may have been obscured by the terrain.

During the shoreline survey, moderate numbers of sheep were observed grazing on the to the east side of the voe, the majority of which were located around the north east corner of the voe. A further 6 sheep, including one dead one, were observed on the western shoreline. The majority of livestock had access to the shoreline and faeces were frequently observed on the foreshore.

A review of publicly available aerial images showed that areas of improved pasture are located on both sides of the voe (Bing Maps, 2014). Areas identified from the aerial images as likely improved pasture are shown in Figure 5.1. The 1:25,000 Ordnance Survey map identified cattle grids on both coastlines at the southern end of the voe as shown in Figure 5.1.

Numbers of sheep are expected to be approximately double during the spring and summer months when lambs are present. Any contributions of faecal contamination from livestock are expected to be moderate. Livestock grazed on the improved pasture surrounding the voe would potentially affect all mussel lines located closest to the shore, with a greater impact on the eastern side of the voe, where there is more pasture and more sheep were seen.

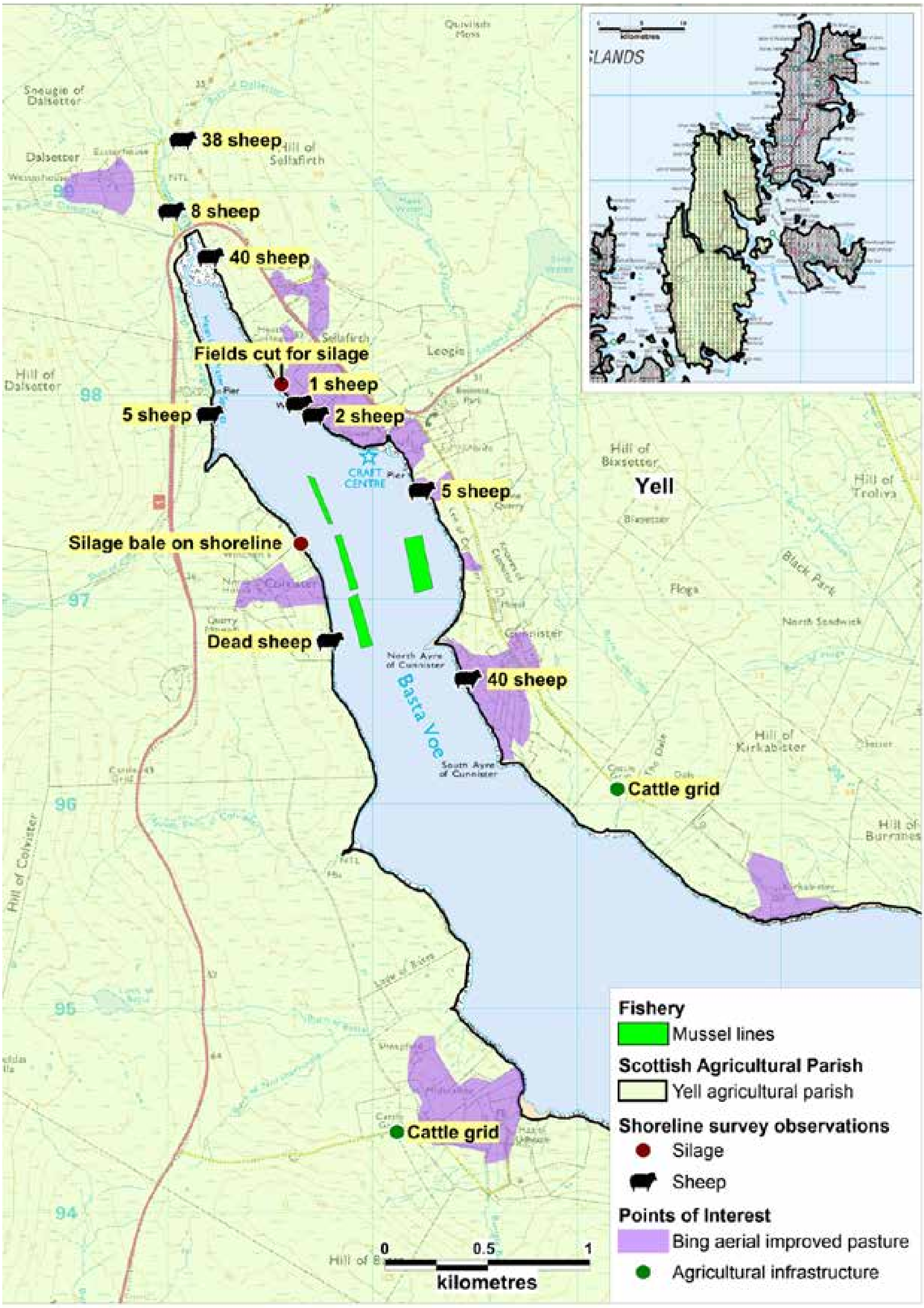


Figure 5.1 Livestock observations at Basta Voe Cove

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 Basta Voe Cove are considered below.

Pinnipeds

Both common seals and grey seals are present around the Shetland Islands, including Yell (Special Committee on Seals, 2013). Data from the 2012 Marine and Spatial Plan for Shetland identified common seal habitat to the northeast of the voe and south of the voe around the island of Hascosay (NAFC Marine Centre, 2012). No seals were observed during the shoreline survey.

Cetaceans

There are reports of a small pod of white sided dolphins in Basta Voe in 2013 (SeaWatch Foundation, 2014). No other cetaceans have been reported within Basta Voe and none were observed during the shoreline survey.

Birds

Seabird data was downloaded from the collated JNCC dataset from the website (JNCC, 2014) in March 2014. The dataset was then manipulated to show the most recent data where repetitions of counts were present. Data applicable for the 5 km area around the fisheries are listed in Table 6.1.

Table 6.1 Seabird counts within 5 km of the Basta Voe Cove fisheries

Common name	Species name	Count	Method	Accuracy
Great Black-Backed Gull	Larus marinus	46	Occupied territory and nests	Accurate
Black-Headed Gull	Chroicocephalus ridibundus	24	Occupied territory and nests	Accurate
Common Gull	Larus canus	116	Individuals on land/occupied nests	Accurate
Herring Gull	Larus argentatus	21	Individuals on land/occupied nests	Accurate
Arctic Skua	*Stercorarius parasiticus*	90	Occupied territory	Accurate
Great Skua	Stercorarius skua	298	Occupied territory	Accurate
Fulmar	*Fulmarus glacialis*	644	Occupied sites	Accurate
Arctic Tern	*Sterna paradisaea*	106	Individuals on land/occupied nests	Accurate
Black Guillemot	*Cepphus grylle*	57	Individuals on land	Accurate

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

The JNCC dataset indicates that the area supports large breeding colonies of seabirds. Dense aggregations were reported directly east of Basta Voe. Significant contributions of faecal contamination may be anticipated from these areas during the breeding season (May to September).

The Marine and Spatial plan data for Shetland indicated the surrounding area contained significant amounts of suitable habitat for eider ducks and long-tailed ducks to the south of the voe (NAFC Marine Centre, 2012). Birds were the most common wildlife observed during the 2014 shoreline survey; particularly geese and eider ducks. Goose faeces were also noted adjacent to the fisheries.

Otters

Shetland has been identified as containing national and internationally important populations of the Eurasian otter (*Lutra lutra*). It contains approximately 12% of the UK population (Shetland Otters, 2014). The Marine and Spatial Plan for Shetland data indicated the majority of the east side and northern extent of Basta Voe Cove contains suitable otter habitat. One otter was observed during the shoreline survey, approximately 500 m south of the fishery.

Overall

The Basta Voe Cove fisheries are expected to receive low levels of contamination from wildlife, in particular birds such as geese and ducks that were observed in moderate numbers along the east shore of the voe. Otters, seals, and dolphins are also reported to be found within the voe and will add to background levels of contamination there. Highest impacts are expected at the easternmost mussel farm.

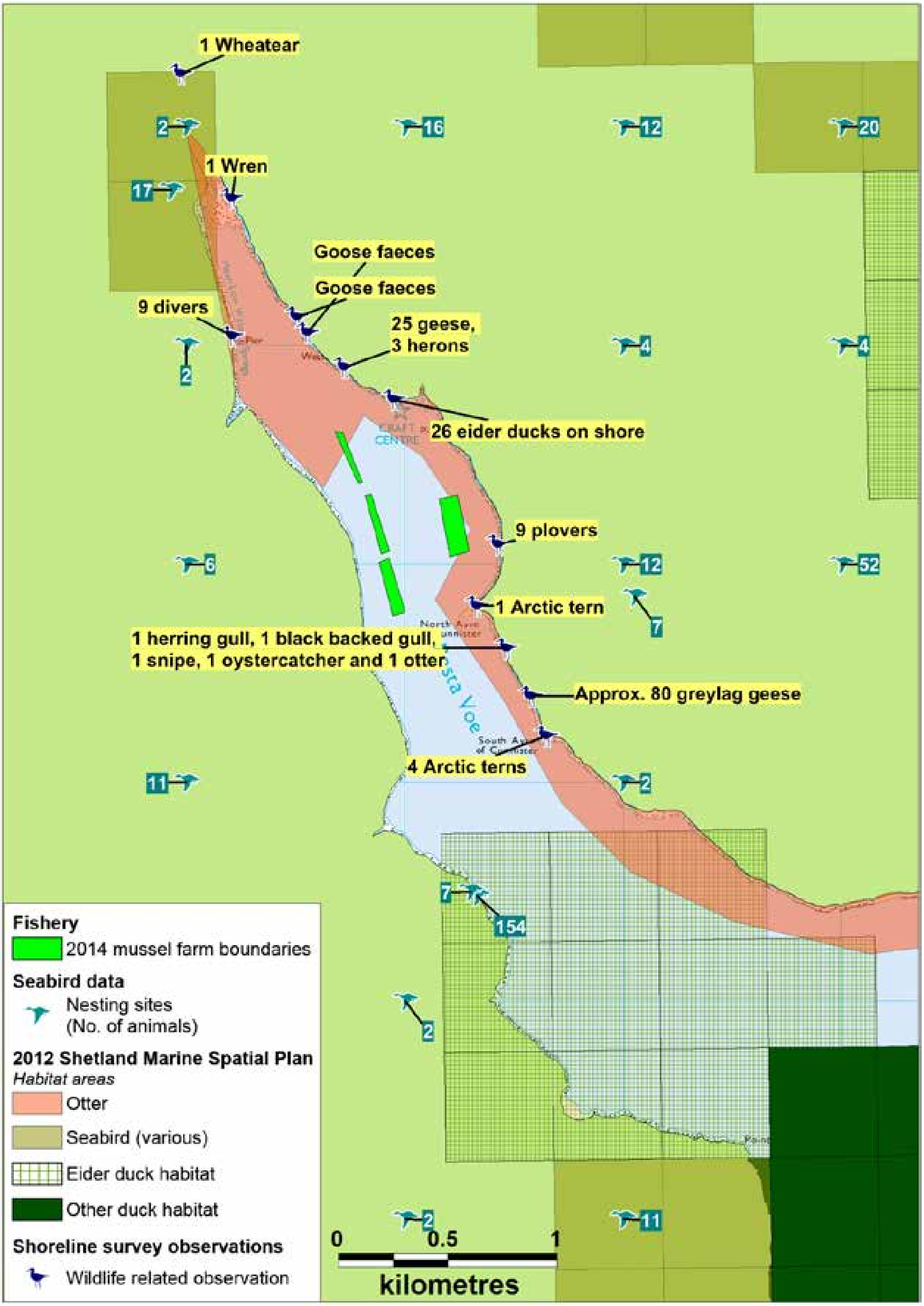


Figure 6.1 Map of wildlife around Basta Voe Cove

7. Land Cover

The Land Cover Map 2007 data for the area is shown in Figure 7.1. Much of the land around Basta Voe is bog, although both natural and improved grasslands and heath are reported along the shoreline, particularly along the northeast shore of the voe. A small number of built up areas are represented. Some appear to correspond with the location of homes at Basta, Colvister, Sellafirth and Cunnister. Others, in particular those directly at the shoreline, appear to be incorrectly classified. These are located at the North Ayre of Cunnister, which is an undeveloped sand spit jutting westward into the voe at Cunnister and at the shoreline east of Colvister, which is undeveloped grassland.

The pier on the northwest shore of the voe and one of the homes at Basta are not identified as built up area, though they have similar footprints to other areas identified as such. Faecal indicator organism export coefficients for faecal coliform bacteria have been found to be approximately1.2 – 2.8×10^9 cfu km^{-2} hr^{-1} for urban catchment areas, 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 farms is from grassland along the northeast shore of the voe. Any impact is likely to be greatest on the mussel lines closest to the shoreline. Areas utilised for grazing, particularly improved grassland areas, would be expected to contribute significantly to faecal contaminant loading carried in watercourses and overland flow draining the area during rainfall.

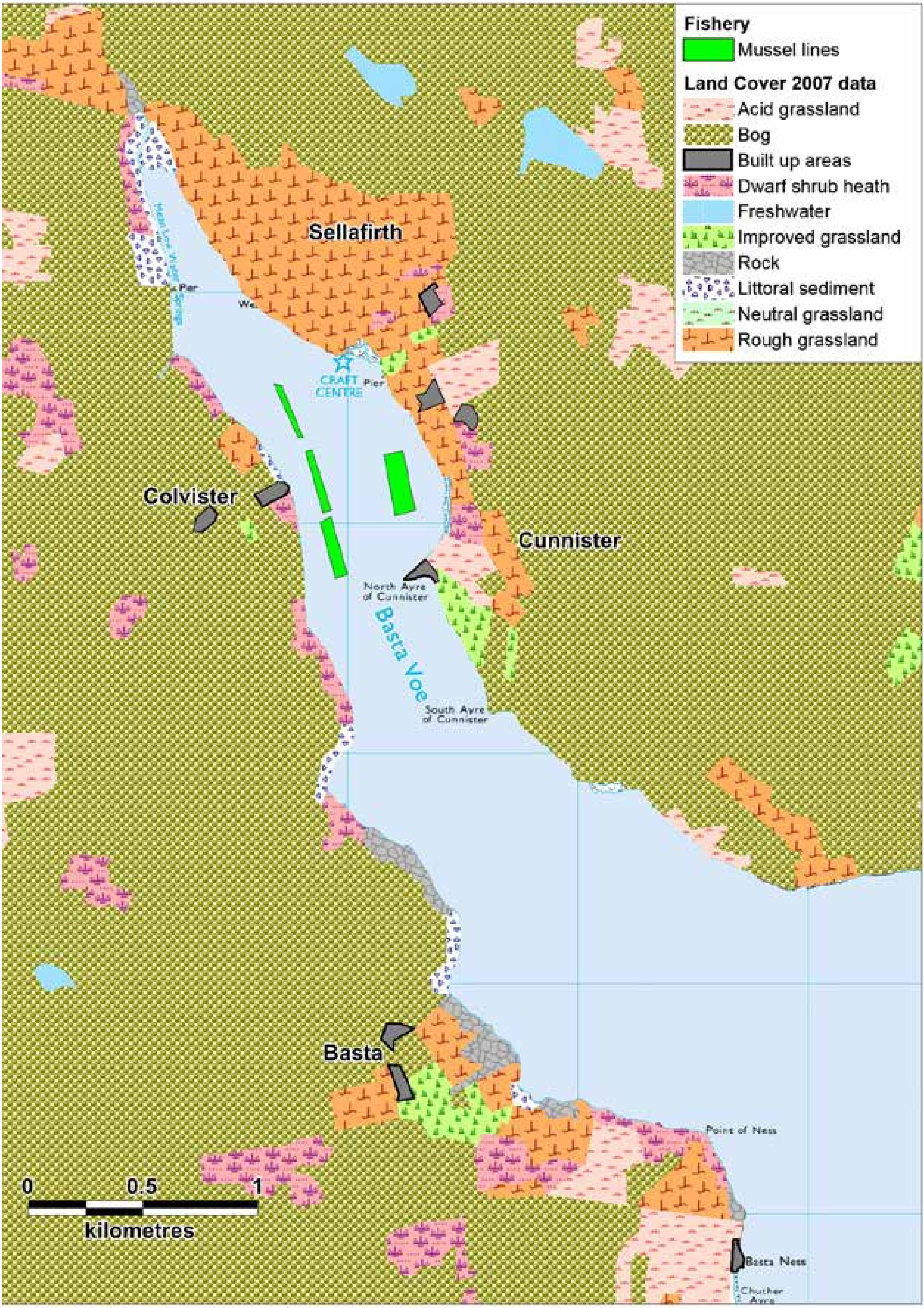


Figure 7.1 LCM2007 land cover data for the area around Basta Voe Cove

8. Watercourses

There are no gauging stations on watercourses that flow into Basta Voe.

Spot measurements of flow and microbial content were obtained during the shoreline survey conducted on the 19th August 2014. Rain showers were recorded in the 48 hrs prior to the survey. Watercourses recorded during the shoreline survey are listed in Table 8.1. An area of land drainage was observed on the northeast shoreline of the voe. The locations and loadings of measured watercourses are shown in Figure 8.1.

Table 8.1 Watercourses entering Basta Voe

No.	Eastings	Northings	Description	Width (m)	Depth (m)	Flow (m^3/d)	Loading (*E. coli* per day)
1	451829	1195756	South Burn of Colvister	0.80	0.25	1935	3.1×10^{09}
2	451440	1197480	Unnamed watercourse	Not measured or sampled			Not determined
3	451179	1197613	Burn of Colvister	0.50	0.25	6577	1.5×10^{10}
4	451101	1198793	Burn of Gossawater	0.60[1] 0.80[2]	0.05[1] 0.08[2]	2102[1] 7476[2]	2.8×10^{10}
5	452089	1197827	Sandwater Burn	0.80	0.20	6760	2.4×10^{10}

[1] Culvert 1 [2] Culvert 2; Loadings for each culvert were estimated separately and then combined to give the overall loading.

The largest watercourses observed entering the survey area were the Burn of Gossawater, Burn of Colvister and Sandwater Burn, all of which are located at the northern end of the voe. A small unnamed watercourse south of the Burn of Colvister was recorded but not measured or sampled due to insufficient flow on the day of the survey. The South Burn of Colvister, which discharges approximately 1 km south of the southernmost mussel farm, had a moderate estimated *E. coli* loading. The Burn of Gossawater enters the head of the voe via two large culverts approximately 1 km north of the northern most mussel farm. The Burn of Colvister discharges approximately 500 m north-northwest of the north end of the Thomason site, and Sandwater Burn discharges approximately 500 m north of the Nisbet site All three of these watercourses carried higher loadings than the other burn, but still within the range that would be considered moderate.

Overall, freshwater inputs are expected to provide moderate levels of contamination to the mussel farms in Basta Voe, in particular the mussel lines situated closest to shore, with the highest impact expected from the watercourses that discharge north of the shellfish farms.

