Scottish Sanitary Survey Programme

Sanitary Survey Report
Production Area: South Uyea
SIN: SI 263 454 08
April 2012

Cefas

Food Standards Agency
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Buidheann Inbhe-Bìdhe

Report Distribution – South Uyea

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I. Executive Summary

The sanitary survey at South Uyea took place based on a failure assessment undertaken to examine areas which had received results that were outside of their normal classification.

The South Uyea fishery is located at the southern end of the small island of Uyea, south of the island of Unst in the Northern Shetland Islands. The general area surrounding the South Uyea fishery is sparsely populated and the island of Uyea is uninhabited. The nearest settlements of Uyeasound and Clivocast are located on the southern coast of the neighbouring island of Unst, to the north of Uyea.

The South Uyea mussel fishery is a longline mussel farm consisting of seven long lines, each 200m in length with 5 – 8m droppers. The mussel farm coincides with a seabed lease and (Shetland Island Council) SIC permit area. The area is not a designated shellfish growing water. The site may be harvested at any time of year.

The nearest sewage discharges are located at Uyeasound, on the south shore of Unst. Most of these are for soakaways from private houses, with one relatively small continuous discharge from a community septic tank. These are not expected to significantly impact the fishery.

Any faecal contamination reaching the South Uyea mussel farm is most likely to come from diffuse source - mainly livestock and wildlife. Sheep are grazed on Uyea and faecal contamination from sheep droppings can reach the fishery from either land runoff or direct deposition of droppings on the shoreline. Seabirds, seals, and potentially otters are the wildlife species most likely to contribute to background levels of faecal contamination in the waters near the fishery. Seabirds are present in very large numbers around Fetlar, to the south of the fishery and in significant numbers around Uyea itself. These animals are present in highest numbers during the summer, when they nest in the area.

Assessment of the potential movement of contaminants suggests that sources arising within the bay in which the mussel farm is located are most likely to have an impact on the bacteriological quality of the shellfish grown there.

Overall, the fishery is subject to low level, diffuse sources of faecal contamination primarily from sheep and wildlife. There is limited seasonal variation in results, and this appears to coincide with increases in both the local sheep and seabird populations.

<u>Recommendations</u>

Production area:
As the current fishery and its underlying seabed lease area extend beyond the current production area boundary, it is recommended that the boundary be extended southward to encompass the entire lease area. The recommended

boundary is described as the area bounded by lines drawn between HU 6022 9803 and HU 6022 9780 and between HU 6022 9780 and HU 6092 9780 and between HU 6092 9780 and HU 6092 9788 and extending to MHWS.

RMP:
It is recommended that the RMP be adjusted southward slightly HU 6073 9812 to coincide with the recorded mussel farm, but still retain the general location at the northeast corner of the mussel farm.

II. Sampling Plan

PRODUCTION AREA	South Uyea
SITE NAME	South
SIN	SI 263 454 08
SPECIES	Common mussels
TYPE OF FISHERY	Aquaculture
NGR OF RMP	HU 6073 9812
EAST	460730
NORTH	1198120
TOLERANCE (M)	40
DEPTH (M)	1-3
METHOD OF SAMPLING	Hand
FREQUENCY OF SAMPLING	Monthly
LOCAL AUTHORITY	Shetland Islands Council
AUTHORISED SAMPLER(S)	
LOCAL AUTHORITY LIAISON OFFICER	

III. Report

1. General Description

The South Uyea fishery is located at the southern end of the small island of Uyea, south of the island of Unst in the Northern Shetland Islands (see Figure 1.1). The bay in which the fishery is located is approximately 0.7 km at its widest point and 0.4 km from the opening of the bay to the shoreline. The bay is relatively exposed to the south, south-east.

The sanitary survey is being undertaken based on a failure assessment undertaken to examine areas which had received results that were outwith their normal classification.