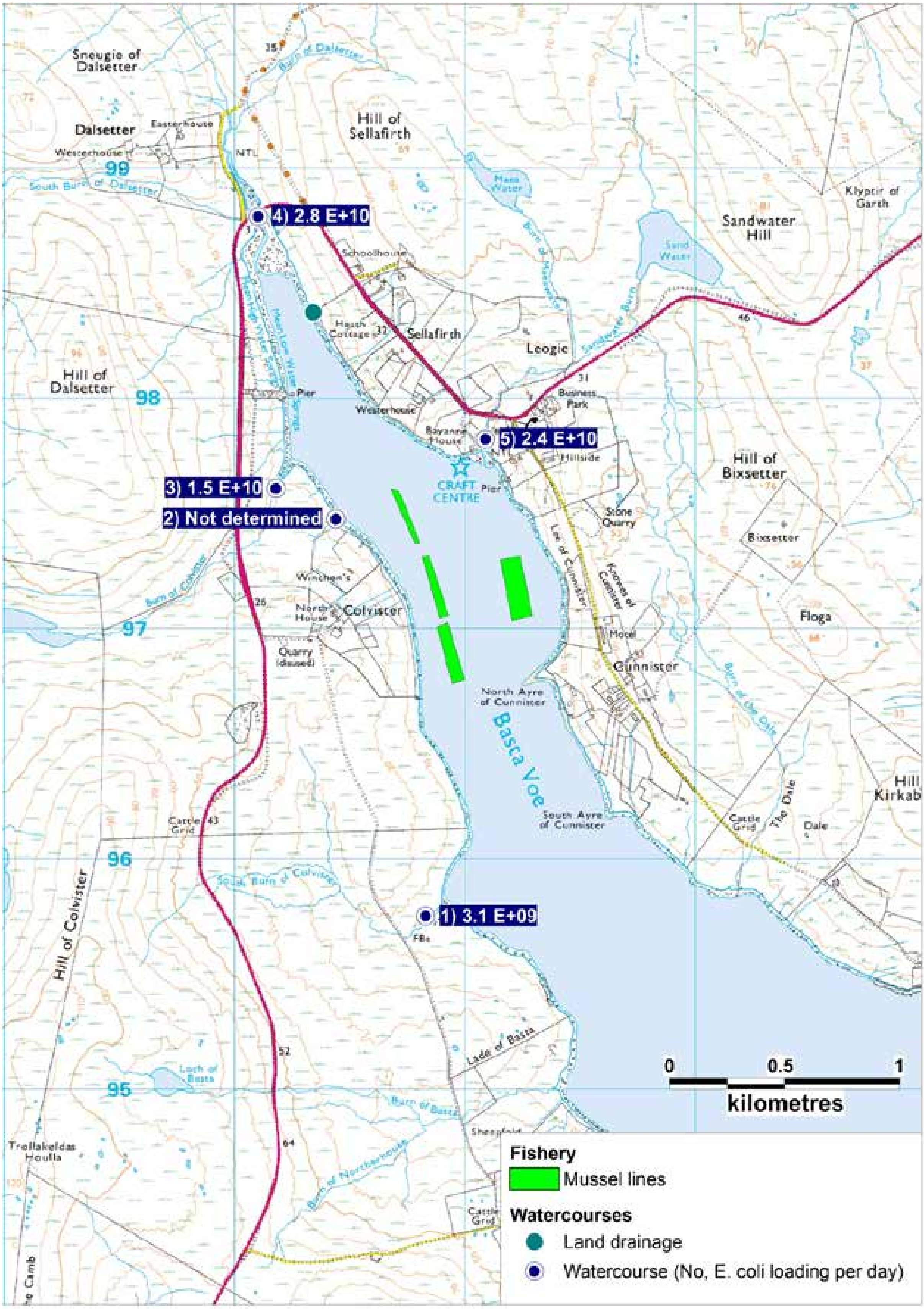


Figure 8.1 Map of watercourse loadings at Basta Voe Cove

9. Meteorological Data

The nearest weather station for which a nearly complete rainfall data set was available is located at Baltasound, situated approximately 15 km to the northwest of the production area. Rainfall data was complete for January 2008 – December 2013, with the exception of April 2010, during which no rainfall data was collected. The nearest wind station is Lerwick, 58 km to the south of Basta Voe. 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 United Kingdom 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 Basta Voe Cove.

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 *.

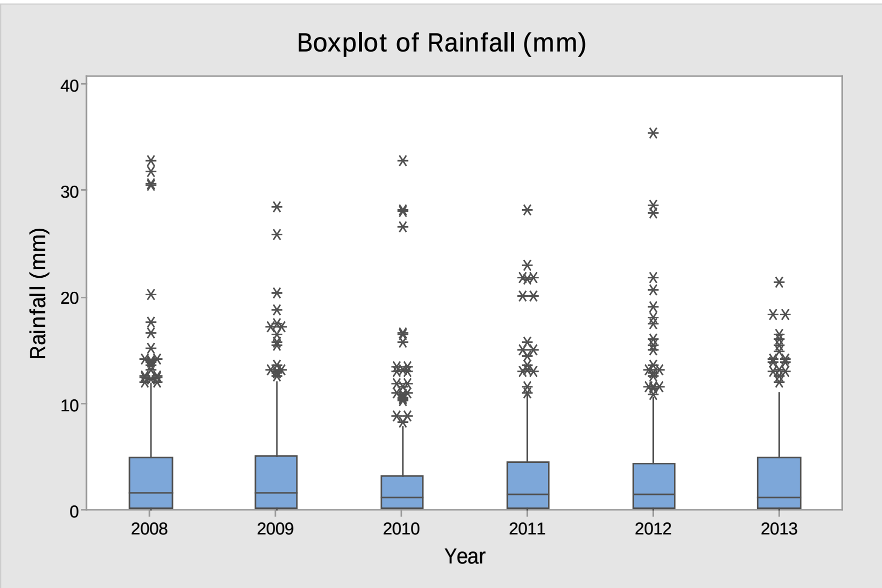


Figure 9.1 Box plot of daily rainfall values by year at Baltasound (2008 – 2013)

Rainfall values varied from year to year, with 2010 being the driest year (866 mm) and 2008 the wettest. (1250 mm). However, this is skewed by the lack of rainfall data for April 2010. Individual rainfall values of more than 30 mm/d were recorded in 2008, 2010 and 2012.

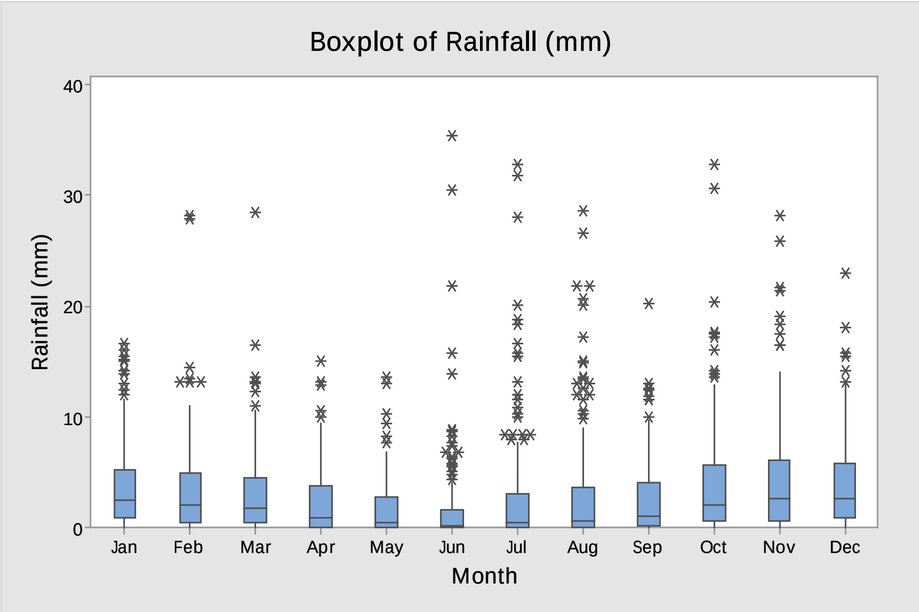


Figure 9.2 Box plot of daily rainfall values by month at Baltasound (2008 – 2013)

Daily rainfall values were higher during the autumn and winter. Total rainfall by month was greatest in November (745 mm). Rainfall values exceeding 30 mm/d occurred in June, July and October. It should be noted that data was missing for the entirety of April 2010. This needs to be taken into account when considering the annual and monthly rainfall figures (with 2010 and April apparently showing the lowest annual and monthly totals over the period considered here).

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.

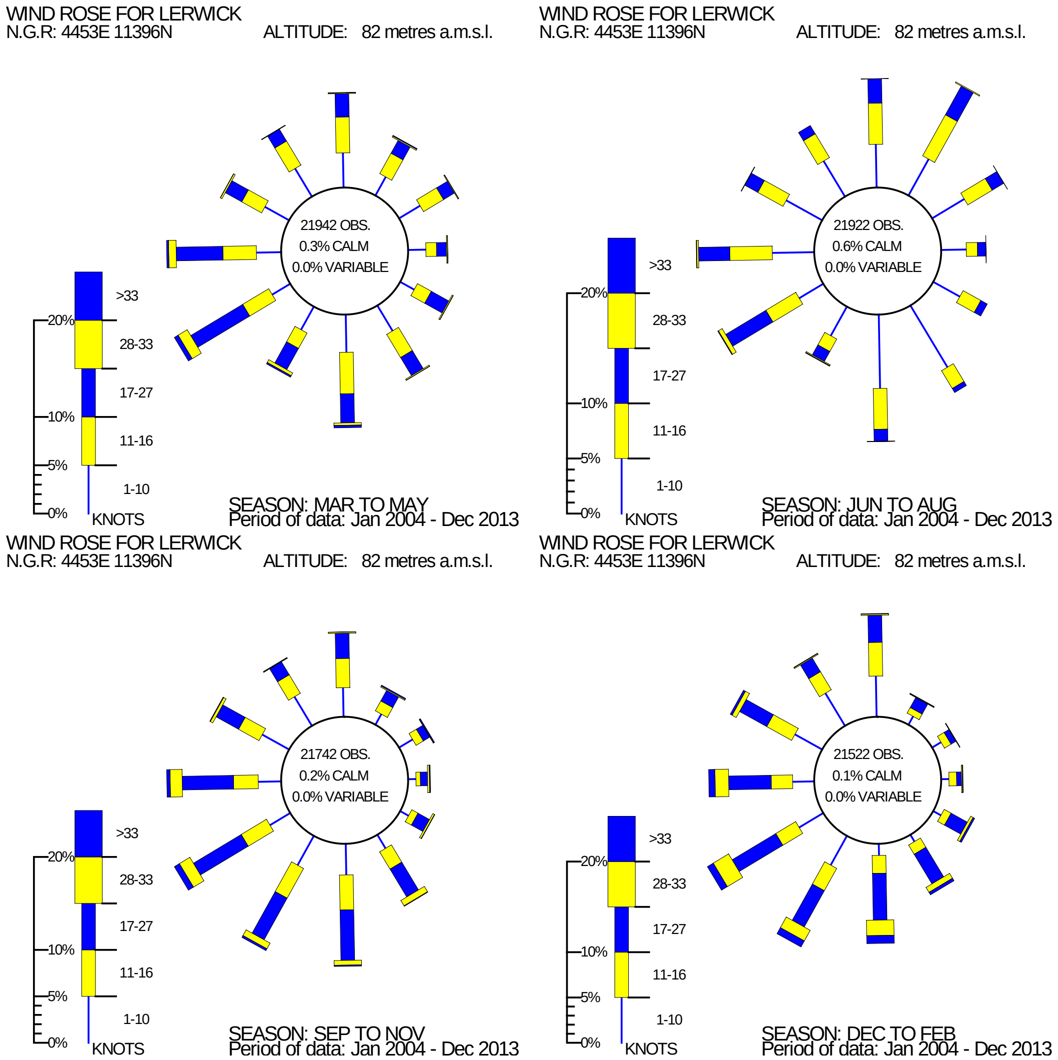


Figure 9.3 Seasonal wind roses for Lerwick

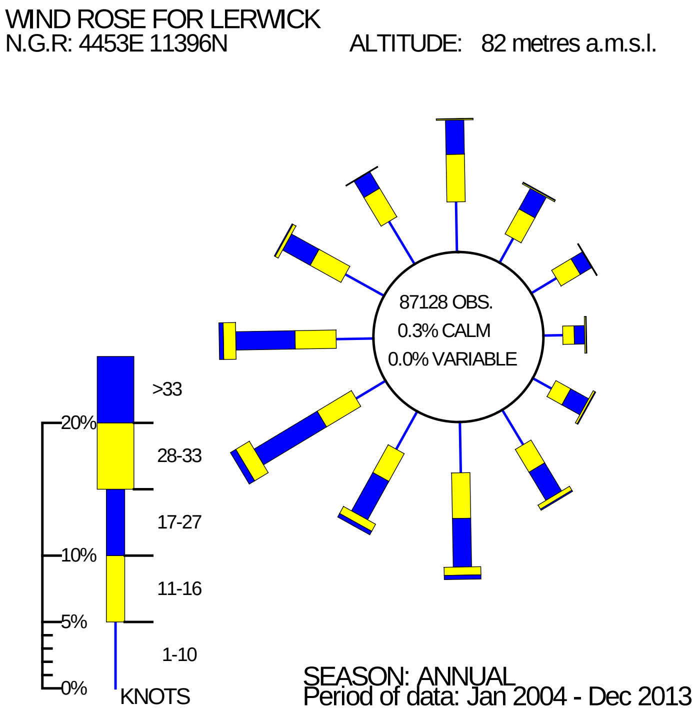


Figure 9.4 Annual wind rose for Lerwick

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 from the southwest quarter. Winds were very rarely calm (0.3% of the time). Seasonally, winds from the northeast quarter were more frequent, and those from the southwest less frequent, in spring and summer. Winds were generally 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

Basta Voe Cove is currently classified for the production of common mussels (*Mytilus edulis*). The classification history since 2006 is listed in Table 10.1 below.

Table 10.1 Basta Voe Cove (common mussel) classification history

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2006	A	A	A	A	A	A	A	A	A	A	A	A
2007	A	A	A	A	A	A	A	A	A	A	A	A
2008	A	A	A	A	A	A	A	A	A	A	A	A
2009	A	A	A	A	A	A	A	A	A	A	A	A
2010	A	A	A	A	A	A	A	A	A	A	A	A
2011	A	A	A	A	A	A	A	A	A	A	A	A
2012	A	A	A	A	A	A	A	A	A	A	A	A
2013	A	A	A	A	A	A	A	A	B	A	A	A
2014	A	A	A	A	A	A	A	A	B	B	A	A
2015	A	A	A									

Basta Voe Cove was consistently classed A year-round until 2013, since when it has received B classifications during some autumn months.

11. Historical *E. coli* Data

11.1 Validation of historical data

Results for all samples assigned against the Basta Voe Cove production area for the period 01/01/2009 to the 24/10/2014 were extracted from the FSAS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. The data was extracted from the database on 24/10/2014. All *E. coli* results were reported as most probable number (MPN) per 100 g of shellfish flesh and intravalvular fluid.

Twenty-three 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.

All 66 samples were identified in the database as validated, were received at the laboratory within 48 hours of collection, had box temperatures of <8^{o}C and plotted within 100 m of the production area boundaries. One sample had an NGR reported with an incorrect two-letter prefix, which was amended to HU.

11.2 Summary of microbiological results

The sampling and results summaries for samples results from Basta Voe Cove are listed in Table 11.1.

Table 11.1 Summary of historical sampling and results

Sampling Summary	
Production area	Basta Voe Cove
Site	Inner-Site 2-Nisbet
Species	Common mussels
SIN	SI-324-400-08
Location	Various
Total no of samples	66
No. 2009	10
No. 2010	11
No. 2011	11
No. 2012	12
No. 2013	12
No. 2014	10
Results Summary	
Minimum	<18
Maximum	5400
Median	45
Geometric mean	42
90 percentile	330
95 percentile	783
No. exceeding 230/100g	7 (11%)
No. exceeding 1000/100g	2 (3%)
No. exceeding 4600/100g	1 (2%)
No. exceeding 18000/100g	0

Sampling has been even across years at Basta Voe Cove. Although one result exceeded 4600 *E. coli* MPN/100 g, the majority of results were below 230 *E. coli* MPN/100 g.

11.3 Overall geographical pattern of results

The geographical locations of all 66 sample results assigned to Basta Voe Cove are mapped in Figure 11.1.

All samples have been taken at the Nisbet site, on the east side of the voe. Excluding the two samples results of <20 *E. coli* MPN/100 g that plot 220 and 221 m south of the RMP, there are two areas of sampling: approximately 170 m north of the RMP and within 50 m of the RMP. Northern samples have mostly been taken between 2009 and 2011, whilst samples in the southern area are from 2012-2014. A table of summary results at these two sampling locations is displayed in Table 11.2.

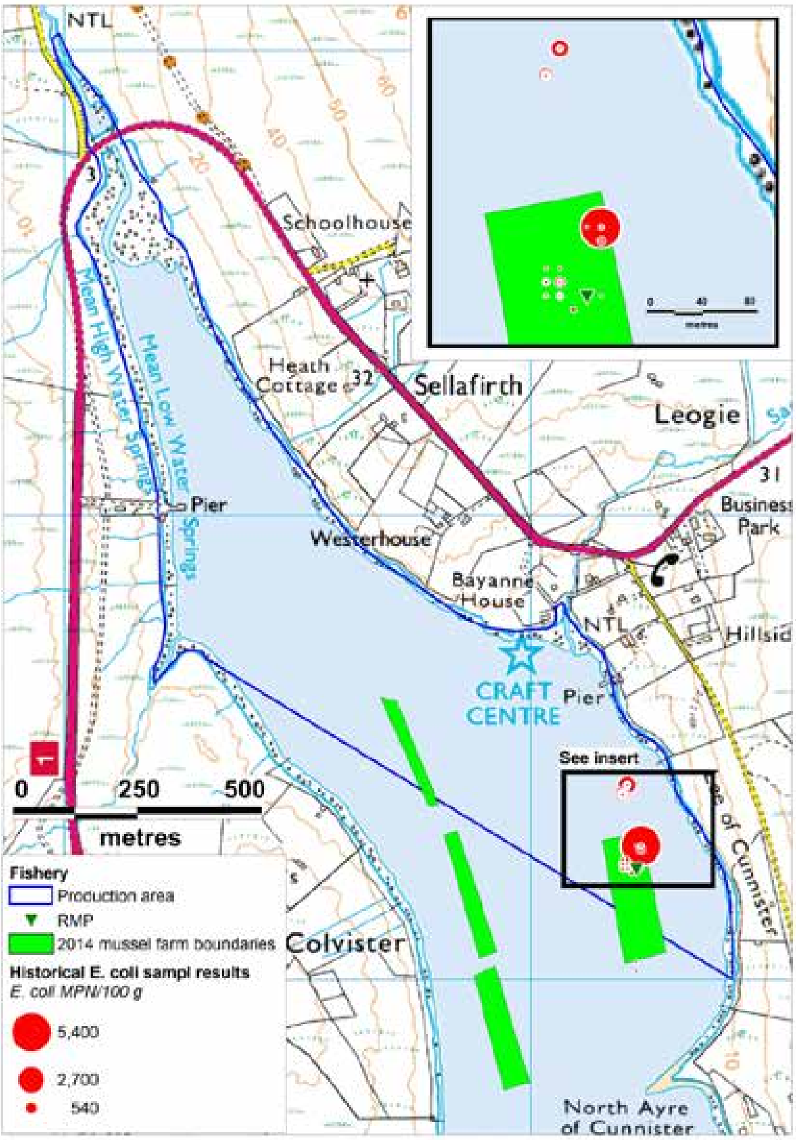


Figure 11.1 Map of reported sampling locations for common mussels at Basta Voe Cove

The highest result was reported from a location within the current mussel farm area and approximately 50 m north of the RMP and along the eastern edge of the mussel farm. However, as this was a single result, it is not clear whether this is due to temporal or spatial variation. Reported sample locations to the west of the RMP formed a regular grid pattern. These sample locations were reported to 10 m accuracy, and the final digits in their reported grid referenced varied by 1.

11.4 Overall temporal pattern of results

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

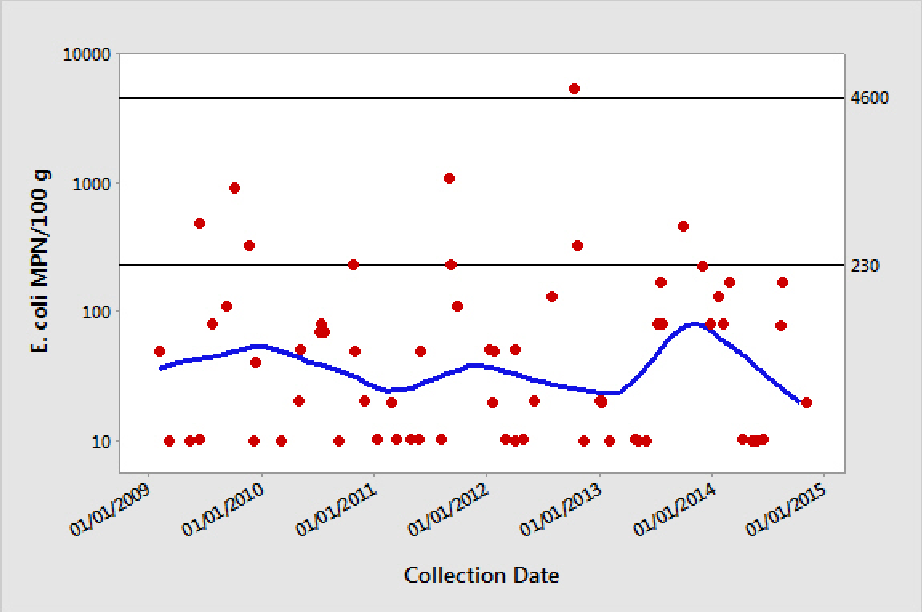


Figure 11.2 Scatterplot of *E. coli* results by collection date at Basta Voe Cove, fitted with a lowess line

Monitoring results have been largely consistent over the period, with one distinct peak in the trend line in late 2013, coinciding with an absence of results at or below the limit of detection (20 *E. coli* MPN/100 g). The highest result of 5400 *E. coli* MPN/100 g was from a sample taken in late 2012.

11.5 Seasonal pattern of results

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

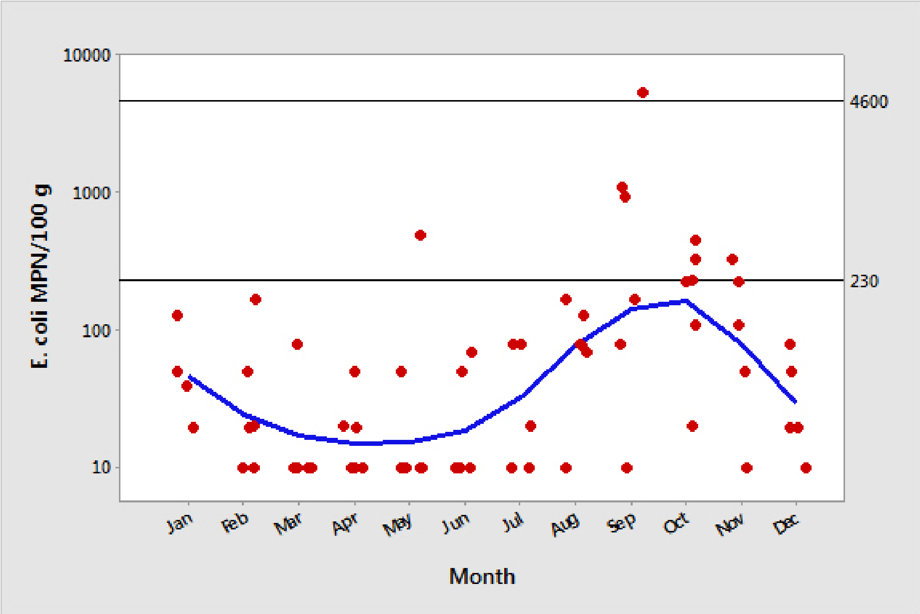


Figure 11.3 Scatterplot of *E. coli* results by month at Basta Voe Cove, fitted with a lowess line

The trend in results appears to increase from roughly June to September, after which it declines rapidly until reaching a minimum in April. The highest results were from samples taken in September.

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

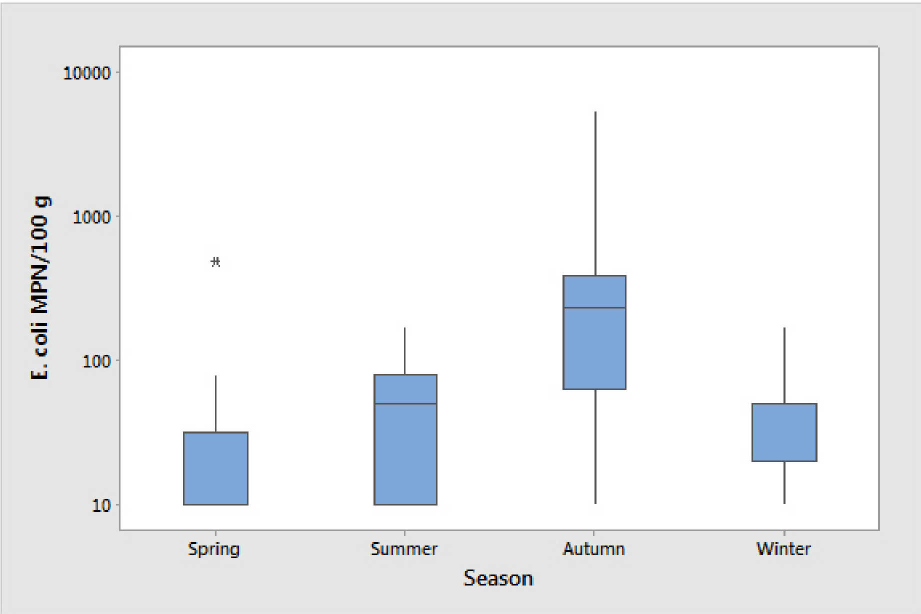


Figure 11.4 Boxplot of *E. coli* results by season at Basta Voe Cove

A very highly statistically significant difference was found between *E. coli* results for Basta Voe Cove by season (one-way ANOVA, p = 0.000) (Appendix 3), with results of samples taken in autumn significantly higher than those taken in any other season.

11.6 Analysis of results against environmental factors

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

11.6.1 Analysis of results by recent rainfall

The nearest weather station with available rainfall data was at Baltasound approximately 15 km northwest of Basta Voe Cove. Rainfall data was purchased from the Meteorological Office for the period of 01/01/08 - 31/12/2013 (total daily rainfall in mm). Data was extracted from this for all sample results at Basta Voe Cove between 01/01/2009 - 31/12/2013.

Two-day rainfall

A scatterplot of *E. coli* results against total rainfall recorded on the two days prior to sampling for Basta Voe Cove is displayed in Figure 11.5. Rainfall data was available for 54 out of the 66 sample results. Jittering was applied to symbols at 0.02 (x-axis) and 0.001 (y-axis) respectively.

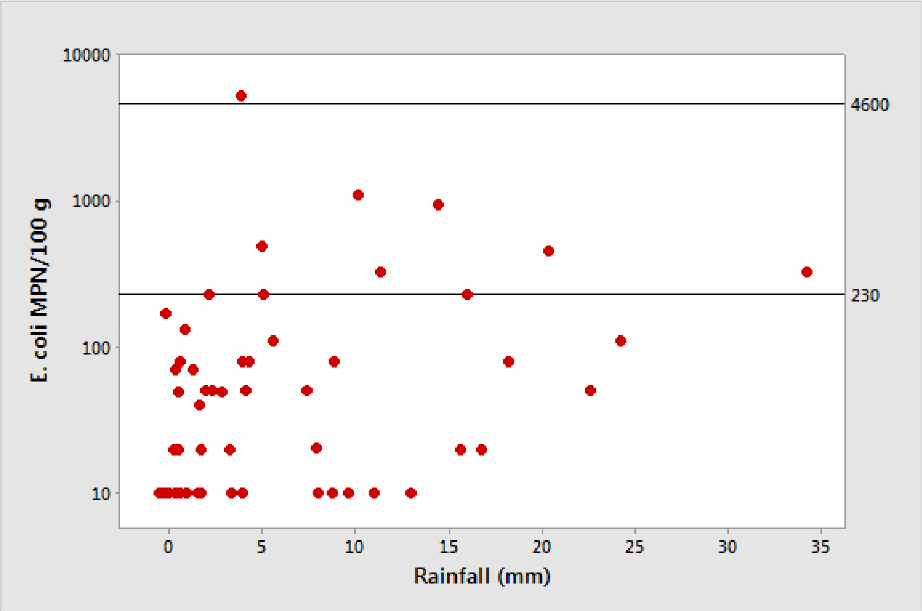


Figure 11.5 Scatterplot of *E. coli* results against rainfall in the previous two days at Basta Voe Cove

A highly significant correlation was found between *E. coli* results and the previous two day rainfall (Spearman's rank correlation r = 0.385, p = 0.004). The highest result occurred after less than 5 mm rainfall over two days. No results below 20 MPN/100 g occurred at rainfall levels above 15 mm.

Seven-day rainfall

As the effects of heavy rainfall may take differing amounts of time to be reflected in shellfish sample results in different systems, the relationship between rainfall in the previous seven days and sample results was investigated in an identical manner to the above. A scatterplot of *E. coli* results against total rainfall for the seven days prior to sampling at Basta Voe Cove is shown in Figure 11.6. Rainfall data was available for 51 out of the 66 sample results. Jittering was applied to symbols at 0.02 (x-axis) and 0.001 (y-axis) respectively.

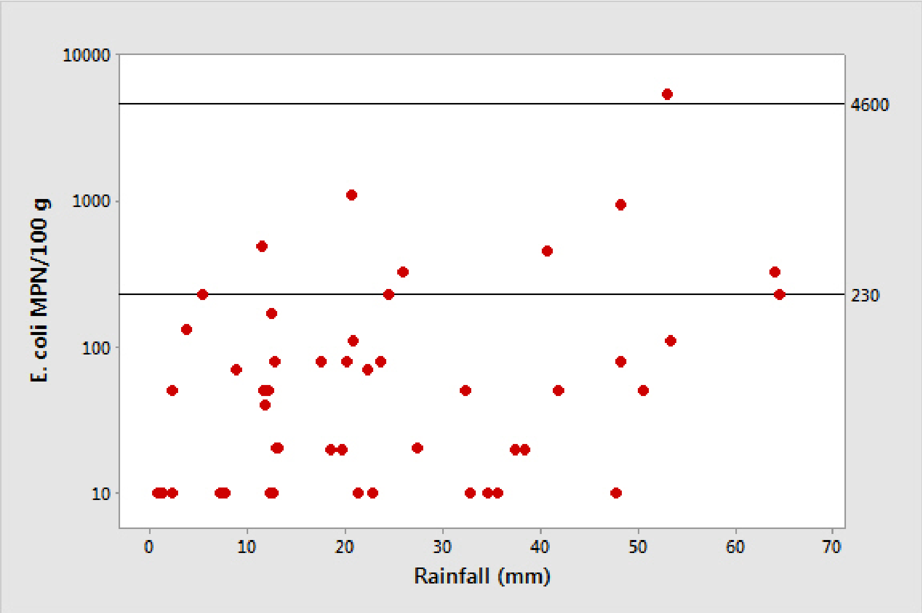


Figure 11.6 Scatterplot of *E. coli* results against rainfall in the previous seven days at Basta Voe Cove

A significant correlation was found between *E. coli* results and the previous seven day rainfall (Spearman's rank correlation r = 0.364, p = 0.009). No very low results occurred above 50 mm rainfall, and the highest result occurred at just over 50 mm.

11.6.2 Analysis of results by tidal height

Spring/neap tidal cycle

Spring tides are large tides that occur fortnightly and are influenced by the state of the lunar cycle. They reach above the mean high water mark and therefore increase circulation and particle transport distances from potential contamination sources on the shoreline. The largest (spring) tides occur approximately two days after the full/new moon, at about 45^{o} on a polar plot. The tides then decrease to the smallest (neap) tides, at about 225^{o}, before increasing back to spring tides. A polar plot of *E. coli* results against the lunar cycle is shown for Basta Voe Cover in Figure 11.7. It should be noted local meteorological conditions (e.g. wind strength and direction) can also influence tide height, but are not taken into account in this section.

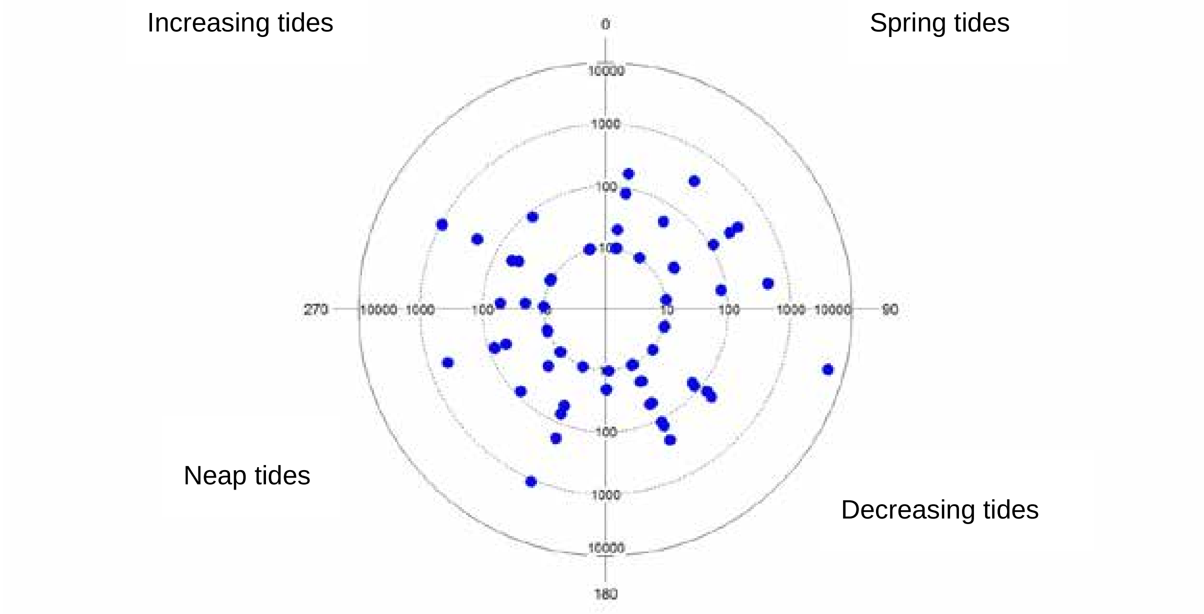


Figure 11**.**7 **Polar plots of *E. coli* results on the spring/neap tidal cycle at Basta Voe Cove**

No statistically significant correlation was found between log_{10} *E. coli* results and the spring/neap tidal cycle (circular-linear correlation r = 0.138, p = 0.301)

High/low tidal cycle

Tidal state (high/low tide) changes the direction and strength of water flow around production areas. Depending on the location of contamination sources, tidal state may cause marked changes in water quality in the vicinity of the farms. Shellfish species response time to *E. coli* levels can vary from within an hour to a few hours. High and low water data from Mid Yell Voe was extracted from POLTIPS-3 in October 2014. This site was the closest to the production area (approximately 6 km south) and it is assumed that the tidal state will be similar between sites.

A polar plot of *E. coli* results against the high/low tidal cycle for Basta Voe Cove is shown in Figure 11.8. High water is located at 0^{o} on the polar plot and low water at 180^{o}.

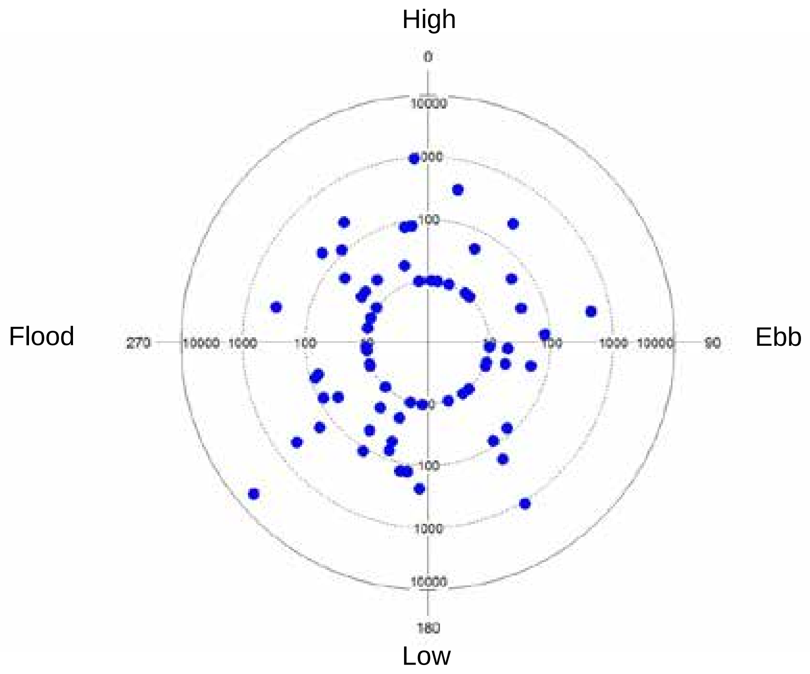


Figure 11.8 Polar plots of *E. coli* results on the high/low tidal cycle at Basta Voe Cove

No statistically significant correlation was found between $\log_{10}$ *E. coli* results and the high/low tidal cycle (circular-linear correlation r = 0.101, p = 0.529).

11.6.3 Analysis of results by water temperature

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

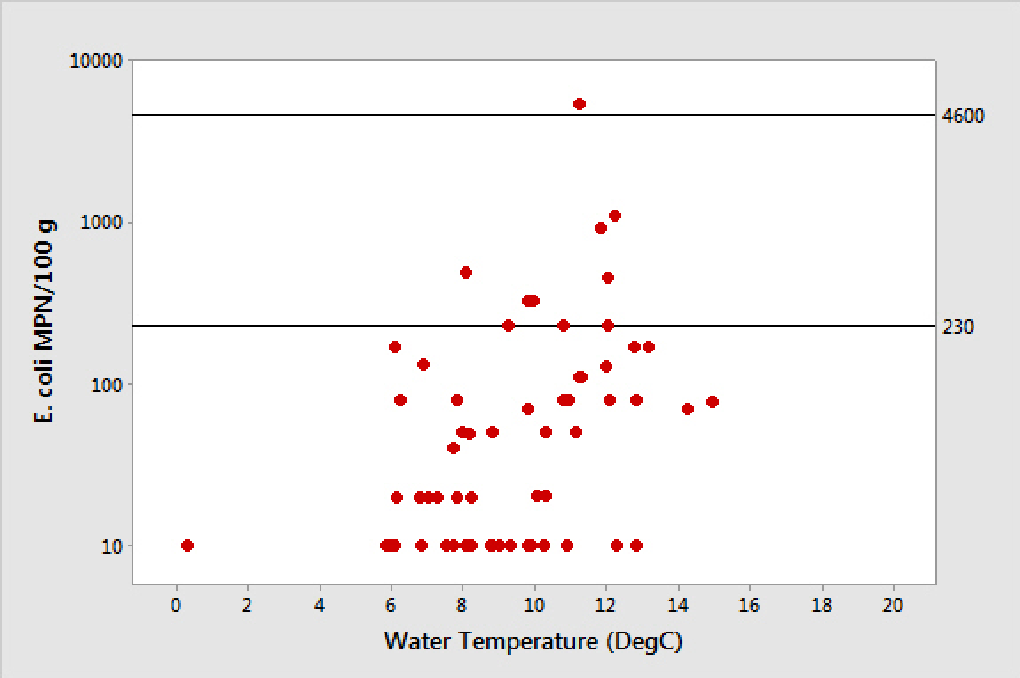


Figure 11.9 Scatterplot of *E. coli* results against water temperature at Basta Voe Cove

A statistically significant correlation was found between *E. coli* results and water temperature (Spearman's rank correlation r = 0.412, p = 0.001). Results >230 *E. coli* MPN/100 g were taken at water temperatures between 8 and 12^{o}C.

11.6.4 Analysis of results by salinity

Salinity will give a direct measure of freshwater influence and hence freshwater-borne contamination at a site. Salinity was recorded for 35 out of the 66 Basta Voe Cove samples and jittering of symbols was applied at 0.02 (x-axis) and 0.001 (y-axis) respectively. A scatterplot of *E. coli* results against salinity for Basta Voe Cove is shown in Figure 11.10.

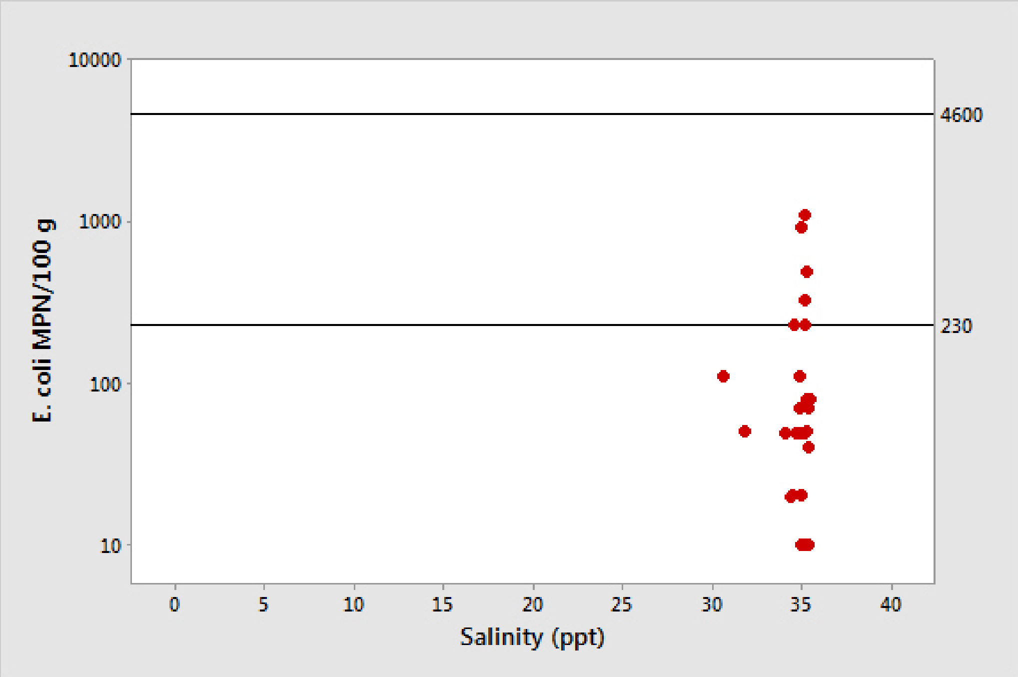


Figure 11.10 Scatterplot of *E. coli* results against salinity at Basta Voe Cove

No statistically significant correlation was found between common mussel *E. coli* results and salinity (Spearman's rank correlation r = -0.143, p = 0.414).