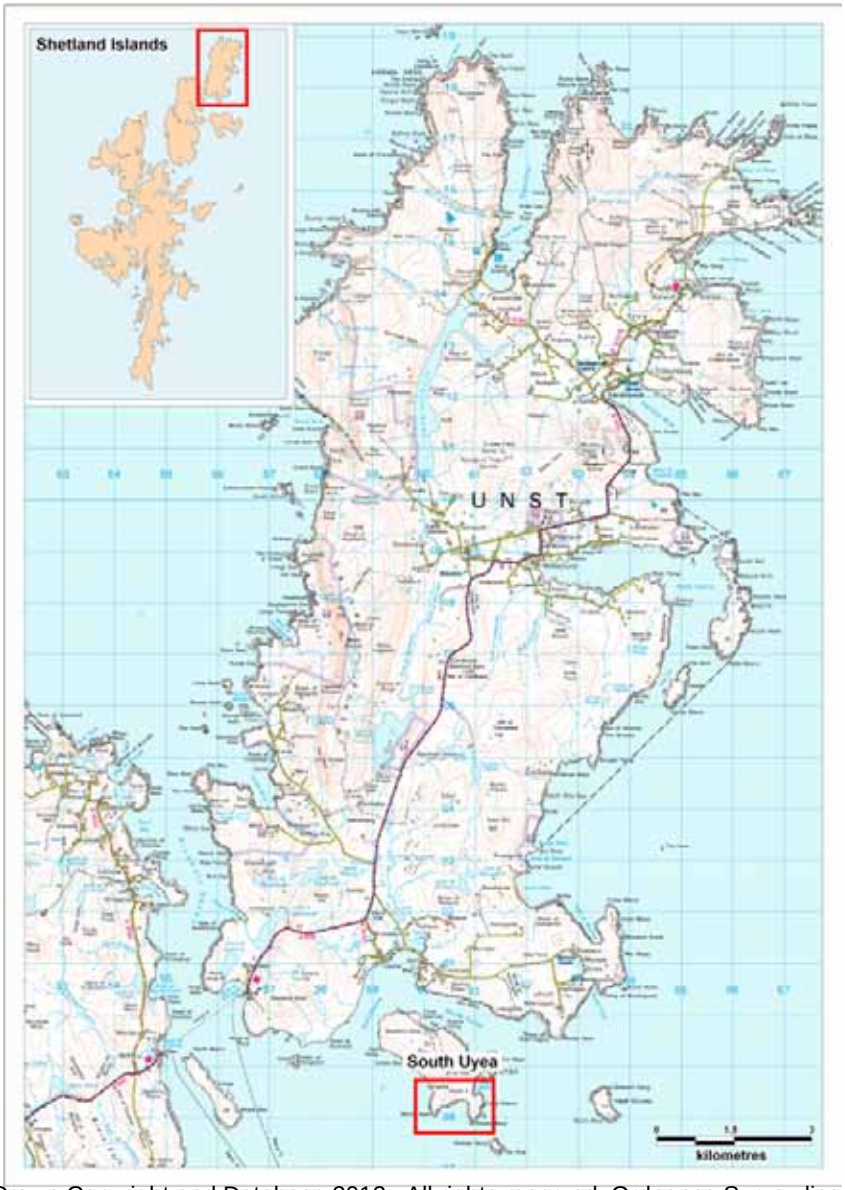

Figure 1.1 Location of South Uyea

2. Fishery

The South Uyea mussel fishery is a longline mussel farm consisting of seven long lines, each 200 m in length with 5 – 8 m droppers. The mussel farm coincides with both a Crown Estate lease and a Shetland Islands Council (SIC) permit area. The site may be harvested at any time of year.

The current production area boundary is defined by the area bounded by a line drawn between HU 6022 9803 and HU 6092 9788 extending to MHWS. The nominal Representative Monitoring Point (RMP) is reported as being located at HU 6073 9814, which lies at the northern end of the mussel lines.

The actual location of the mussel farm within the bay was recorded during the shoreline survey and is shown mapped, together with the production area boundaries, RMP and lease areas, in Figure 2.1.