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

Two common mussel samples from Basta Voe Cove had results >1000 *E. coli* MPN/100 g and these are listed in Table 11.3.

Table 11.2 Basta Voe Cove historic *E. coli* sampling results over 1000 *E. coli* MPN/100 g

Collection Date	*E. coli* (MPN/100g)	Location	2 day rainfall (mm)	7 day rainfall (mm)	Water Temp (°C)	Salinity (ppt)	Tidal state (spring/neap)	Tidal State (high/low)
06/09/2011	1100	HU 5221 9742	9.8	21.6	12	35.15	Neap	Ebb
04/09/2012	5400	HU 5224 9729	3.6	52.0	11	-	Decreasing	Low

-No data available

Both results came from samples taken in September. The highest result occurred after very low 2-day rainfall but very high 7-day rainfall.

Summary and conclusions

Sampling at Basta Voe Cove has taken place along the west side of the voe around Inner Site 2. There was no clear geographic A statistically significant difference was found between results and season, with highest results in autumn. A strong seasonal increase was noted that peaked in September, when the two results exceeding 1000 *E. coli* MPN/100 g occurred.

Statistically significant correlations were found between results and previous two- and seven-day rainfall. It was noted that results >230 *E. coli* MPN/100 g occurred at rainfall levels >5 mm and >10 mm in the previous two days and seven days respectively.

A statistically significant correlation was found between results and water temperature, with results >230 *E. coli* MPN/100 g occurring in samples taken between 8 and 12^{o}C. No statistically significant correlation was found between results and salinity, or between sample results and spring/neap or high/low tide.

12. Designated Waters Data

Shellfish Water Protected Areas

The Shellfish Waters Directive (2006/113/EC) has been repealed (as at 31 December 2013) and equivalent protection for areas previously designated under that Directive is given by The Water Environment (Shellfish Water Protected Areas: Environmental Objectives etc.) (Scotland) Regulations 2013. The Basta Voe, Yell Shellfish Water Protected Area (SWPA) has slightly extended boundaries compared to the previous Basta Voe, Yell Shellfish Growing Water (SGW). The SWPA designation covers matches the production area boundary and includes all of the mussel farms. The designated SWPA for Basta Voe, Yell is shown in Figure 12.1. Since 2007, assessment of the bacteriological status of shellfish waters has been undertaken using the shellfish hygiene *E. coli* data and this data has been reviewed in Section 11.

Bathing Waters

There are no designated bathing waters within Basta Voe.

Figure 12.1 Designated shellfish water protected area – Basta Voe

13. Bathymetry and Hydrodynamic Assessment: Basta Voe Cove

13.1 Introduction

The study area is located within Basta Voe, an inlet on the east coast of the island of Yell in Shetland and comprises all waters north of a boundary defined between (HU 5311 9586) and (HU 5246 9529). This includes the headwaters and approximately two thirds of the length of the voe. Basta Voe is one of the larger Shetland voes and opens out into the waters to the north of the island of Hascosay, which itself lies between Yell and the island of Fetlar to the east. The voe is orientated roughly north-west/south-east and broadens steadily from the headwaters to mouth.

13.2 Bathymetry

An extract from Admiralty chart BA3292 (1:30,000) annotated with the limits of the study area, production area and the location of the mussel farm mooring containment areas is given in Figure 13.1.

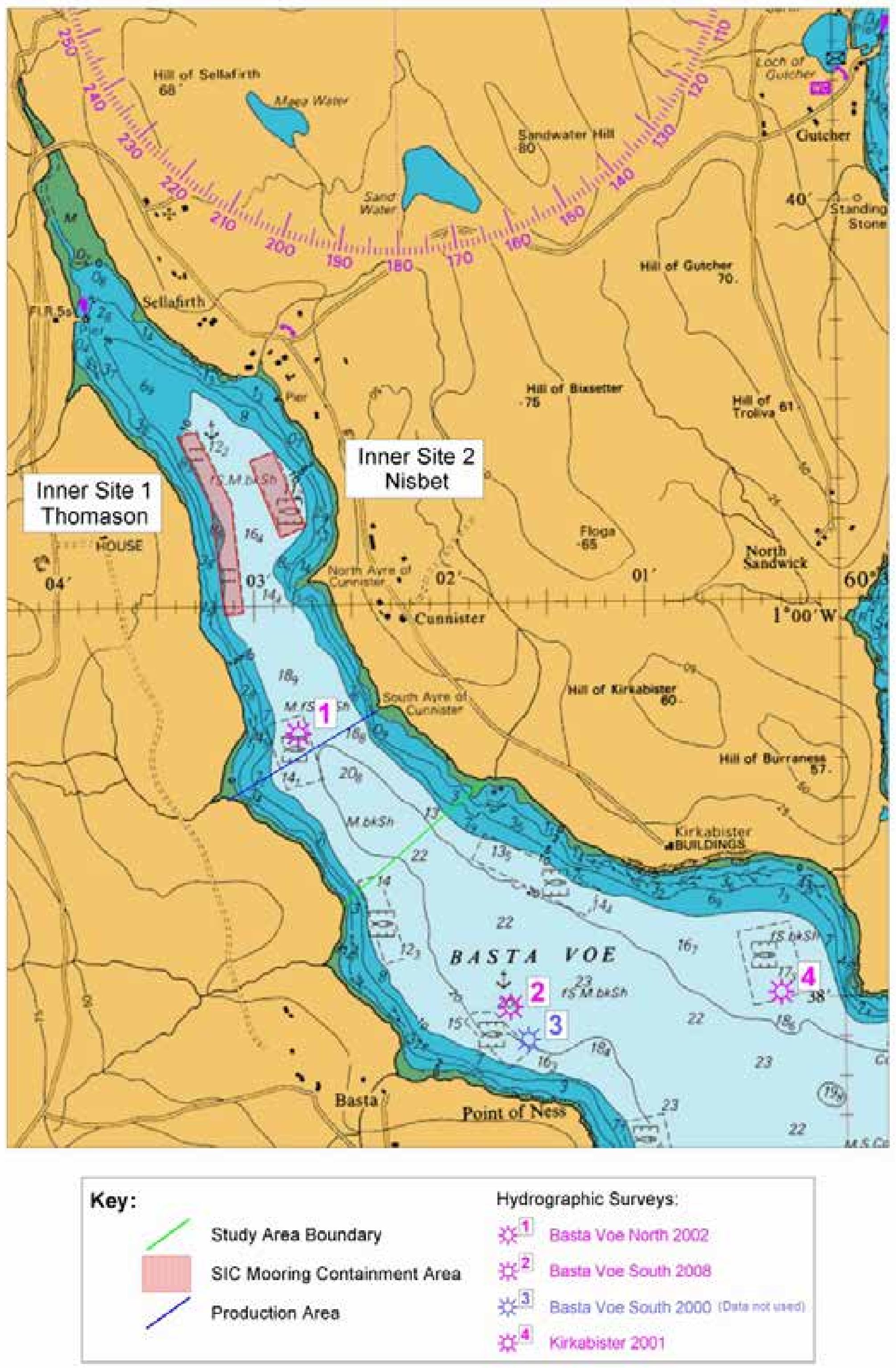
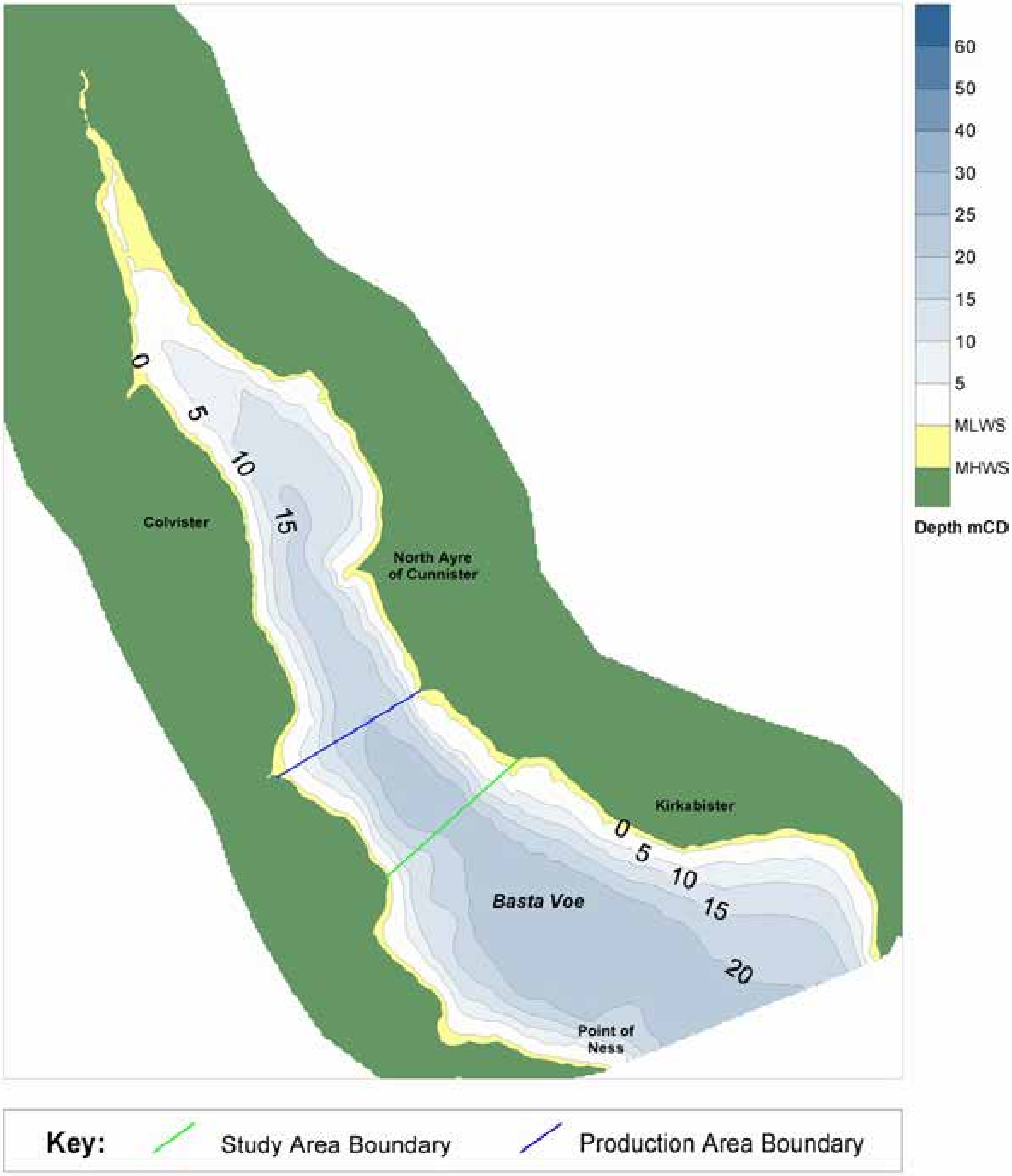


Figure 13.1 Admiralty chart extract

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



Depths given as metres chart datum

Figure 13.2 Bathymetry of Basta Voe..

The contour plot illustrates:

- There are no sill or basin features within Basta Voe.
- Gentle gradients are present from the shore, in particular at the head of the voe and at the bay at Kirkabister.
- The depth of the production area is largely between 10 and 20 metres

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	Basta Voe
Area (km^2)	1.3	1.8	4.1
Volume (Mm^3)	11.3	17.8	52.1
Mean depth (m)	8.7	10.0	12.9
Maximum depth (m)	19.9	22.0	23.0

* All values at chart datum

Basta Voe is included in both the *Scottish Sea Lochs Catalogue* (Edwards & Sharples, 1986) and the *Catalogue of Voes, Firths and Sounds in Shetland* (Dixon, 1987). For the calculations the mouth of the voe is defined between Point the Ness and the western side of Burra Ness, as per Dixon. The estimated area derived for this assessment is comparable to the figures presented in these publications (Edwards and Sharples; 4.1 km^2; Dixon; 4.2 km^2). The estimated volume is smaller than that presented in Edwards and Sharples (52.7 Mm^3) and this parameter was not calculated in Dixon. The difference is likely to be attributed to the method employed to derive the published figures which was through manual measurement with a planimeter.

13.3 Tidal Information

Information pertaining to predicted tide height is derived from the UKHO TotalTide prediction for Mid Yell Voe, the nearest secondary port which is located in the neighbouring inlet to the south of Basta Voe. Figures 13.3 and 13.4 show tidal curves for a fifteen day period starting on the 19 August 2014 which the date of the shoreline survey.

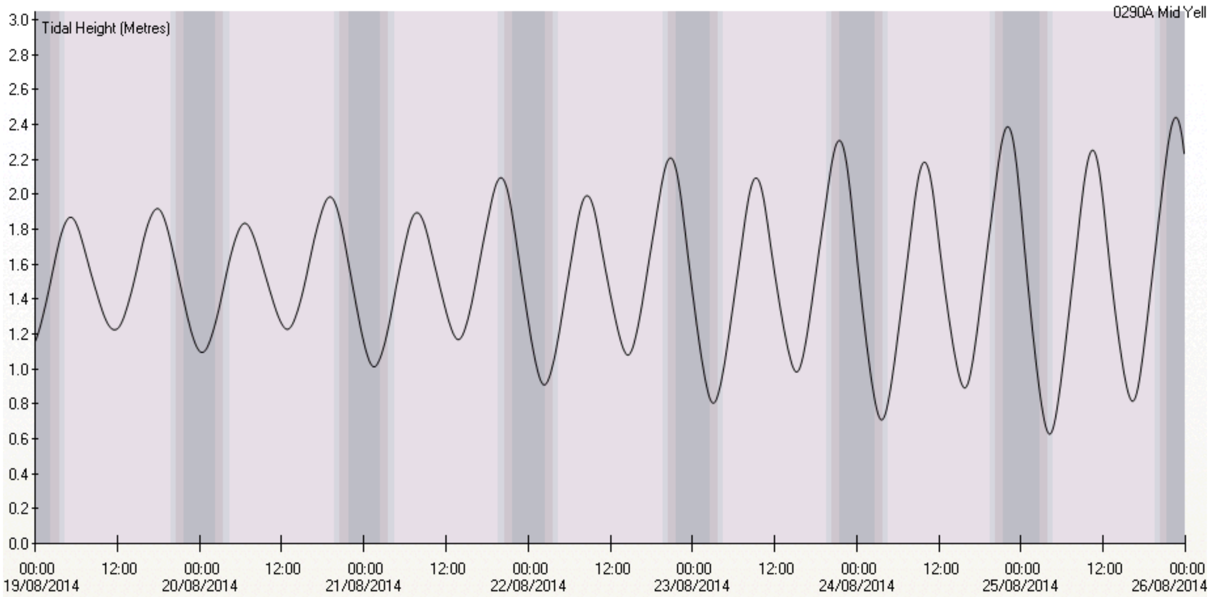


Figure 13.3 Tidal Curve Mid Yell Voe 19 to 26 August 2014

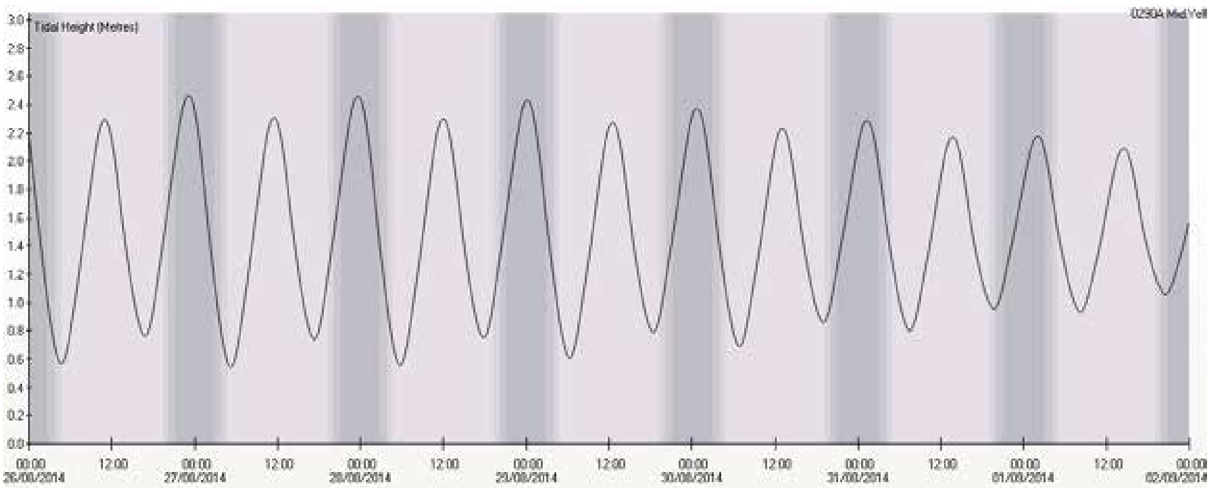


Figure 13.4 Tidal Curve Mid Yell Voe 26 August to 2 September 2014

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

0290A Mid Yell is a Secondary Non-Harmonic port.

The tide type is Semi-Diurnal.

HAT	2.9 m
MHWS	2.4 m
MHWN	1.9 m
MSL	1.52 m
MLWN	1.1 m
MLWS	0.6 m
LAT	0.0 m

Predicted heights are in metres above Chart Datum

Based on the above Mid Yell Voe would be classified as micro-tidal with a low tidal range of 1.8 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 2008 to the north of the Point of Ness in Basta Voe (0.9 km south-east from the study area boundary). Although there is data for a survey conducted within the study area from 2002, the pressure data is not useful to this assessment due to a faulty pressure sensor. The 2008 data were compared to the Mid Yell Voe 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 water to occur at Basta Voe marginally (less than 20 minutes) before high water in Mid Yell Voe.

13.3.2 Range

The range of three tides around the spring tide and three tides around the neap tide for the 2008 deployment in Basta Voe were compared to that predicted for the corresponding tides at Mid Yell Voe. The observed tidal range during spring tides is comparable to the prediction (observed range 2.3 dBar, predicted range 2.2 m). Neap tidal range was also similar although not as close as the prediction (observed range 0.9 dBar, predicted range 0.7 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 Basta Voe, the study area and the production area using the tidal prism method.

Input:		Production Area	Study Area	Basta Voe
Volume* (V)	Mm^3	12.15	18.86	54.59
Area* (A)	Km^2	1.38	1.86	4.17
Tidal range (R)	m	1.80		
Output:				
Flushing Time (T_f)	days	3.63	4.18	5.40
Flushing Rate (Q)	Mm^3/year	1,220	1,648	3,689
Flushing Rate (Q)	Mm^3/day	3.34	4.51	10.10
Flushing Rate (Q)	Mm^3/tidal cycle	1.74	2.35	5.25

- *Calculated for MLWS.

The tidal prism method indicates that 9.6 % of the low water volume of Basta Voe is exchanged during each tidal cycle, a figure which increases to 14.3 % for the production area alone. Total exchange would take just under five and half days for the whole voe and just over three and a half days for the production area.

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 Basta Voe, the study area and the production area using Surfer grid volume calculation.

Tide	Z (m)	Production Area Volume (Mm^3)	Study Area Volume (Mm^3)	Basta Voe Volume (Mm^3)
MLWS	0.5	12.15	18.86	54.59
MHWS	1.6	14.80	22.40	62.38
Difference (spring tide)		2.64	3.54	7.79
MLWN	0.6	12.86	19.81	56.70
MHWN	1.3	14.03	21.38	60.16
Difference (Neap tide)		1.17	1.57	3.46
Average Difference		**1.91**	**2.56**	**5.62**

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 Basta Voe may be considered typical of a semi-enclosed water body for which the tidal prism calculation is suited, the proximity of a strong tidal stream present on the east coast of Yell could serve to influence exchange. Such interactions are beyond the scope of simple box modelling techniques.

13.4 Currents

Admiralty charts provide no tidal stream information within the study area. The Admiralty Tidal Stream Atlas for Orkney and Shetland (UKHO, 1986) does not detail tidal flow within the study area however information pertaining to the currents to be expected to the east of Yell is given. The flood tide flows from north to south from approximately 3⅓ hours before high water at Mid Yell, to 1⅔ hours after high water. After a period of slack water the ebb tide flows to the north from approximately 4⅔ hours after high water to 4⅓ hours before high water. Peak flow off the Burra Ness peninsular for each tide would appear to be coincidental with high and low water in Basta Voe.

13.4.1 Field Data

Historically there have been four field studies which give an insight into the current flow patterns of the study area. Summary information of the deployments is given in Appendix 4.1 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 conducted at the Basta Voe North fish farm in 2002 is the only data collected from within the study area and this produced high quality data that is considered representative of the location. Of the two surveys at Basta Voe South the earlier deployment at the site is disregarded from further study in favour of the higher precision survey conducted in 2008. The survey data from Kirkabister (Basta Voe North West) in 2001 yielded the poorest quality data. The velocity precision is predicted to be 0.047 m/s which is above the 0.020 m/s threshold required by the standards defined in Attachment VIII. The effect this has on the data is mitigated to a certain extent by the relatively high current speeds recorded however the reliability of the data will be affected.

13.4.2 Survey Data Assessment

An assessment of the hydrographic data collected at the Basta Voe North, Basta Voe South and Kirkabister fish farms was undertaken with detailed summary statistics tabulated in Appendix 4.2. Figure 13.5 illustrates the frequency of currents by vector and the pertinent summary statistics for near-surface waters.

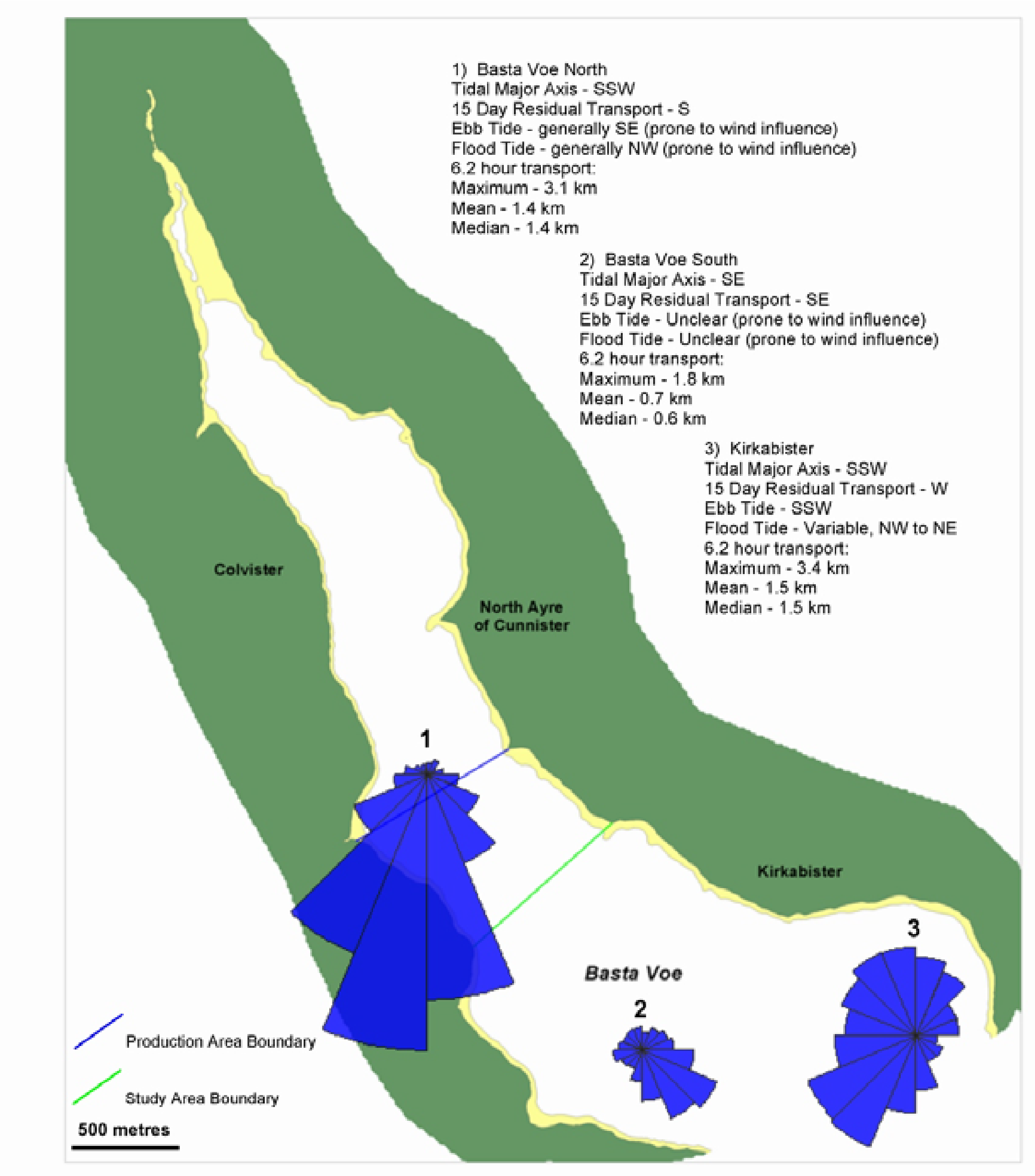


Figure 13.5 Near-surface current direction frequency (bin size 22.5°) for the surveys at Basta Voe North, Basta Voe South and Kirkabister, including a summary of residual and tidal transport at each location.

Chart based on data extracted from Admiralty Chart BA3292

The hydrographic data collected at Basta Voe North 2002 indicates that the influence from tidal currents is relatively low. Current velocities are marginally greater at the seabed than they are in the near surface layer although the summary statistics generally show largely consistent hydrographic conditions throughout the water column.

It is apparent through assessment of the near-surface record that wind forcing has a strong influence on the currents observed during the fifteen day period analysed. Meteorological data shows breezy conditions on average with winds rarely falling below Beaufort Force 6 with instances of stronger winds on five occasions exceeding F7. Throughout the survey there was a dominant south south-east airflow with the only variation from this recorded during a brief instance of calm conditions. There is a dominance of currents flowing towards the south in all three layers of the water column that were analysed, with little transport in the reciprocal direction. This flow is more or less unidirectional, with some variability associated with flood tides, periods of low wind forcing and during spring tides. The direction of flow is in the opposite direction to the wind forcing, even in the near-surface record. This could indicate that a counter current has been recorded at this depth and that water above this depth may be flowing north into Basta Voe with the wind. The minimum depth recorded at the survey location was 22 metres, while the near -surface data was recorded at 16.7 metres above the seabed. Unfortunately there is no data above this owing to the configuration of the instrument at the time of the survey which led to the data collected above 16.7 metres being deemed unreliable due to surface interference. There is some variation in current velocity which has a resolution equivalent to the tidal cycle and peak speeds are to be expected during the ebb tide. However these are dominated by a longer term pattern where overall current velocity is greater during periods of strong wind forcing.

The survey location is moderately exposed with fetches of 6.5 km to the south-east, and 2.7 km to the north-west. With respect to patterns of tidal movement data from the near seabed record was examined where there is the least direct influence from wind forcing. During the short period of calmer weather (<F4) tidal direction follows the pattern defined by the topography of the voe with the flood tide flowing north-west and the ebb tide flowing south-east. As described above tidal flow and direction will be affected by wind forcing.

Periods of greatest transport during a 6.2 hour period (up to 3.1 km) occur in two clusters during separate ebb tides, which are coincidental with strong winds being recorded.

The data collected during the survey at Basta Voe South in 2008 demonstrate a more quiescent current regime than that observed to the north. The highest average speed was again recorded close to the seabed although at this location surface water movement differs from that present in the remainder of the water column. Close to the surface there is a dominance of currents flowing to the south-east, while at the seabed the dominate direction is to the west north-west. Again it would appear that wind forcing has an influence on water movement at this location. The survey period was characterised by wind conditions that varied from day to day, with speeds from F2 to F6 and above repeatedly experienced within a 24 hour period. Variation in wind direction follows the same pattern, with winds changing from southerly to west north-west several times for the first 13 days of the analysis period, followed by a northerly airstream for the remaining time. The strongest winds are largely associated with those from the west north-west and this appears to be translated to periods of near unidirectional flow to the south-east across adjacent tidal cycles in the near-surface record. Again this location is moderately exposed with fetches of 4 km to the north-west and 4.8 km to the east south-east.

The tidal cycle is poorly defined in the time series of the current data throughout the water column. Again an assessment is made of the near-seabed record where the influence of wind forcing is expected to be lower. Peak velocity would appear to occur at the start of the flood tide although this is only evident during spring tides, and there is a regular recurrence of a brief period of slack water shortly after high water. Tidal direction shows considerable variation from one tide to the next which is related to the influence of wind driven transport at the survey location. The only evidence of the tidal cycle in the directional data is a brief deviation from a given period of near unidirectional flow present at the time, events that are often coincidental with low current speeds.

Periods of greatest transport during a 6.2 hour period (up to 1.8 km) occurred in two clusters each during an ebb tide of the springs phase of the tidal cycle and these where were associated with F6 winds from the west and north-west. There is also a periodicity in the level of excursion that matches the tidal cycle, although there is no particular bias for either the flood or the ebb tide.

Due east of Basta Voe South the data collected during the survey at Kirkabister in 2001 would indicate that a more energetic current regime is present at this location than that observed elsewhere in the voe which is a reflection of the proximity of the strong tidal streams present to the east of Yell. Throughout the water column the majority of currents recorded are along a north/south south-west axis and are therefore not aligned with the long axis of Basta Voe. This could be evidence of a deflection of tidal currents in the bay at Kirkabister. Overall transport is to the south south-west.

The tidal cycle is clearly defined in the time series of the current data throughout the water column both in terms of speed and direction and as expected greater velocities are present during the springs phase of the tidal cycle. Peak velocities frequently occur at low water and during the early part of the flood tide. Regarding tidal direction the pattern observed is not synchronous with the timing of high and low water. The latter part of the ebb tide, through low water and the early part of the flood tide show a consistent flow to the south south-west, while the weaker flow for the remainder of the tidal cycle shows a more variable pattern between the north-west and north-east. This deviation from a classic pattern where the tide flows into the voe on the flood and drains in the opposite direction on the ebb tide may be explained by the proximity to the tidal streams present in Colgrave Sound and Hascosay Sound. The flood tide flowing from north to south diverges around Hascosay while the ebb tide flowing north through these straits converges to the north of the island. This and the additional influence of the ebb tide leaving Basta Voe have the potential for complex hydrographic conditions and may lead to the formation of eddies in the approaches to the voe.

Wind forcing would appear to have little influence on tidal currents even during the three periods of F6 and greater winds encountered during the survey period. This location is moderately exposed and although the maximum fetch (>5 km) is to the south this includes Hascosay Sound were strong tidal currents are likely to dominate any wind driven transport which may form here.

Periods of greatest transport during a 6.2 hour period (up to 3.4 km) occur during three clusters during the spring tidal phase. There is again a periodicity in the level of excursion that matches the tidal cycle, with the larger excursions repeatedly occurring during the flood tide.

In summary tidal currents in the study area are weak and subject to significant influence from wind forcing to the extent that the latter can totally dominate the former. While empirical data only exist for the southern end of the study area it is considered likely that these conditions can be expected for all of the northern part of Basta Voe. Towards the mouth of the voe the tidal cycle has the strongest influence on water movement although the pattern observed is indicative of complex hydrographic conditions where Basta Voe meets the region of water to the north of Hascosay. Strong tidal streams are present along the east coast of Yell flowing though Colgrave Sound, and to a lesser extend Hascosay Sound, and Bluemull Sound to the north.

13.5 Stratification

Salinity and temperature profiles were collected at three locations within the production area during the shoreline survey in August 2014. These locations corresponded to the northern and southern extents of the Inner Site 1 Thomason fishery, and a single profile at the northern end of the Inner Site 2 Nisbet fishery. At all three locations the observed change over the profile was within the accuracy for the instrument used (± 0.35 ppt). When the individual profiles are compared to each other the readings collected at Inner Site 2 Nisbet showed marginally lower values than those collected at Inner Site 1 Thomason (mean difference 0.63 ppt) although overall near-uniform salinity levels typical of normal seawater are illustrated. The degree of change observed is comparatively low with respect to sea lochs on the Scottish Mainland, where a difference in the order of 20 ppt may be seen between bottom and surface waters. The surface seawater samples collected at each of these locations, and from two additional locations close to each site also showed nominal levels.

The three temperature profiles showed minor variation, both over the depth of the profile and between each location; a variation of 0.1°C at the northern extents of the two fisheries and no change at the southern end of Inner Site 1 Thomason. Complete salinity and temperature profile data and water sample analysis are available in the shoreline survey report.

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, there was no evidence of this phenomenon during the fieldwork conducted in August 2014 at the locations sampled.

A total of five watercourses as well as several field drains were recorded draining into the production area during the shoreline survey, the largest of which was at the head of Basta Voe. Annual rainfall patterns could therefore have an effect on surface salinity. Figure 13.6 illustrates the monthly total rainfall and the 24 hour average rainfall from the Lerwick Meteorological Office from 2007 to 2012. During the autumn and winter months reduced salinity in near surface waters may occur with higher fresh water input, however the timing of the fieldwork precluded any further study of this phenomenon.

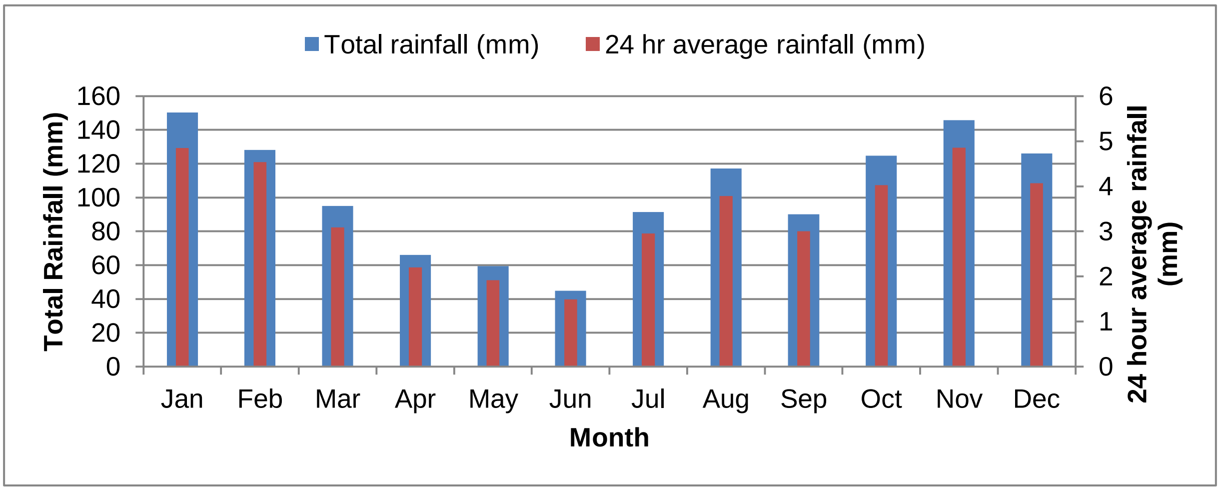


Figure 13.6 Total monthly and mean 24 hour rainfall for the period 2007 to 2012

Various parameters pertaining to freshwater input are described by Edwards and Sharples, 1986 and later by Dixon, 1987 in which the values for the sea water inlets of Shetland were refined. These figures have been updated using digital mapping techniques and modern rainfall totals in Table 13.4 below.

Table 13.4 Comparing freshwater runoff parameters

Parameter	Units	Edwards & Sharples 1986	Dixon 1987	SSQC 2013
Watershed	km^2	32	32.3	32.8
Annual Rainfall	(mm)	1,100	1,150	1,223*
Runoff	(Mm^3/yr)	27.2	29.1	31.9
Fresh/tide, per thousand	-	6.8	7.1	8.8
Salinity reduction	ppt	0.23	0.24	0.30
Runoff/width	m^2/d	91	92	106

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

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

6 Summary

- The tidal prediction for Mid Yell Voe is applicable to the study area in terms of timing and range.
- Figures for tidal exchange derived from the two methods indicate that between 14.3 % to 15.7 % of the low water volume of the production area is exchanged during the tidal cycle leading to a flushing time of approximately 3.6 days.
- The production area represents only the upper part of Basta Voe (approximately 50 % of the length, or 22 % of the total volume). Tidal exchange figures for the whole voe that between 9.6 % to 10.3 % of the low water volume is exchanged during the tidal cycle leading to a flushing time of approximately 5.4 days.
- Field observations indicate that tidal currents are relatively weak and variable in the production area and these conditions persist for the majority of the length of voe. Generally the tide appears to conform to the topography of the voe flowing north-east on the flood and south-west on the ebb, although during the survey periods these currents were dominated by those attributed to wind forcing.
- Wind forcing, particularly when blowing along the long axis of the voe can produce periods of near unidirectional flow over sequential tidal cycles.
- Towards the mouth of the voe tidal currents dominate water flow however the complex pattern observed could be indicative of the influence of tidal streams along the east coast of Yell.
- Near the production area the greatest transport events during a 6.2 hour (tidal) period of up to 3.1 km are associated with elevated wind forcing, and are coincidental with ebb tides.

- The production area is exposed to 6.5 km fetch to the south-east. Data from the only survey conducted within the study area recorded a dominant south-easterly airflow that led to the formation of a current flowing in this direction below a depth of 5 metres. This is potentially evidence of a counter current at this depth if surface waters are being transported towards the head of the voe during the survey period.
- Salinity profiles collected during the August 2014 shoreline survey showed little definitive evidence of freshwater influence in the surface waters of the production area. Freshwater runoff calculations based on the watershed and bathymetric properties of Basta Voe would suggest that there is potential for a low degree salinity reduction in the order of 0.3 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 Basta Voe Cove shoreline survey was conducted on the 19th August 2014. Rain was recorded in the 48 hours prior to the survey, with heavy showers and sunny spells and an F6 northerly wind experienced on the survey day.

The fishery consisted of two common mussel farms, with one being divided into three separate blocks of lines. All shellfish samples returned low results (<230 *E. coli* MPN/100 g), though results were generally higher in samples taken at the top than at the bottom of the droppers. This excluded samples taken at the Inner 2 site where the opposite was found. Associated seawater sample results were between <1 and 2 *E. coli* cfu/100 ml.

Adjacent shorelines were sparsely populated. Most properties were observed along the east side of the voe, set back from the shoreline. Two industrial premises were observed; Yell water treatment works at the head of the voe and a shore base facility associated with C&A Thomason and Thompson Brothers Salmon located west of the voe. No visitor accommodation was noted.

One active septic outfall to sea was observed from a concrete ST with an outfall serving a house on the east side of the voe. An inactive septic tank and outfall was seen at the derelict North Isles Motel. It was unclear whether discharge pipes at a shore base also carried septic waste, and a further discharge pipe on the northeast shore was assumed to be field drainage.

Four moored workboats were observed adjacent to the shore base pier. A disused pier was also located south of Sandwater Burn. Sheep were observed on common grazing land near the head of the voe, which extends along much of the western shore and hillside beyond. Livestock here had access to the shore and faeces were frequently recorded on the foreshore.

Four watercourses were sampled and measured and two other watercourses were observed but had insufficient flow to sample or measure. Freshwater sample results ranged from 160 to 350 *E. coli* cfu/100 ml.

Birds were the main wildlife observed, with large numbers of geese and eider ducks seen. An otter was observed at Cunnister.