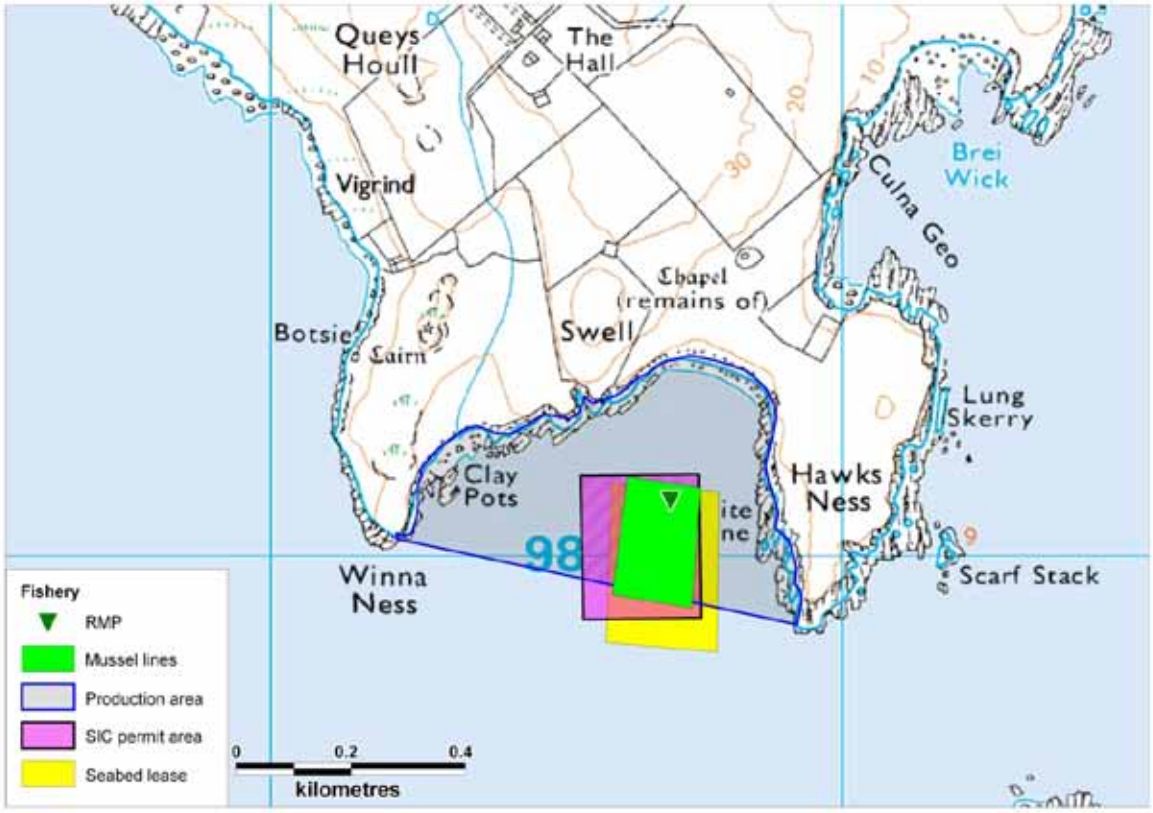

Figure 2.1 South Uyea Fishery

3. Human Population

Information on the human population of the area around South Uyea was obtained from the General Register Office for Scotland. Data was provided for the 2001 census by output area. The population density for the output areas nearest the fishery is shown thematically mapped in Figure 3.1.

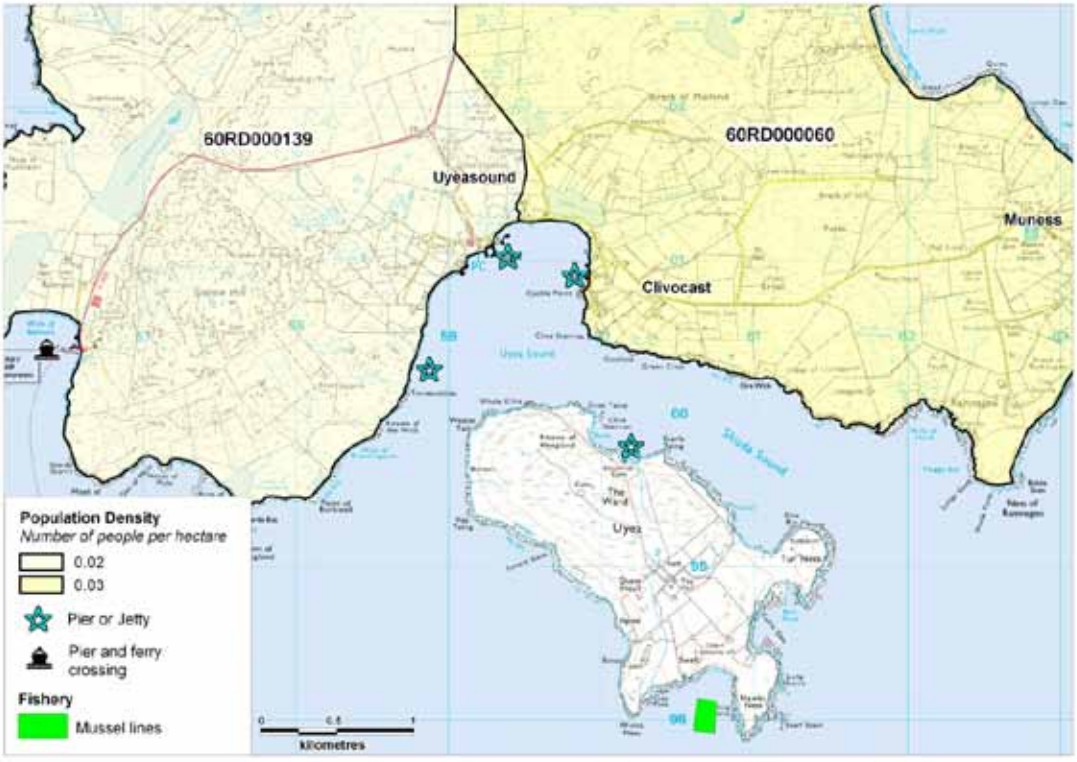

Figure 3.1 Population map of South Uyea

The population of southern Unst is spread across two census output areas, listed in Table 3.1. The large majority of the population for these areas is located near the coast.

Table 3.1 Census output areas: South Uyea

Output area	Population
60RD000139	77
60RD000060	82
Total	**159**

Overall, the area surrounding the fishery is sparsely populated. The island of Uyea is uninhabited, though it is accessible via a small pier on the northern shore of the island. There is an abandoned farm in the centre of the island. The shoreline at South Uyea is inaccessible as there are no footpaths or tracks on the southern side of the island. The nearest settlements are at Uyeasound and Clivocast, both are located on Uyea Sound along the southern coast of Unst. A further settlement is located at Muness, situated approximately 3.8km to the north east of the South Uyea fishery, on the island

of Unst, where there is a castle that is an historic attraction, and therefore would draw tourism to the area.

Ferry services operate daily from the Wick of Belmont on the south western coast of Unst to the islands of Yell and Fetlar. In addition to the pier on Uyea, a new 100 m pier was completed at Uyeasound in 2009 for use by boats servicing salmon farms (http://www.tullochdev.co.uk/uyeasound-pier, Accessed 20/04/12). The pier is intended to provide safe mooring area as well as a working pier. No anchorages were identified in the surrounding area.