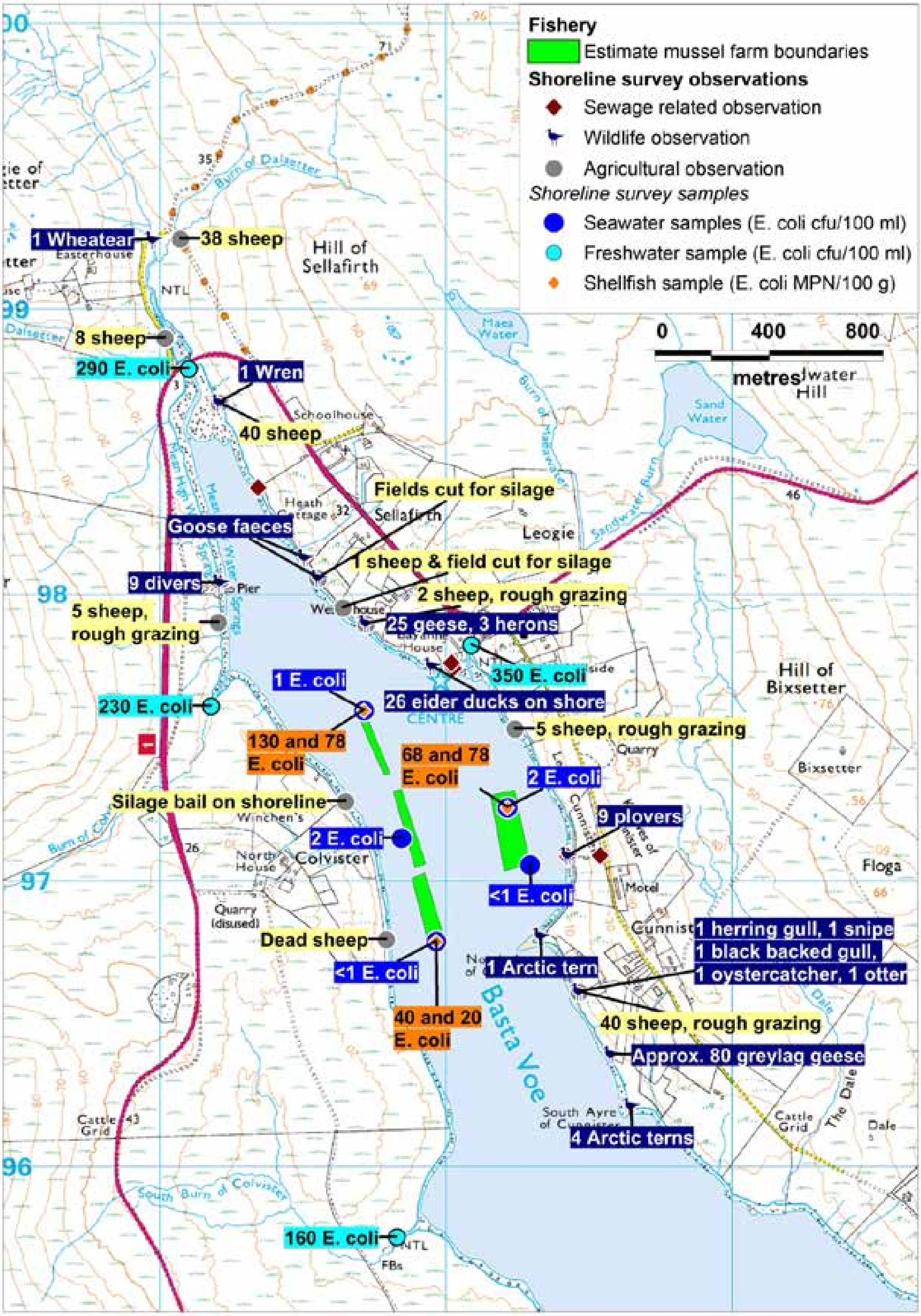


Figure 14.1 Map of shoreline survey observations at Basta Voe Cove

15. Bacteriological Survey

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

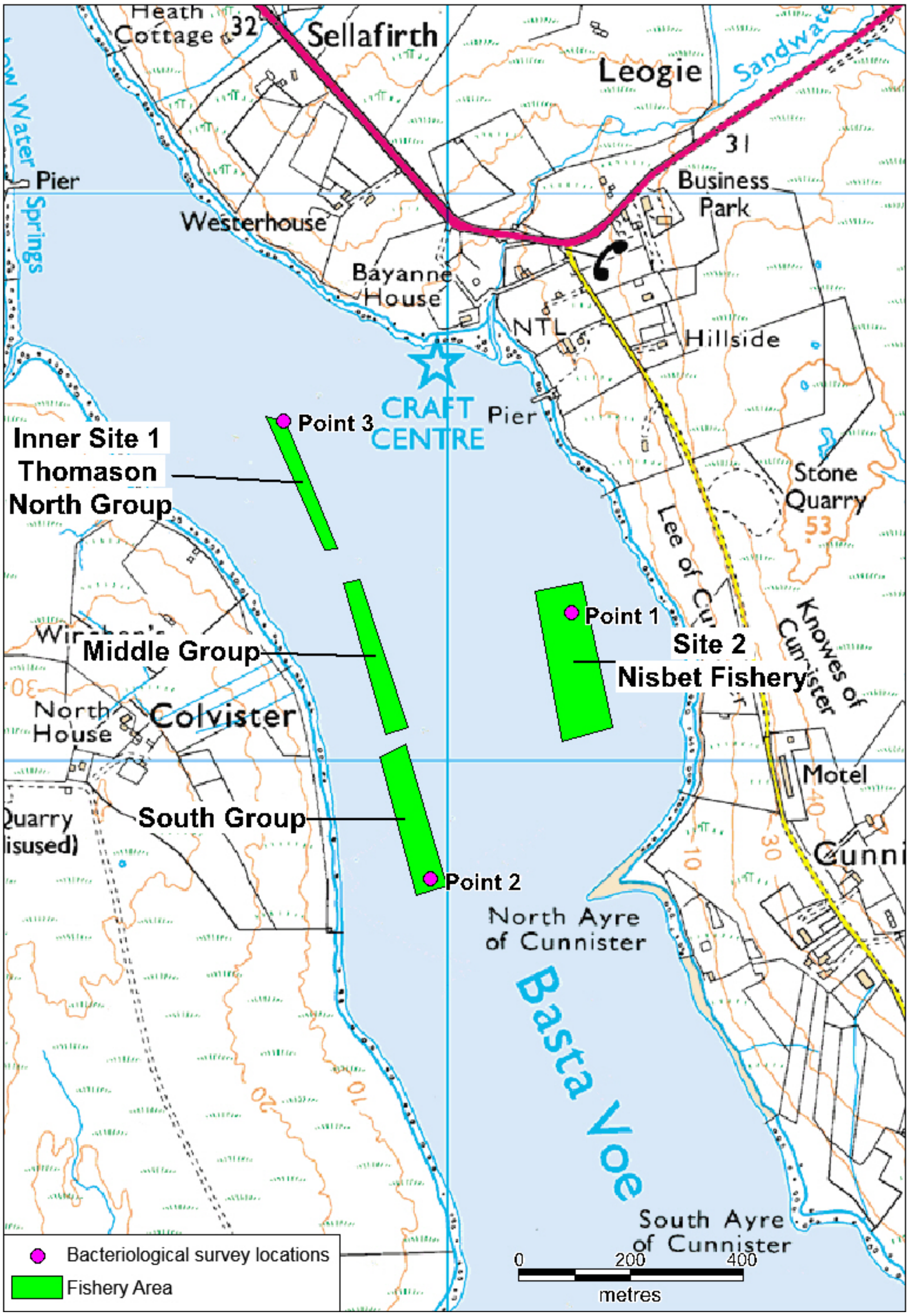


Figure 15.1 Bacteriological Survey Site Locations

Table 15.1 Geometric mean and range of bacteriological survey results

Location	Maximum Value *E. coli*/100g	Minimum Value *E. coli*/100g	Geometric Mean *E. coli*/100g
Point 1	330	68	170
Point 2	790	40	220
Point 3	1300	130	380

All samples from the second and third sampling dates yielded results at or above 230 *E.coli* MPN/100 g. The geometric mean of the sample results was highest at Point 3, at the northern end of the Thomason (N) site.

16. Overall Assessment

Human sewage impacts

There is very little point source sewage pollution to the voe, with only one confirmed active private septic tank discharging to the east shore. No consent was received for the shorebase on the west side of the voe, and though no discharge was identified it is likely to have toilet facilities and therefore a septic system on site. Any discharge to the voe from this facility would be most likely to impact the northern end of the Thomason mussel farm.

The majority of human sewage in the area is discharged to land or soakaway well away from the shoreline, and would not normally be considered a significant risk to water quality in the voe.

An anchorage was identified to the north of the Nisbet site, and any overboard discharges from boats on the anchorage would have an impact on the northern end of that mussel farm. However, it is not clear how often the anchorage is used and it is not expected to be continuously occupied.

Agricultural impacts

The principal source of faecal contamination to the area is likely to be diffuse contamination from livestock, predominantly sheep. The majority of sheep seen during the shoreline survey were located around the north east side of the voe. Livestock droppings were frequently observed on the foreshore, indicating that animals were accessing these areas. Some fields were used for production of silage, and any stable waste or other organic fertilisers applied to these during wet conditions may result in contaminated runoff to the voe. The highest impact is likely to be to the northern end of the voe.

Wildlife impacts

Seals, geese, ducks, seabirds, otters and dolphins are all expected to contribute to background levels of faecal contamination within the voe. Geese and ducks were observed in moderate numbers along the east shore of the voe during the shoreline survey, and any impacts from these would be highest at the Nisbet site.

Seasonal variation

Very little seasonal variation is expected in the human population in the area. Although there is a motel, it has been derelict for many years and unless it is brought back into use there is no other tourist accommodation in the area. Seasonal variation in agricultural practices is expected, with increases in the sheep population occurring from late spring to autumn, and production of silage also occurring during the spring and summer months. Rainfall varies by season, with highest rainfall occurring in autumn and winter.

A statistically significant correlation was found between *E. coli* monitoring results and water temperature, with higher results corresponding with higher water temperatures. Results greater than 230 *E. coli* MPN/100 g occurred at water temperatures ranging from 8 to 12, which incorporates much of the observed range of recorded temperatures, therefore this correlation should be interpreted with caution.

Days with exceptional rainfall tended to occur more often between June and December. A highly significant difference was found between *E. coli* results by season, with highest results seen in autumn. The trend in results by month is for an increase beginning in June and peaking in October before decreasing again until a low in April and May. This appears to coincide roughly with the pattern seen in daily rainfall.

Watercourses

A small number of watercourses were observed to be flowing during the shoreline survey. Three of these were estimated to carry moderate loadings at the time of shoreline survey. All of these discharged to the northern end of the voe, with the northern ends of both the Thomason and Nisbet sites roughly the same distance south of different watercourses. The northern ends of both sites are likely to receive similar impacts from these sources, with higher impacts near the surface at lines closest to shore.

Highly significant correlations were found between *E. coli* monitoring results and rainfall recorded during both the two-day and seven-day periods prior to sampling. This suggests that surface water runoff to watercourses after rainfall is a significant pathway for contamination reaching the mussel farms. It should be noted that the highest recorded result coincided with low two-day rainfall (3.6 mm) but relatively high seven-day rainfall (52.0 mm). This suggests that effects of rainfall over a longer period than two days may be more important at this site.

No statistically significant correlation was found between results and salinity, however salinity was only recorded for approximately half the samples analysed. Salinity profiles taken during the shoreline survey showed no apparent reduction in salinity, with salinity levels typical of normal seawater recorded and little variance in observations between sites.

Movement of contaminants

Tidal currents are relatively weak within the voe, and generally follow the topography flowing north-east on the flood and south-west on the ebb. Wind-driven circulation is therefore predicted to be a significant factor affecting the movement of contaminants within the voe. Data suggested that persistent winds along the long axis of the voe can cause water to flow in one direction over several consecutive tidal cycles. The maximum estimated transport distance is 3.1 km, though this was associated with wind forcing and ebb tides and therefore may not be achieved under other conditions. Analysis of *E. coli* monitoring results by tidal cycles showed no significant correlation with either the high/low or spring neap tidal cycles. No analysis of results by wind direction was undertaken for this report.

Temporal and geographical patterns of sampling results

Monitoring results were consistent over most of the period analysed, however there was a peak in the trend line in late 2013, when there were no results ≤20 *E. coli* MPN/100 g. This peak did not coincide with the highest observed result, which occurred in late 2012.

Sample results were reported against two main locations within the production area: one around the RMP and one approximately 170 m north of the RMP and north of the current mussel farm area. No statistically significant difference was found between results from these two locations. The northernmost sample location coincided with older sampling dates, and this may therefore reflect a southward shift in the location of the mussel farm.

There was an interesting cluster of results forming a grid pattern to the west of the RMP. Results from these locations were reported to 10 metre accuracy, with the last digit varying by 1.

Samples of mussels taken during the shoreline survey returned results varying from 20 to 130 E. coli MPN/100 g, with little difference between samples from the tops and bottoms of the lines. The sample with the highest result came from the northern end of the Thomason site, whilst that with the lowest result came from the southern end of the Thomason site.

Bacteriological Survey

Results from a bacteriological survey showed that, whilst overall levels of contamination were broadly similar across the sites, highest results were obtained on two occasions at the northern end of the Thomason site. This location lies nearer the head of the voe, where the majority of potential sources of faecal contamination were identified.

Conclusions

Overall, the sources of human sewage contamination are limited, though not all sources have been accounted for. The main source of faecal contamination to the shellfish production area is livestock, with sheep droppings frequently seen on the foreshore of the voe during the shoreline survey. Watercourses in the area drain land used for grazing livestock and the largest of these were estimated to carry high *E. coli* loadings at the time of shoreline survey. The significant correlation found between E. coli monitoring results and rainfall further supports the assessment that contamination associated with fresh-water runoff from land is the main pathway for contamination at this production area. Although results were broadly similar across the sites, the highest results were obtained from the north end of the Thomason site. It should be noted that the harvester refers to this mussel farm as Colvister, and therefore consideration should be given to renaming the site in order to ensure consistent reference between the agency and the harvester.

17. Recommendations

Production area

It is recommended that discharges to the marine environment be excluded from the production area boundary. The head of the loch between the A968 bridge and the normal tidal limit has also been excluded, bringing the boundary in line with that of the Shellfish Waters Protected Area. Therefore it is recommended that the production area be amended to the area bounded by lines drawn between HU 5263 9620 and HU 5193 9578, HU 5196 9774 and HU 5215 9763, HU 5108 9878 and HU 5114 9881 and extending to MHWS.

RMP

It is recommended that the RMP be moved to the northern end of Inner-Site 1-Thomason (Colvister), at HU 5171 9758. This location lies nearest the identified sources to the north of the mussel farms and at the head of the loch, and also yielded the highest results during the bacteriological survey.

Tolerance

A standard tolerance of 40 metres is recommended to allow for some movement of the lines. It is recommended that the sampling location be recorded to the nearest 10 metres using GPS equipment on each sampling occasion.

Depth of sampling

As the main pathway for contamination is via freshwater sources, a sampling depth of 1-3 metres is recommended.

Frequency

It is recommended that monthly sampling frequency be retained.

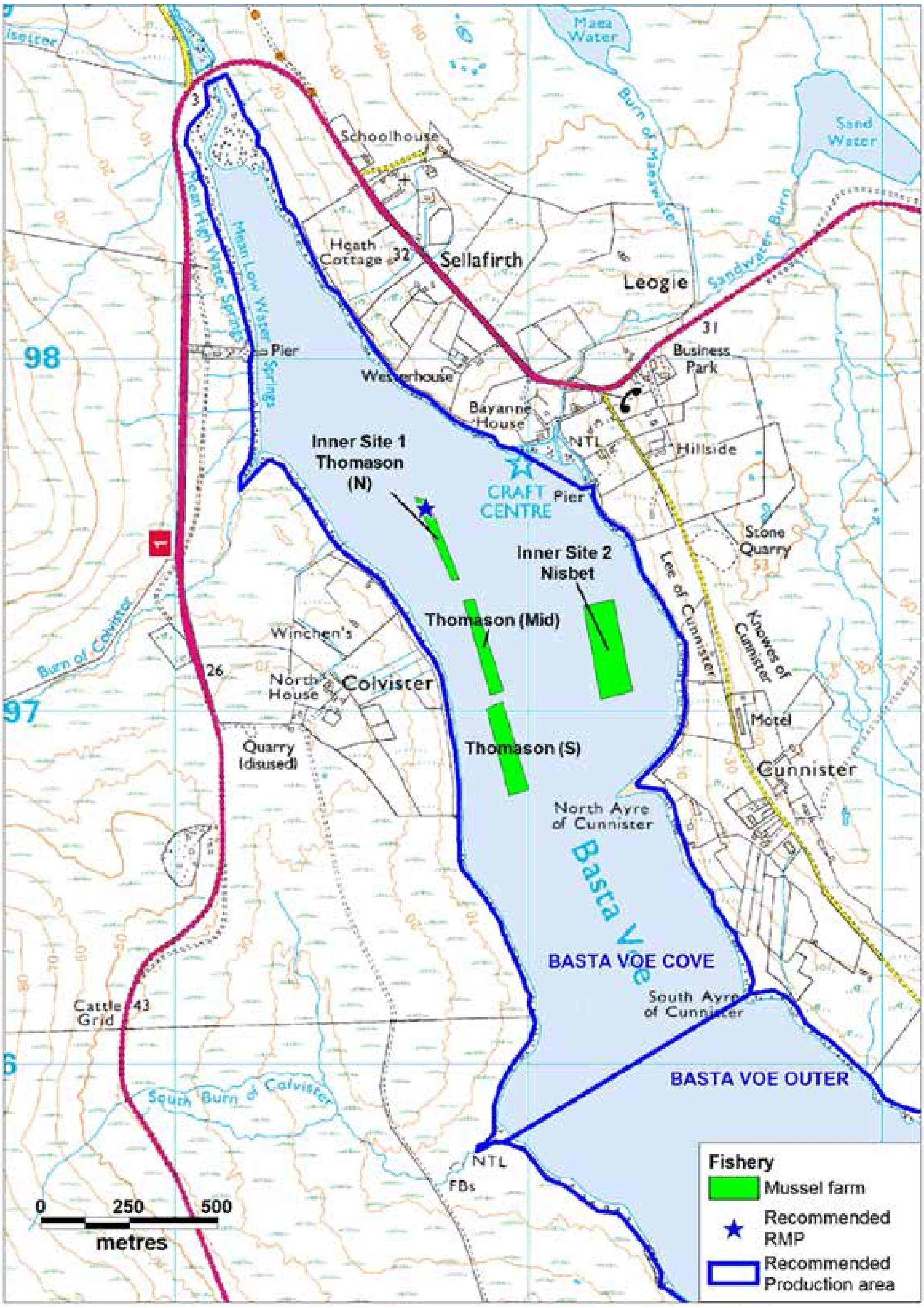


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Figure 17.1 Map of recommendations at Basta Voe Cove

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

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)

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3. Hydrographic Assessment Glossary

The following technical terms may appear in the hydrographic assessment.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4. Hydrographic Section Appendix

Appendix 4.1: Hydrographic survey details

Site Name	NGR	Survey Period	Equipment
Basta Voe North	HU 52257 96086	19/11/02 – 09/12/02	Nortek 500 kHz ADCP
Basta Voe South	HU 53249 94816	08/10/08 – 29/10/08	Nortek 500 kHz ADCP
Kirkabister (Basta Voe North West)	HU 54511 94885	23/03/01 – 10/04/01	Nortek 500 kHz ADCP

Appendix 4.2: Hydrographic survey summary statistics

Parameter	Units	Near-surface / Mid-depth / Near-bottom	Basta Voe North	Basta Voe South	Kirkabister
Mean speed	m/s	Near-surface	0.072	0.042	0.130
		Mid-depth	0.080	0.039	0.128
		Near-bottom	0.080	0.053	0.130
Tidal major axis	°Grid	Near-surface	195	125	205
		Mid-depth	180	290	210
		Near-bottom	175	290	210
Amplitude anisotropy	-	Near-surface	1.30	1.30	1.46
		Mid-depth	1.60	1.27	1.74
		Near-bottom	1.47	1.31	1.65
Residual speed	m/s	Near-surface	0.057	0.014	0.039
		Mid-depth	0.071	0.012	0.039
		Near-bottom	0.064	0.032	0.040
Residual direction	°Grid	Near-surface	190	136	260
		Mid-depth	179	215	228
		Near-bottom	183	255	194
Vector averaged residual	-		0.064 m/s at 183° Grid	0.013 m/s at 225° Grid	0.035 m/s at 226° Grid
Tidal excursion	km	Near-surface	0.93	0.74	2.39
		Mid-depth	0.92	0.69	2.55
		Near-bottom	1.01	0.82	2.54

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:	Basta Voe Cove	
Site Names & SIN:	Inner Site 1 Thomason	SI-323-399-08
	Inner Site 2 Nisbet	SI-324-400-08
Harvesters:	**C & A Thomason Ltd:** Christopher Thomason	
Local Authority:	Shetland Islands Council	
Status:	Existing area	
Date surveyed:	19 August 2014	
Surveyed by:	Sean Williamson (Hall Mark Meat Hygiene Ltd.) Alan Harpin (SSQC Ltd.) We are grateful to C & A Thomason for providing assistance during the marine survey work.	
Existing RMP:	HU 3929 4035 *(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 4-15.