4. Sewage Discharges

Information on sewage discharges in the vicinity of the fishery was sought from Scottish Water and the Scottish Environment Protection Agency (SEPA). One Scottish Water community septic tank was identified for the area surrounding the fishery: this is listed in Table 4.1.

Table 4.1 Discharges identified by Scottish Water

Consent Ref No.	NGR of discharge	Discharge Name	Discharge Type	Level of Treatment	Consented flow m^3/day	Consented Design PE
CAR/L/1004026	HP 59872 00853	Uyeasound ST, East Rd, Uyeasound, Unst	Continuous	Septic tank	NA	250

Scottish Water provided further clarification that based on the number of properties connected to the tank and the Scottish mean household population, the actual population connected to the tank is 43. The consented design population equivalent is often established to allow for future population growth and therefore exceeds the actual usage.

Discharge consents provided by SEPA are listed in Table 4.2. There are no intermittent discharges in the area. Although 8 consents were received for Marine Cage Fish Farms and one for a freshwater hatchery, these were not included in the table below as they are not considered likely to contribute faecal coliform contamination to the area. All discharges are shown in Figure 4.1.

Table 4.2 Discharge consents identified by SEPA

No.	Ref No.	NGR of discharge	Discharge Type	Level of Treatment	Consented/ design PE	Discharges to
1	CAR/R/1057845	HP 58770 00630	Sewage (Private)	Septic tank	-	Soakaway
2	CAR/R/1057847	HP 58660 00770	Sewage (Private)	Septic tank	-	Soakaway
3	CAR/R/1057768	HP 58750 00990	Sewage (Private)	Septic tank	-	Soakaway
4	CAR/R/1047372	HP 58840 01100	Sewage (Private)	Septic tank	-	Soakaway
5	CAR/R/1059213	HP 59150 01230	Sewage (Private)	Septic tank	-	Soakaway
6	CAR/R/1078688	HP 59160 01210	Sewage (Private)	Septic tank	-	Soakaway
7	CAR/R/1082617	HP 59480 01380	Sewage (Private)	Septic tank	-	Soakaway
8	CAR/L/1004026	HP 59872 00853	Sewage (Public)	Septic tank	250	Uyea Sound, Unst
9	CAR/R/1067314	HP 60270 00630	Sewage (Private)	Septic tank	-	Land

- data not provided

The area surrounding the South Uyea fishery is sparsely populated and the island of Uyea itself is uninhabited. The nearest settlements, with associated sewage discharges, are located to the north of the island of Uyea, at Uyeasound, on the southern shore of the neighbouring island of Unst. Most of these are for soakaways from private houses, with one relatively small continuous discharge from a septic tank. No sewage infrastructure or sewage

debris was recorded during the shoreline survey and there are no sewage discharge consents for the island of Uyea.

Although the discharges to Uyea sound may contribute to background levels of contamination in Uyea Sound, it is unlikely that the mussel fishery at South Uyea is significantly impacted by human sewage.