Weather

Tuesday 19 August 2014

A fresh northerly F6 wind persisted throughout the day with conditions alternating between sunny spells and overcast with frequent heavy showers and squalls.

Preceding the shoreline survey, Sunday 17 August was partly to mostly cloudy with a period of rain in the afternoon. Initial F4 south south-westerly winds increased to F5/F6 from the north north-east. On Monday partly cloudy conditions with occasional showers were accompanied by a persistent F5/6 wind from the north.

Fishery

The location of the mussel lines for each of the fisheries are mapped in Figure 1. Both fisheries had stocked mussel lines on site. It should be noted that weather conditions and poor manoeuvrability of the workboat used meant that in some cases it was not safe to pass very close to the end of the lines to obtain an accurate fix. These instances are detailed in the observations table.

The Inner Site 1 Thomason fishery (known to the harvester as Colvister) consisted of three groups of mussel lines running parallel to the eastern shoreline (Figures 4 and 5). The southernmost group had five lines present, one of which was a single double-headed longline with the remaining four lines arranged as quad-headed longlines (i.e. a pair of double-headed lines to a single mooring at either end). The middle group consisted of four lines arranged as quad-headed longlines and the northernmost group consisted of two double-headed long lines. The site was being harvested at the time of the survey. The site is licenced for nine 220 metre quad-headed longlines.

The Inner Site 2 Nisbet fishery is located on the opposite side of the voe and consisted of a single group of nine double-headed long lines aligned with the shore (Figures 6 and 7). This site is licenced for three 220 metre quad-headed longlines. All lines on both fisheries were with 8 metre droppers.

Sewage/Faecal Sources

Basta Voe is sparsely populated with most properties scattered along the eastern coast and in the majority of cases these are located away from the shore. Nine dwellings were recorded during the shoreline walk. One dwelling near the Sandwater Burn was situated directly above the shoreline. This had a concrete septic tank with an outfall to the beach which had a grey water discharge dripping from the end (Figures 8 and 9). A large concrete septic tank with a discharge pipe not visible underwater was identified to be associated with the former North Isles Motel (Figure 10). These dilapidated premises have not been used as a motel for some time.

Also on the eastern shore there was a discharge pipe emerging from the bank above the shore which discharged to the beach (Figure 11). No properties were visible, with the nearest being marked on the map over 200 metres away beyond the A986 road. With a clear discharge and none of the typical signs of enrichment this was considered to be associated with field drainage.

The Yell Water Treatment Works is located at the head of Basta Voe (Figure 12). A sampling point was located next to a drainage ditch which led to a tributary of the Burn of Gossawater although an outfall from the plant was visible in the area.

Shore base facilities shared by C & A Thomason and Thompson Brothers Salmon are located on the western shore of the Voe. Two large diameter pipes were recorded with a clear discharge dripping on to the rock armouring above the pier (Figure 13). These appeared to be associated with a drainage ditch running along the north side of the track serving the pier. On the southern side of this track there was a large shed present directly above the shoreline, with a second building above the shore. No further discharges were identified.

Sample analysis

Four freshwater samples were obtained from watercourses around the Basta Voe Cove production area, two on the western shore, one on the eastern shore and one from the head of the voe. Six sampling points were outlined in the survey plan and four of these were collected. No additional samples were collected. The two planned samples not collected were both defined as unnamed field drains in the survey plan. On the eastern shore two field drains in close proximity were considered to be the likely candidate sample points however both were chocked with vegetation and had no flow present. On the western shore near Colvister there were no significant watercourses in the vicinity of the planned sample. While several adjacent field drains were noted, some of which had been recently cleared and some were overgrown, none had significant flow.

The four watercourses sampled were found to have *E.coli* levels between 160-350 cfu/100 ml. The lowest levels were present at the South Burn of Colvister and the highest levels were present at Sandwater Burn. The Burn of Gossawater at the head of Basta Voe was the largest watercourse encountered and this passed beneath the A986 road via two culverts (Figure 14). A pool was present on the landward side of this and strandline debris on the grass surrounding the pool indicated that this was subject to tidal influence (Figure 15).

A total of five seawater samples were collected all of which were indicted in the sampling plan. Three samples were obtained from the Inner Site 1 Thomason fishery; at the southern end of the southernmost group of lines, from the shoreward side of the middle group of lines and from the north-east corner of the northernmost group of lines. Two samples were obtained from the Inner Site 2 Nisbet fishery; from a point near the middle of northern end of the site at the RMP sampling location and from the south-east corner of the site. *E.coli* levels were between <1 to 2 cfu/100ml at all locations.

Mussel samples were obtained from the northernmost and southernmost extents of the Inner Site 1 Thomason fishery and from the RMP sampling location on the Inner Site 2 Nisbet fishery. 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 north-east corner of the northernmost group of lines of the Inner Site 1 Thomason fishery returned results of 130 *E.coli* MPN/100g and 78 *E.coli* MPN/100g for the top and bottom samples respectively. At the southern end of the southernmost group of lines levels were 40 *E.coli* MPN/100g and 20 *E.coli* MPN/100g for the top and bottom respectively. At the northern end of the Inner Site 2 Nisbet fishery counts were 68 *E.coli* MPN/100g and 78 *E.coli* MPN/100g for the top and bottom samples respectively.

Salinity profiles were obtained from the two fisheries at the three locations described above. In all cases observed variation in salinity measurements with depth did not exceed the accuracy value of the probe used (± 0.35 ppt). Surface salinity ranged from 34.07 ppt to 34.84 ppt at each location.

Temperature profiles were also obtained from these locations. All three profiles showed little variation with depth (+/- 0.1°C). Surface temperature ranged from 12.3°C to 12.4°C.

Salinities of the seawater samples analysed at the laboratory showed salinities ranging from 35.02 PSU present at the northern end of the Inner Site 2 Nisbet fishery to 34.89 PSU present at the shoreward side of the middle group of lines of the Inner Site 1 Thomason fishery.

Seasonal population

There is no guest house accommodation adjacent to the Basta Voe Cove fishery. The North Isles Motel at Cunnister on the eastern shore of the voe has been unoccupied for a number of years.

Boats/Shipping

Boat traffic within the Basta Voe Cove production area is largely associated with the fishery, salmon farming and leisure activities. At the shore base shared by C & A Thomason and Thompson Brothers Salmon there is a pier and slipway with four workboats present. The pier marked on the Ordnance Survey map to the south of Sandwater Burn is in poor condition and unlikely to be in use. Two rowing boats were recorded pulled up above the shore elsewhere during the walk.

Farming and Livestock

The majority of the land observed during the survey around the production area was either rough grazing or common grazing on heather moorland. A total of approximately 142 sheep were observed on the eastern shore of the voe and 5 sheep on the western shore. The largest proportion of these (78) were recorded near the head of the voe on an extensive area of common grazing which is present here and which extends to include the majority of the western shore and the hillside beyond. This livestock had access to the shore and faeces were frequently recorded on the foreshore near the head of the voe. Approximately 40 sheep were present near Cunnister. A deceased animal was recorded obstructing a drainage ditch within a fenced enclosure to the south of Colvister. No other livestock were recorded during the shoreline walk.

Land Use and Land Cover

The western shoreline of Basta Voe was characterised as heather moorland with drainage ditches and peat cuttings. These surround several fields of rough grassland enclosed by fencing near Colvister. Enclosed fields are more common on the eastern shoreline again with rough grassland which had some boggy areas with cottongrass and wild flag iris. Two fields which had been cut for silage were recorded at Sellafirth.

Watercourses

Four watercourses were sampled and measured during the shoreline survey, all of which were outlined on the sample plan. Two watercourses identified on the plan were not sampled or measured due to insufficient flow.

Wildlife/Birds

Birds were observed throughout the survey, mostly along the eastern shoreline. Geese were disturbed on two occasions from fields on the eastern shore (one flock of approximately 25 and later a second of around 80 birds). Eider ducks were also common with 26 recorded in the small bay near the Sandwater Burn. In addition to these species wren, wheatear, plover, herring gull, snipe, Arctic tern, oystercatcher, and red breasted merganser were recorded.

An otter was observed foraging along the shore near Cunnister.

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.

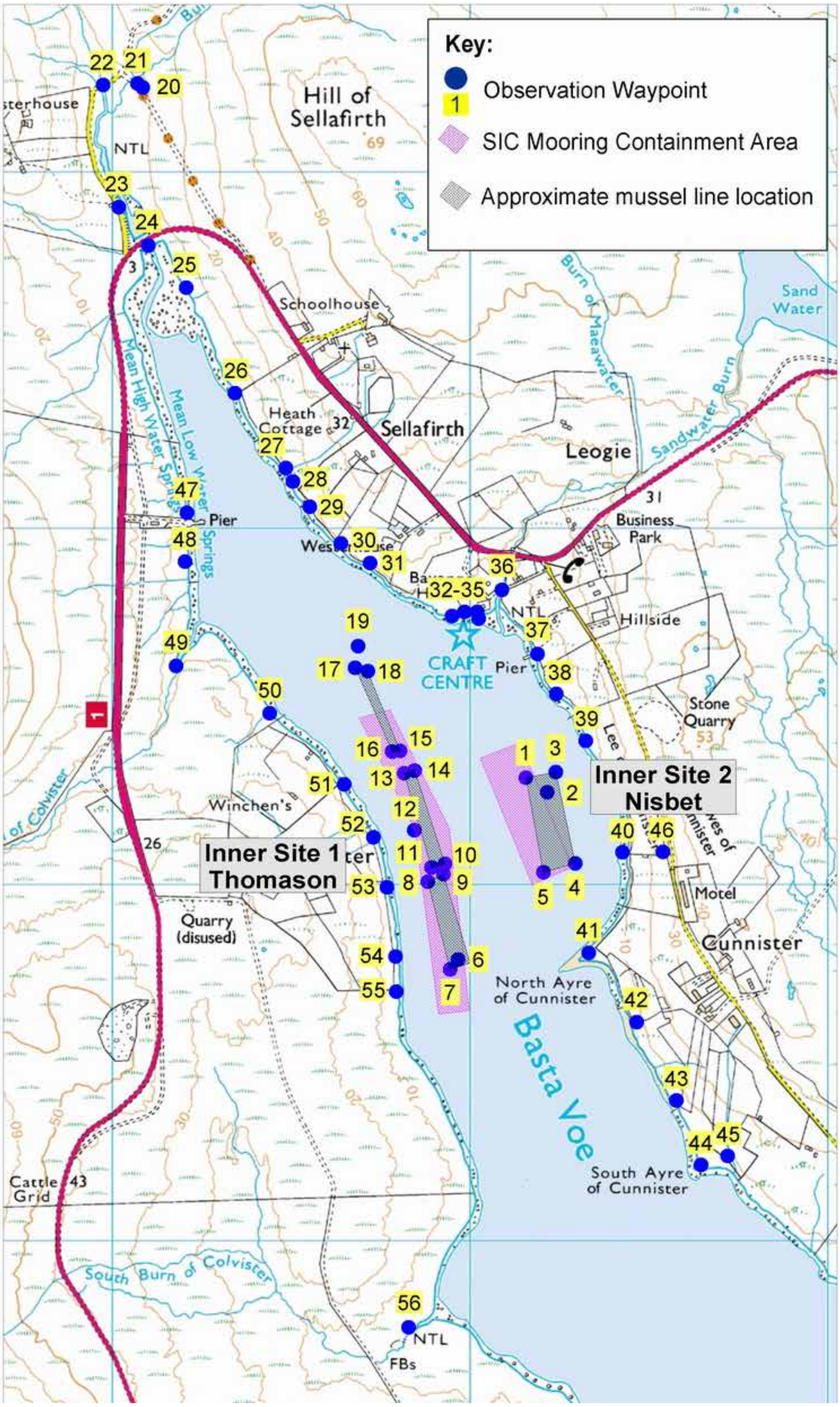

Figure 1 Map of shoreline observations Basta Voe Cove.

Table 1 Shoreline Observations

No.	Date/Time (UT)	NGR	Easting	Northing	Associated Figure	Associated Sample	Description
1	19/08/2014 07:39	HU 52156 97299	452156	1197299			Basta Voe Cove shoreline survey; boat work. Weather - Fresh F6 northerly wind with choppy sea state and white caps. Partly sunny with some cloudy and regular heavy showers. NW corner of the Inner Site 2 Nisbet fishery. The weather conditions and poor manoeuvrability of the workboat meant that it was not safe to pass very close to the end of the line to get an accurate fix. Approximately 10m off.
2	19/08/2014 07:41	HU 52215 97258	452215	1197258		BVC-MUSS01 (Top), BVC-MUSS02 (Bottom), & BVC-SW01	Sampling at the northern end of Inner Site 2 Nisbet, RMP sampling point, 4th line in from west, 9 buoys in from end. Fishery consists of 9 double-headed longlines with a dropper depth of 8m. 2 mussel samples collected; surface sample collected from the top of a dropper, bottom sample collected from bottom of a dropper. Salinity Profile 1 collected (ppt/°C): 10m 34.34/12.3, 5m 34.31/12.3, 3m 34.26/12.3, surface 34.07/12.4. Seawater sample collected. SW collected weekly biotoxin and phytoplankton sample.
3	19/08/2014 07:55	HU 52240 97315	452240	1197315	Figure 6		NE corner of the Inner Site 2 Nisbet fishery. Photo looking SW across fishery.
4	19/08/2014 07:58	HU 52294 97058	452294	1197058		BVC-SW02	SE corner of the Inner Site 2 Nisbet fishery. Seawater sample collected.
5	19/08/2014 07:59	HU 52205 97033	452205	1197033			SW corner of the Inner Site 2 Nisbet fishery (approximate, close pass not possible)

No.	Date/Time (UT)	NGR	Easting	Northing	Associated Figure	Associated Sample	Description
6	19/08/2014 08:04	HU 51967 96789	451967	1196789		BVC-MUSS03 (Top), BVC-MUSS04 (Bottom), & BVC-SW03	At Inner Site 1 Thomason fishery, which consists of three groups of lines arranged along the long axis of the voe. Known to the harvester as Colvister. Presently harvesting this site. Sampling at the southern end of the southernmost group, 2nd line in from east. 5 lines present, with 4 arranged as quad-headed longlines (i.e. pair of double-headed lines moored together at either end). Dropper depth 8m. 2 mussel samples collected; surface sample collected from the top of a dropper, bottom sample collected from bottom of a dropper. Salinity Profile 2 collected (ppt/°C): 10m 34.90/12.3, 5m 34.86/12.3, 3m 34.82/12.3, surface 34.77/12.3. Seawater sample collected. Photo looking NW towards southern group.
7	19/08/2014 08:12	HU 51945 96761	451945	1196761			SW corner of the Inner Site 1 Thomason fishery, S group.
8	19/08/2014 08:17	HU 51881 97007	451881	1197007			NW corner of the Inner Site 1 Thomason fishery, S group. (approximate)
9	19/08/2014 08:17	HU 51926 97028	451926	1197028			NE corner of the Inner Site 1 Thomason fishery, S group (approximate)
10	19/08/2014 08:19	HU 51930 97058	451930	1197058	Figure 4		SE corner of the Inner Site 1 Thomason fishery, middle group (approximate). Photo looking NW towards middle group.
11	19/08/2014 08:19	HU 51892 97046	451892	1197046			SW corner of the Inner Site 1 Thomason fishery, middle group. This group consists of 4 lines arranged as a pair of quad-headed longlines.

No.	Date/Time (UT)	NGR	Easting	Northing	Associated Figure	Associated Sample	Description
12	19/08/2014 08:21	HU 51845 97151	451845	1197151		BVC-SW04	Seawater sample collected from mid-point of the westernmost line of the middle group of the Inner Site 1 Thomason fishery.
13	19/08/2014 08:24	HU 51816 97312	451816	1197312			NW corner of the Inner Site 1 Thomason fishery, middle group.
14	19/08/2014 08:25	HU 51845 97319	451845	1197319			NE corner of the Inner Site 1 Thomason fishery, middle group.
15	19/08/2014 08:27	HU 51805 97374	451805	1197374			SE corner of the Inner Site 1 Thomason fishery, N group (approximate). This group consists of 2 double-headed longlines. Photo looking S towards middle group
16	19/08/2014 08:27	HU 51783 97372	451783	1197372			SW corner of the Inner Site 1 Thomason fishery, N group (approximate).
17	19/08/2014 08:31	HU 51679 97607	451679	1197607			NW corner of the Inner Site 1 Thomason fishery, N group (approximate).
18	19/08/2014 08:33	HU 51714 97598	451714	1197598		BVC-MUSS05 (Top), BVC-MUSS06 (Bottom), & BVC-SW05	NE corner of the Inner Site 1 Thomason fishery, N group. 2 mussel samples collected; surface sample collected from the top of a dropper, bottom sample collected from bottom of a dropper. Salinity Profile 3 collected (ppt/°C): 10m 34.94/12.4, 5m 34.93/12.3, 3m 34.92/12.4, surface 34.84/12.3. Seawater sample collected.
19	19/08/2014 08:42	HU 51688 97668	451688	1197668			Photo looking south towards the Inner Site 1 Thomason fishery. End of boat work.

No.	Date/Time (UT)	NGR	Easting	Northing	Associated Figure	Associated Sample	Description
20	19/08/2014 09:23	HU 51085 99236	451085	1199236	Figure 12		Shoreline walk: East coast of Basta Voe, north to south. Weather - overcast and showers and some sunny spells between. Started at the Yell Water Treatment Works.
21	19/08/2014 09:24	HU 51072 99248	451072	1199248			Yell WTW sampling point next to drainage ditch. Approximately 38 sheep. Land use, heather moor with some rough grass and peat cuttings.
22	19/08/2014 09:26	HU 50975 99243	450975	1199243			Watercourse; Burn of Gossawater and ruined bridge. In fenced off field above the burn rough grass with cottongrass. Wheatear.
23	19/08/2014 09:32	HU 51018 98900	451018	1198900	Figure 15		Pool behind embankment carrying A968 road, potentially influenced by tide implied by strandline debris on grass and water level marks on culvert present beneath road for the burn. 8 sheep along shoreline.
24	19/08/2014 09:35	HU 51101 98793	451101	1198793	Figure 14	BVC-FW01	Sampling point for the Burn of Gossawater. Culvert consists of two large circular profile tunnels which empty onto a concrete apron before flowing onto the natural stream bed. Flow measured on both sides. West side: 5cm deep, 60cm wide. Flow 0.811 cm/s and SD 0.038 cm/s. East side: 8cm deep, 80cm wide. Flow 1.352 cm/s and SD 0.036 cm/s. Freshwater sample collected. Burn meets the sea at a beach of gravel and sand. Tidal state, mid tide and falling.

No.	Date/Time (UT)	NGR	Easting	Northing	Associated Figure	Associated Sample	Description
25	19/08/2014 09:44	HU 51207 98674	451207	1198674			Approximately 40 sheep on common grazing land above shore and on either side of the road. Entire area not visible due to topography. Have access to the shore and prints and faeces present on the beach. Wren.
26	19/08/2014 09:49	HU 51343 98378	451343	1198378	Figure 11		Discharge pipe emerging from bank on to shore. Clear discharge and no evidence of septic discharge or atypical algae growth below the outfall. Two houses above the road are the nearest properties and it was considered unlikely to originate from these. Depression running parallel to the fence line in the field above implied that this was field drainage. Field above fenced off from the shore with rough grass.
27	19/08/2014 10:01	HU 51486 98168	451486	1198168			Approximate location of planned water sample from an unnamed field drain, however no flowing water present. Depression choked with vegetation indicates former drain. Photo including view to the north.
28	41870.41853	HU 51506 98131	451506	1198131			Adjacent choked drain. Geese faeces. Beach below comprised of coarser material, stones and rocks.
29	41870.42035	HU 51553 98060	451553	1198060			Fenced off field previously cut for silage. Geese faeces.
30	41870.42317	HU 51640 97957	451640	1197957			Adjacent fenced field also cut for silage. 1 sheep present.