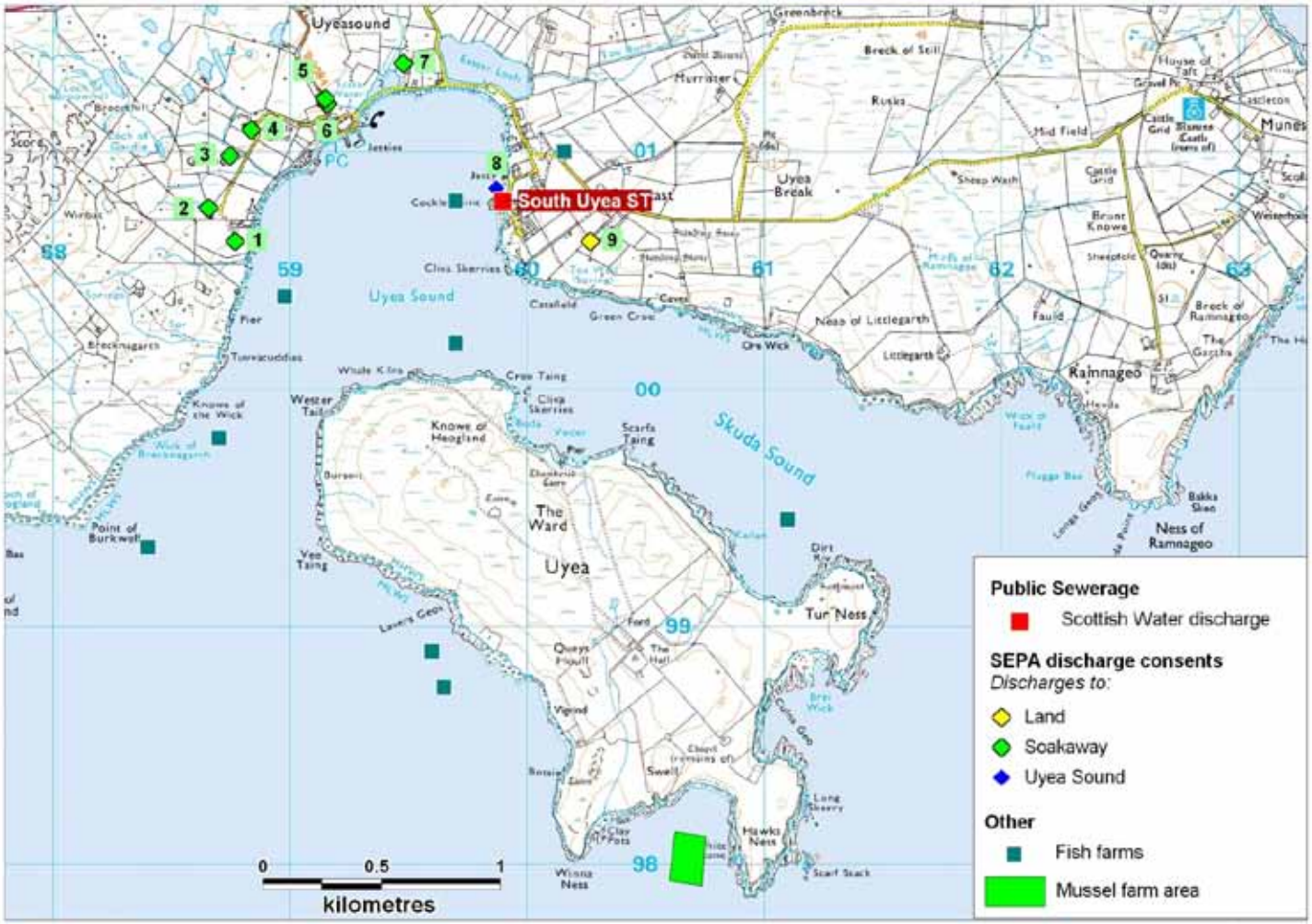

Figure 4.1 Map of discharges for South Uyea

5. Geology and Soils

Geology and soil types were assessed following the method described in Appendix 2. A map of the resulting soil drainage classes is shown in Figure 5.1. Areas shaded red and orange indicate poorly draining soils while areas shaded blue indicate more freely draining soils.

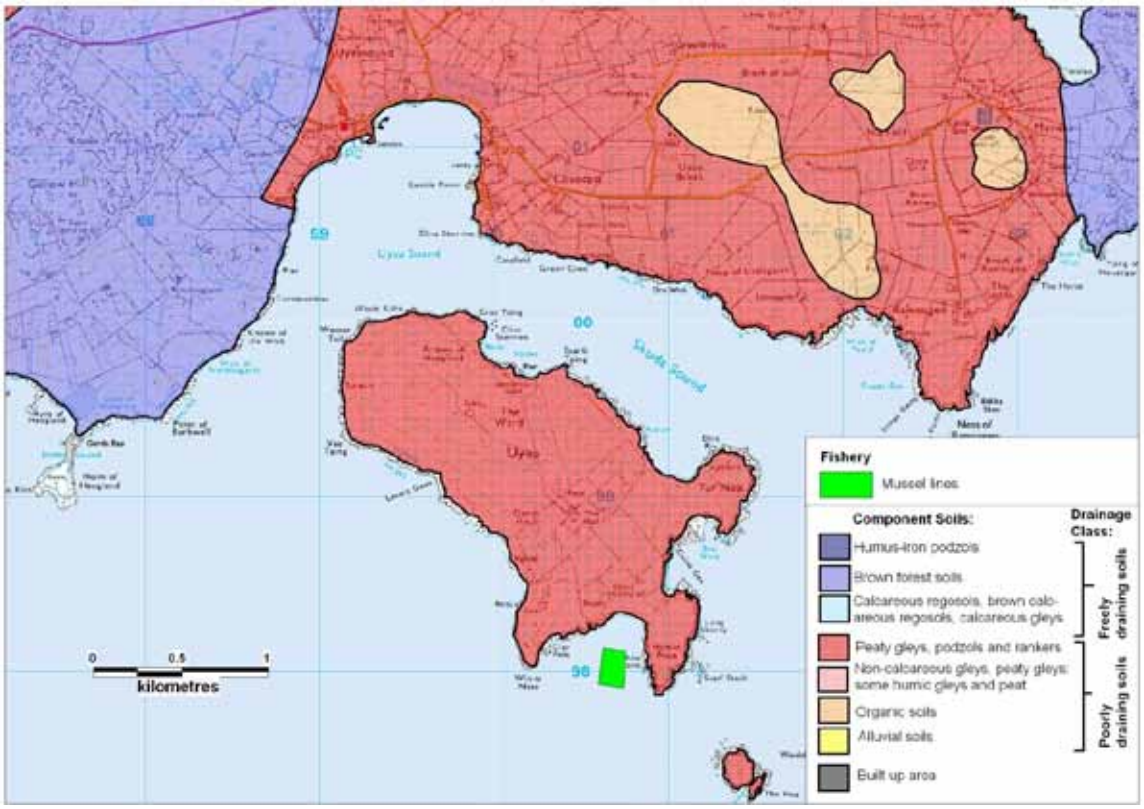

Figure 5.1 Component soils and drainage classes for South Uyea

Three component soil types are found in the area of southeastern Unst and Uyea. Peaty gleys, podzols and rankers are found on the island of Uyea and majority of the south east end of the island of Unst. Small areas of organic soils are also found within this area. Both these types of soils are classed as poorly-draining. Freely-draining brown forest soils are found on the southwestern side of the island and on the small peninsula at the southeastern eastern end of Unst. Land immediately adjacent to the fishery and around the settlement of Uyeasound is composed of poorly-drained soils and therefore the potential for runoff contaminated with *E. coli* from human and/or animal waste is therefore high in these areas.

6. Land Cover

The Land Cover Map 2000 data for the area is shown in Figure 6.1 below:

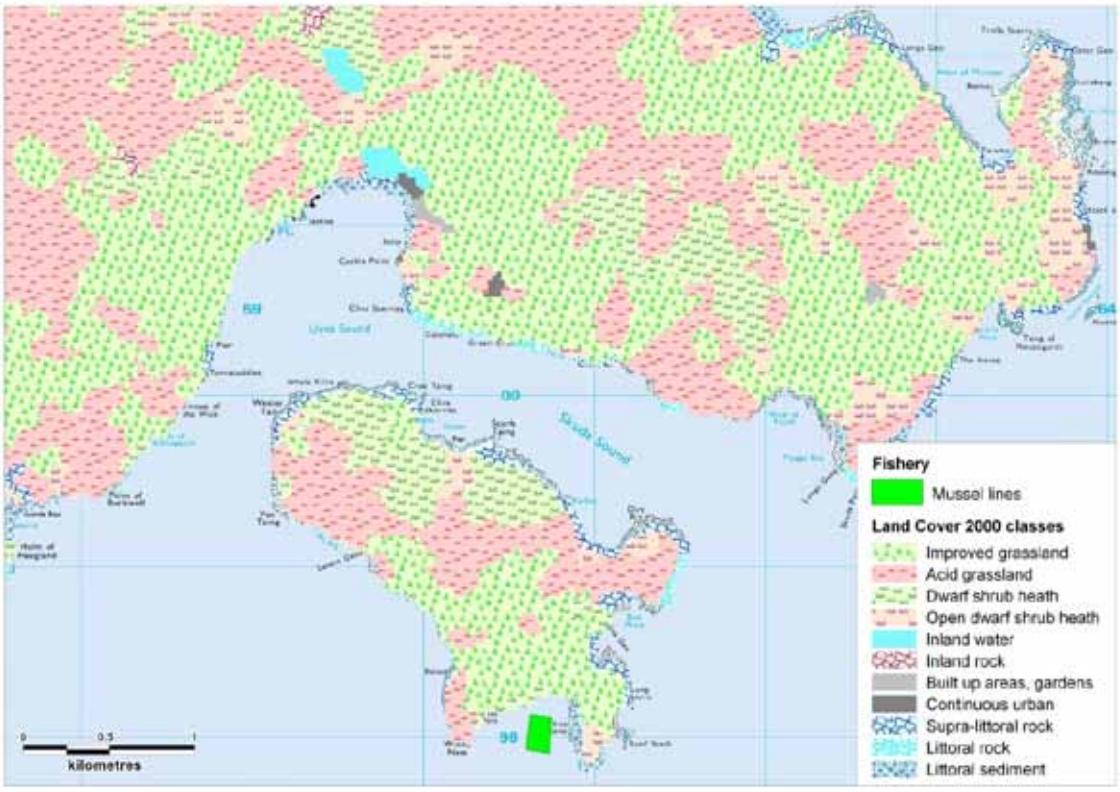

Figure 6.1 LCM2000 class land cover data for South Unst and Uyea

There are three main land cover types found on the island of Uyea and the southern end of the neighbouring island of Unst. Improved grassland dominates the southern half of the island of Uyea and is present in large patches on the southern coastline of Unst. In addition to improved grassland there are large patches of dwarf shrub heath and acid grassland in both areas. Smaller patches of supra-littoral rock, littoral rock and littoral sediment can be found along the shoreline of both islands. The settlement of Clivocast, on the southern coastline of Unst is shown as a built up/continuous urban area.

Faecal indicator organism export coefficients for faecal coliform bacteria have been found to be approximately $8.3x10^{8}$ cfu km^{-2} hr^{-1} for areas of improved grassland and approximately $2.5x10^{8}$ cfu km^{-2} hr^{-1} 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 potential for the highest contribution of faecal coliform bacteria attributable to land cover type is greatest along the shoreline adjacent to the fishery where there are areas of improved grassland.

7. Farm Animals

Information on the spatial distribution of animals on land adjacent to or near the fishery can provide an indication of the potential amount of organic pollution from livestock entering the shellfish production area. Agricultural census data to parish level was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the Unst parish. Reported livestock populations for the parish in 2009 and 2010 are listed in Table 7.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data. Any entries which relate to less than five holdings, or where two or fewer holdings account for 85% or more of the information, are replaced with an asterisk.

Table 7.1 Livestock numbers in Unst parish 2009 - 2010

	Unst 123 km^2			
	2009		2010	
	Holdings	Numbers	Holdings	Numbers
Pigs	*	*	*	*
Poultry	14	282	15	231
Cattle	13	321	14	312
Sheep	116	26266	114	25972
Other horses and ponies	26	239	28	257

The Unst agricultural parish encompasses the entire island of Unst and nearby small islands, including Uyea. A large number of sheep were reported in the Unst parish in 2010, which was slightly lower than that reported in 2009. Much smaller numbers of cattle, horses and ponies, and poultry were reported. Although pigs are kept in the parish, the numbers could not be provided.