No.	Date/Time (UT)	NGR	Easting	Northing	Associated Figure	Associated Sample	Description
31	41870.42442	HU 51721 97901	451721	1197901			Adjacent fenced field, rough grazing with 2 sheep present. 25 geese took flight. 8 sheep outside the field on bank above the shore. 3 heron disturbed. Photo of Inner Site 1 Thomason fishery.
32	41870.43045	HU 51950 97752	451950	1197752			Archaeological ruins. 26 eider ducks at sea close to the shore.
33	41870.43152	HU 51984 97765	451984	1197765			Property close to the shore with outbuildings and gardens.
34	41870.43258	HU 52020 97765	452020	1197765	Figure 8		Concrete septic tank associated with property closest to shore with outfall to shore.
35	41870.4333	HU 52025 97746	452025	1197746	Figure 9		Location of outfall. Grey discharge dripping from end.
36	41870.43527	HU 52089 97827	452089	1197827		BVC-FW02	Watercourse; Sandwater Burn. Flows to gravel beach in small embayment. 20cm deep, 80cm wide. Flow 0.489 cm/s and SD 0.029 cm/s. Freshwater sample collected. Overcast with heavy shower. Second property adjacent to the burn.
37	41870.44315	HU 52188 97647	452188	1197647			Old pier and shed adjacent to shore. Rowing boat pulled up.
38	41870.44624	HU 52241 97534	452241	1197534			5 sheep on bank above shore. 3 properties above the field of rough grazing.
39	41870.44878	HU 52323 97402	452323	1197402	Figure 7		Foreshore of gravel, rocks and exposed bedrock. Banks higher here than previously encountered, approximately 10m. Photo adjacent to Inner Site 2 Nisbet fishery.

No.	Date/Time (UT)	NGR	Easting	Northing	Associated Figure	Associated Sample	Description
40	41870.45337	HU 52426 97089	452426	1197089	Figure 10		Discharge pipe to sea, end not visible underwater. Appears to originate from the septic tank associated with the former North Isles Motel which has been unoccupied for 20 years or so. 9 plovers took flight.
41	41870.46021	HU 52331 96807	452331	1196807			North Ayre of Cunnister beach. Gravel promontory. 1 Arctic tern disturbed.
42	41870.46497	HU 52466 96613	452466	1196613			Ruined crofthouse. Herring gull, black backed gull, snipe and oystercatcher. Property situated away from shore. Approximately 40 sheep in field of rough grass with several drainage ditches present. 1 otter foraging close to the shore.
43	41870.47042	HU 52577 96393	452577	1196393			Approximately 80 greylag geese disturbed from same field. Here closely cropped grass and stands of flag iris. 1 property above shore.
44	41870.47299	HU 52646 96212	452646	1196212			South Ayre of Cunnister beach. Smaller promontory of coarser material than the northern one. Four Arctic terns disturbed.
45	41870.47622	HU 52720 96237	452720	1196237			End of shoreline walk, east Basta Voe
46	41870.48419	HU 52539 97091	452539	1197091			Large concrete septic tank associated with the disused motel.

No.	Date/Time (UT)	NGR	Easting	Northing	Associated Figure	Associated Sample	Description
47	41870.49589	HU 51210 98043	451210	1198043	Figure 13		Shoreline walk: West coast of Basta Voe. North to south starting at the shore base shared by C & A Thomason and Thompson Brothers Salmon Ltd. Weather unchanged. Pier and slipway with 2 small workboats present. Previously 2 additional larger workboats at the pier; 1 for the salmon farms and 1 for the mussel farms used for the boat work earlier. Pair of black pipes dripping with clear discharge emerging on to rock armour above shore - appears to be associated with drainage on the north side of the track that serves the shore base. Large shed directly adjacent to the shore, another further up the track. 9 divers on water near pier (red-breasted merganser?)
48	41870.49954	HU 51204 97906	451204	1197906			5 sheep on heather moorland hillside above rocky beach separated by low bank. Animals would have access to the shore. Occasional drainage ditches and peat cuttings.
49	41870.50498	HU 51179 97613	451179	1197613		BVC-FW03	Watercourse: Burn of Colvister. Flows into rocky inlet. 25cm deep, 50cm wide. Flow 0.609 cm/s and SD 0.038 cm/s. Freshwater sample collected.
50	41870.51199	HU 51440 97480	451440	1197480			Small watercourse flowing through stones and over grass. Open boat pulled up above MHWS. Sand and gravel beach with disused noosts.
51	41870.51764	HU 51649 97280	451649	1197280			Squall and shower. Photos looking SE towards the Inner Site 1 Thomason fishery. Silage bail washed up on the beach, thought to have rolled off the hillside on the other side of the voe. Beach of pebbles and rocks here, with fenced off fields above with rough grass present.

No.	Date/Time (UT)	NGR	Easting	Northing	Associated Figure	Associated Sample	Description
52	41870.5237	HU 51730 97132	451730	1197132			In the region of a planned freshwater sample although no sign of significant watercourse. Several straight field drains noted, some recently cleared, some overgrown, however flow was too shallow to measure.
53	41870.52615	HU 51768 96991	451768	1196991	Figure 5		Short grass between fields and banks with faeces presents. Banks steep in some places. Photo looking east towards the Inner Site 1 Thomason fishery.
54	41870.52868	HU 51792 96797	451792	1196797			Dead sheep blocking drainage ditch.
55	41870.53032	HU 51794 96698	451794	1196698			End of shoreline walk. West Basta Voe.
56	41870.55569	HU 51829 95756	451829	1195756		BVC-FW04	Watercourse, South Burn of Colvister. Accessed from the road, some evidence upstream of the burn recently being in spate with flattened vegetation on the banks. 25cm deep, 80cm wide. Flow 0.112 cm/s and SD 0.014 cm/s. Freshwater sample collected.

Sampling

Water and shellfish samples were collected at the locations indicated in Figures 2 and 3. Four of the six freshwater samples detailed in the survey plan were obtained from watercourses. 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	BVC-SW01	19/08/14 07:41:40	HU 52215 97258	SW	2	35.02
2	BVC-SW02	19/08/14 07:58:14	HU 52294 97058	SW	<1	34.92
3	BVC-SW03	19/08/14 08:04:40	HU 51967 96789	SW	<1	35.01
4	BVC-SW04	19/08/14 08:21:39	HU 51845 97151	SW	2	34.89
5	BVC-SW05	19/08/14 08:33:10	HU 51714 97598	SW	1	35.01
6	BVC-FW01	19/08/14 09:35:25	HU 51101 98793	FW	290	-
7	BVC-FW02	19/08/14 10:26:47	HU 52089 97827	FW	350	-
8	BVC-FW03	19/08/14 12:07:10	HU 51179 97613	FW	230	-
9	BVC-FW04	19/08/14 13:20:12	HU 51829 95756	FW	160	-

*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	BVC-MUSS01	19/08/14 7:41:40	HU 52215 97258	Common Mussel	Top	68
2	BVC-MUSS02	19/08/14 7:41:40	HU 52215 97258	Common Mussel	Bottom	78
3	BVC-MUSS03	19/08/14 8:04:40	HU 51967 96789	Common Mussel	Top	40
4	BVC-MUSS04	19/08/14 8:04:40	HU 51967 96789	Common Mussel	Bottom	20
5	BVC-MUSS05	19/08/14 8:33:10	HU 51714 97598	Common Mussel	Top	130
6	BVC-MUSS06	19/08/14 8:33:10	HU 51714 97598	Common Mussel	Bottom	78

Table 4 Salinity profiles

Profile	Date/Time (UT)	Position	Depth (m)	Salinity (ppt) (± 0.35 ppt)	Temperature (°C)
1	19/08/14 07:41:40	HU 52215 97258	surface	34.07	12.4
			3	34.26	12.3
			5	34.31	12.3
			10	34.34	12.3
2	19/08/14 08:04:40	HU 51967 96789	surface	34.77	12.3
			3	34.82	12.3
			5	34.86	12.3
			10	34.90	12.3
3	19/08/14 08:33:10	HU 51714 97598	surface	34.84	12.3
			3	34.92	12.4
			5	34.93	12.3
			10	34.94	12.4

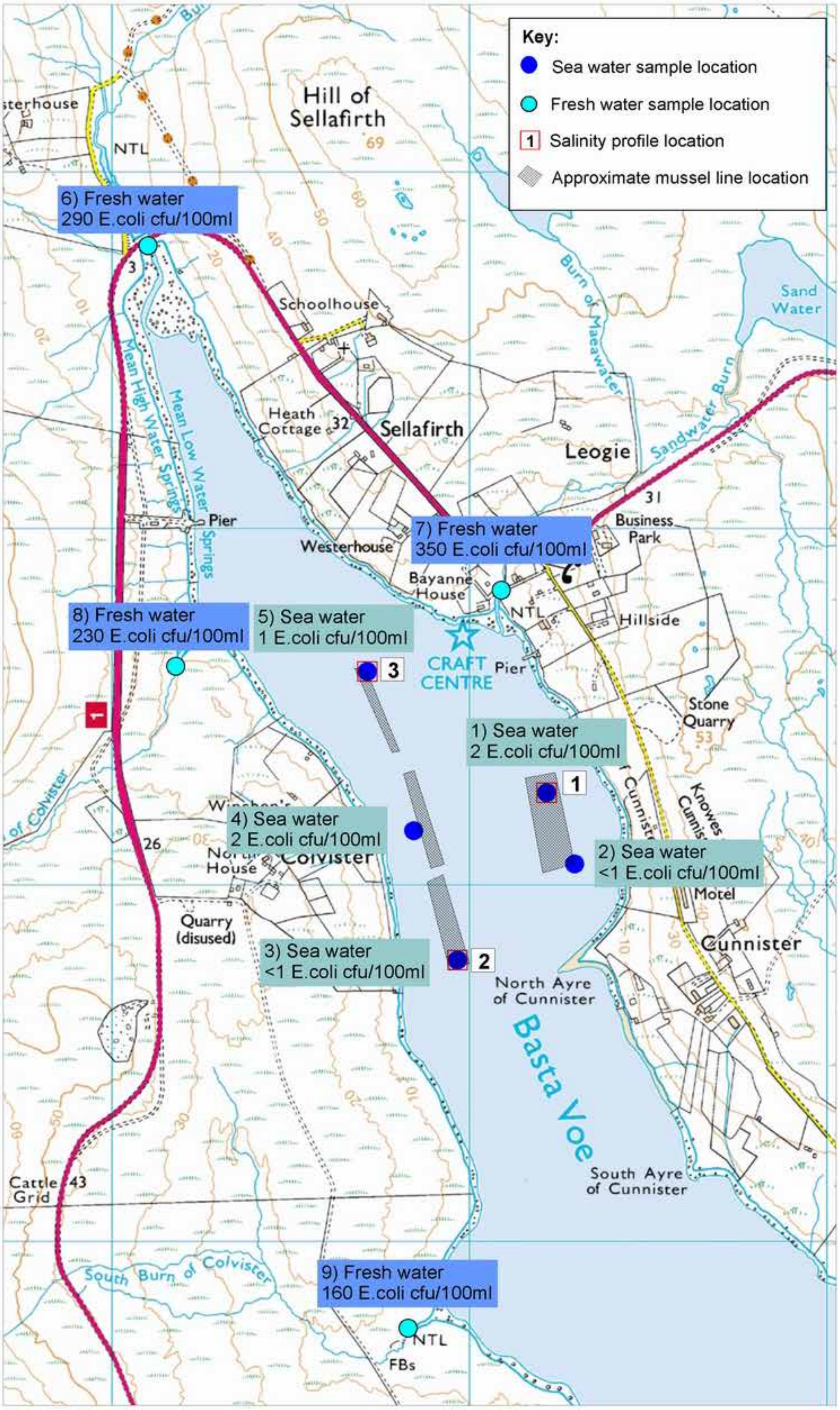

Figure 2 Map of water sample results and salinity profile locations Basta Voe Cove.

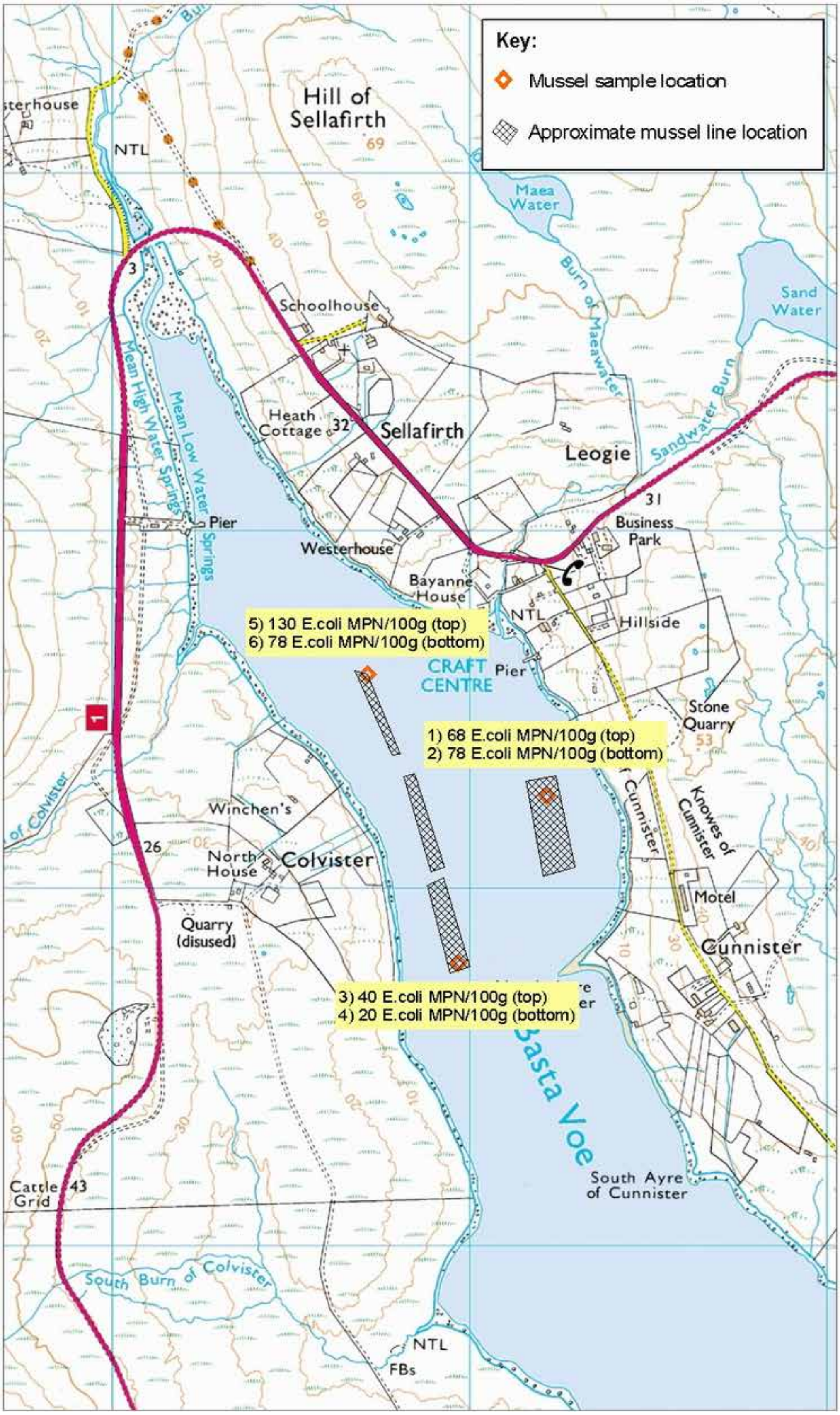

Figure 3 Map of shellfish sample results Basta Voe Cove.

Photographs

Figure 4 – Mussel lines at the Inner Site 1 Thomason fishery, middle group, looking north-west

Figure 5 – Mussel lines at the Inner Site 1 Thomason fishery, southern group, looking east

Figure 6 – Mussel lines at the Inner Site 2 Nisbet fishery looking south-west

Figure 7 – Mussel lines at the Inner Site 2 Nisbet fishery looking west

Figure 8 – Concrete septic tank and outfall associated with property close to shore. Sandwater Burn beyond.

Figure 9 – The outfall associated with the septic tank illustrated in Figure 8.

Figure 10 – Discharge pipe to sea associated with the septic tank of the disused North Isles Motel.

Figure 11 – Pipe with clear discharge. No source identified, potentially field drainage.

Figure 12 – Yell Water Treatment Works

Figure 13 – Shore base and pier operated by C & A Thomason and Thompson Brothers Salmon Ltd. Two discharge pipes to the rock armouring.

Figure 14 – Culvert for the Burn of Gossawater under the A968 road at the head of Basta Voe.

Figure 15 – Pool at the Burn of Gossawater inshore from the culvert.

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6. SEPA Private Discharge Consents

Licence No.	NGR	Discharge Type	Site Description	Discharges to	Op	PE
CAR/R/1009334	HU 51610 98270	Sewage (Private) Primary	Dwelling, Yell, Shetland, STE to soakaway	Soakaway	=	5
CAR/R/1029905	HU 54650 99030	Sewage (Private) Primary	Dwelling, STE to soakaway, Gutcher, Shetland	Soakaway	=	5
CAR/R/1036925	HU 54640 97030	Sewage (Private) Primary	Dwelling, STE to soakaway, North Sandwick, Shetland	Soakaway	=	5
CAR/R/1037580	HU 52640 96600	Sewage (Private) Primary	Dwelling, STE to Soakaway, Sellafirth, Shetland	Soakaway		
CAR/R/1037652	HU 54780 99530	Sewage (Private) Secondary	Dwelling, STE to soakaway, Gutcher, Shetland	Soakaway	=	5
CAR/R/1038770	HU 54710 97180	Sewage (Private) Primary	Dwelling, North Sandwick, STE to soakaway, Shetland	Soakaway	=	5
CAR/R/1039223	HU 54410 99110	Sewage (Private) Primary	Dwelling, STE to soakaway, Shetland	Soakaway	=	5
CAR/R/1039531	HU 54610 98870	Sewage (Private) Primary	Dwelling,STE to land, Gutcher, Shetland	Land	=	5
CAR/R/1039536	HU 52330 97540	Sewage (Private) Primary	Dwelling, STE to land, Sellafirth, Shetland	Land	=	5
CAR/R/1039537	HU 52700 96780	Sewage (Private) Primary	Dwelling, STE to land, Connister, Shetland	Land	=	5
CAR/R/1039538	HU 52120 97880	Sewage (Private) Primary	Dwelling,STE to land, Sellafirth, Shetland	Land	=	5
CAR/R/1039547	HU 54820 96980	Sewage (Private) Primary	Dwelling, STE to land, North Sandwick, Shetland	Land	=	5
CAR/R/1039899	HU 52670 94440	Sewage (Private) Primary	Dwelling, STE to soakaway, Basta, Yell, Shetland	Soakaway	<=	15
CAR/R/1039912	HU 52350 94390	Sewage (Private) Primary	Dwelling, STE to soakaway, Basta, Yell, Shetland,	Soakaway	=	5
CAR/R/1039916	HU 52220 94470	Sewage (Private) Primary	Dwelling, STE to soakaway, Basta, Yell, Shetland	Soakaway	<=	15
CAR/R/1039938	HU 54910 98990	Sewage (Private) Primary	Dwelling, STE to soakaway, Gutcher, Yell, Shetland	Soakaway	=	5
CAR/R/1039954	HU 52760 96450	Sewage (Private) Primary	Dwelling, STE to soakaway, Cunnister, Yell, Shetland	Soakaway	=	6

Licence No.	NGR	Discharge Type	Site Description	Discharges to	Op	PE
CAR/R/1040187	HU 54433 98921	Sewage (Private) Primary	Dwelling, STE to soakaway, Shetland	Soakaway	=	5
CAR/R/1046278	HU 51990 97757	Sewage (Private) Primary	Dwelling, STE to Basta Voe, Sellafirth	Basta Voe	=	5
CAR/R/1067522	HU 51560 92700	Sewage (Private) Primary	Dwelling, STE to soakaway, Camb, Yell	Soakaway	=	5
CAR/R/1077854	HU 51828 97971	Sewage (Private) Primary	2 Dwellings,Sellafirth, STE to soakaway, Shetland	Soakaway	=	10
CAR/R/1079161	HU 52310 97810	Sewage (Private) Primary	Dwelling, STE to soakaway, Sellafirth	Soakaway	=	5
CAR/R/1082094	HU 51080 99250	Sewage (Public) Primary	Yell WTW, STE to soakaway, Dalsetter, Shetland	Soakaway	<	5
CAR/R/1086285	HU 54820 99240	Sewage (Private) Primary	Dwelling, STE to soakaway, Gutcher, Shetland	Soakaway	=	5
CAR/R/1089818	HU 52043 97833	Sewage (Private) Primary	Dwelling, STE to soakaway, Sellafirth, Shetland	Soakaway	=	5
CAR/R/1097197	HU 52432 97090	Sewage (Private) Primary	Dwelling, STE to coastal waters, Yell, Shetland	Coastal Waters	=	5
CAR/R/1111171	HU 52640 96600	Sewage (Private) Primary	Dwelling, STE to Soakaway, Sellafirth, Shetland	Soakaway	=	5