The only significant source of spatially relevant information was the shoreline survey (see Appendix 6), which only relates to the time of the site visit on 18th October 2011. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 7.1. It was not possible to access the shoreline of Uyea during the survey so all livestock observations were made from a boat.

Sheep were observed grazing along the southern shore of Uyea on the day of the shoreline survey (18th October 2011). Only some of the livestock appeared to be fenced off from the shoreline. Six sheep were observed on the shoreline in the bay north of the shellfish farm.

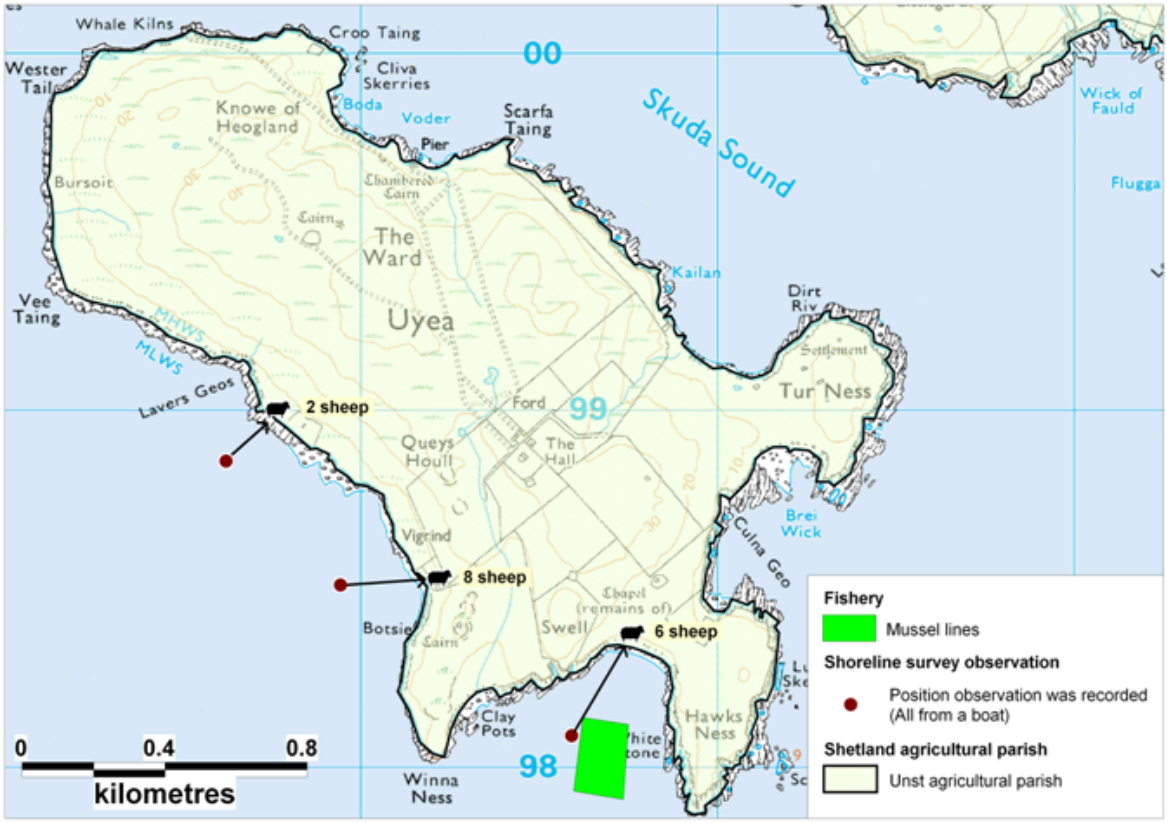

Figure 7.1 Livestock observations at South Uyea

Diffuse pollution from livestock sources is very likely to contribute faecal contamination to the waters around the fishery. Direct deposition of droppings at the shoreline and in and around watercourses is likely to be a significant pathway of contamination.

8. Wildlife

Wildlife is likely to be present in fishery areas and may contribute to the faecal bacterial load in a water body either via direct deposition of faeces or via diffuse runoff from land areas. General information on the impacts of wildlife species can be found in Appendix 2.

The fishery falls within the Fetlar Special Protected Area (SPA) which covers the southern shore of Uyea and extends south, covering the island of Fetlar. The Fetlar SPA is designated for a range of habitats including species-rich heathland, marshes and is of importance for a number of northern breeding waders, as well as breeding seabirds (http://jncc.defra.gov.uk/page-1893, Accessed 20/03/2012).

There are two National Nature Reserves (NNR's) on Unst: one at Hermaness on the far north western shoreline and the other at Keen of Hamar on the eastern shoreline. Hermaness NNR is home to large populations of great skua (*Stercorarius skua*) and Atlantic puffins (*Fratercula arctica*) amongst other seabirds (http://www.nature-shetland.co.uk/snh/hermaness.htm).

The following are considered most likely to be present at or near the fishery.

Seabirds

Seabird 2000 census data was queried for the area within a 5 km radius of the South Uyea production area. This census, undertaken between 1998 and 2002, covered the 25 species of seabird that breed regularly in Britain and Ireland. The recorded numbers are listed in Table 8.1 below.

Table 8.1 Seabird counts within 5km of the South Uyea

Common name	Species	Count	Method
Atlantic Puffin	*Fratercula arctica*	23	Individuals on land or sea
Arctic Tern	*Sterna paradisaea*	801	Occupied territory[1]
Common Tern	*Sterna hirundo*	6	Individuals on land
Northern Fulmar	*Fulmarus glacialis*	36	Occupied sites[1]
Herring Gull	*Larus argentatus*	216	Individuals on land/Occupied territory[1]
Common Gull	*Larus canus*	84	Occupied sites[1]
Black Guillemot	*Cepphus grylle*	279	Individuals on land
Great Black-backed Gull	*Larus marinus*	231	Individuals on land/Occupied territory or nests[1]
Lesser Black-backed Gull	*Larus fuscus*	140	Individuals on land/Occupied territory[1]
Black-headed Gull	*Larus ridibundus*	6	Occupied nests[1]
European Storm Petrel	*Hydrobates pelagicus*	46	Occupied sites[1]
Great Skua	*Stercorarius skua*	160	Occupied territory[1]
European Shag	*Phalacrocorax aristotelis*	4	Occupied nests[1]
European Storm Petral	*Hydrobates pelagicus*	46	Occupied sites[1]

[1]Counts for occupied sites, nests or territories were doubled to reflect the number of individuals

Seabird 2000 records showed an estimated total 2078 seabirds within a 5km radius of the fishery.

During the breeding season, the Fetlar SPA area supports, on average, in excess of 20,000 individual seabirds. A proposed extension of the SPA to include waters extending 2km beyond the island is intended to allow essential water habitat area required by some of the seabird species for maintenance activities (http://www.snh.org.uk/pdfs/directives/b269966.pdf).

During the shoreline survey on the 18th October 2011, approximately 100 European shags (*Phalacrocorax aristotelis*) were disturbed on the water close to the fishery and 3 gulls were observed on the mussel lines. A further 7 gulls were observed nesting on the shoreline west of the Winna Ness headland to the west of the fishery.

Seabirds nesting nearest the fishery are most likely to contribute diffuse faecal contamination to the area, particularly after rainfall. Guano deposited around nest areas is likely to contribute to faecal contamination of rainfall runoff over period extending beyond the nesting season. Birds may also deposit droppings as they fly over or rest on the mussel farm, and where they swim or preen in the sea, therefore some direct impact at the fishery is expected.

Many of the seabirds will only be present near shore during the summer nesting season, however some species will be present year round. Overall, however, seabirds are likely to have a greater impact on water quality during the summer months when more of them are present in the area.

Wildfowl and wading birds

Wildfowl, such as geese and ducks, and wading birds, such as oyster catchers, are likely to be present in the area though no specific data were found on populations at or near the fishery.

Seals

Both grey seals (*Halichoerus grypus*) and common or harbour seals (*Phoca vitulina vitulina*) are recorded in Shetland, and are commonly found around the coast of Unst (http://www.saxavord.com/unst-wildlife.php). Harbour seal haulouts are recorded on Fetlar and Hascosay (which both lie to the south of the fishery) and a survey undertaken in 2001 found 126 seals on these two islands. A grey seal haulout and breeding site is located off the northwest coast Fetlar, just over 3 km south of the fishery and surveys undertaken during 2007-2009 found up to 100 grey seals on land. It is estimated that approximately 35% of the grey seal population is hauled out at the time of annual harbour seal survey, which would suggest a local population of up to 287 animals (Special Committee on Seals, 2011). No seals were observed during the shoreline survey.

Seals forage widely and therefore these animals are likely to be present in and around the fishery from time to time, where they could potentially leave faeces behind. However, impacts from this source are likely to be unpredictable in terms of timing and location. In light of the numbers of seals

recorded in the general area, it is likely that seals contribute to background levels of faecal contamination in the waters south of Unst.

Cetaceans

Whales and dolphins are common in the area though numbers of animals likely to be routinely present in the vicinity of the fishery are not known. These animals are likely to contribute to background levels of faecal contamination when they are present.

Otters

Otters (*Lutra lutra*) have been recorded in Uyea Sound in the past, however no recent records of otter numbers were found. No otters were seen during the shoreline survey. Otters typically defecate in established latrines adjacent to freshwater courses. Both Unst and Uyea have a number of burns that may host otters, and any faecal contamination from these animals is likely to be carried in the streams. Typical population densities of coastal otters are low and therefore any impact is expected to be relatively minor.

Conclusions

Wildlife of various species are likely to contribute to background levels of contamination found in the waters around the fishery. Those most likely to impact the mussel farm are seabirds, seals, and otters as these animals are most likely to occur in close proximity to the lines. There is likely to be seasonal variation in the impact from seabirds, as larger numbers of these animals are present in the area during the summer months.

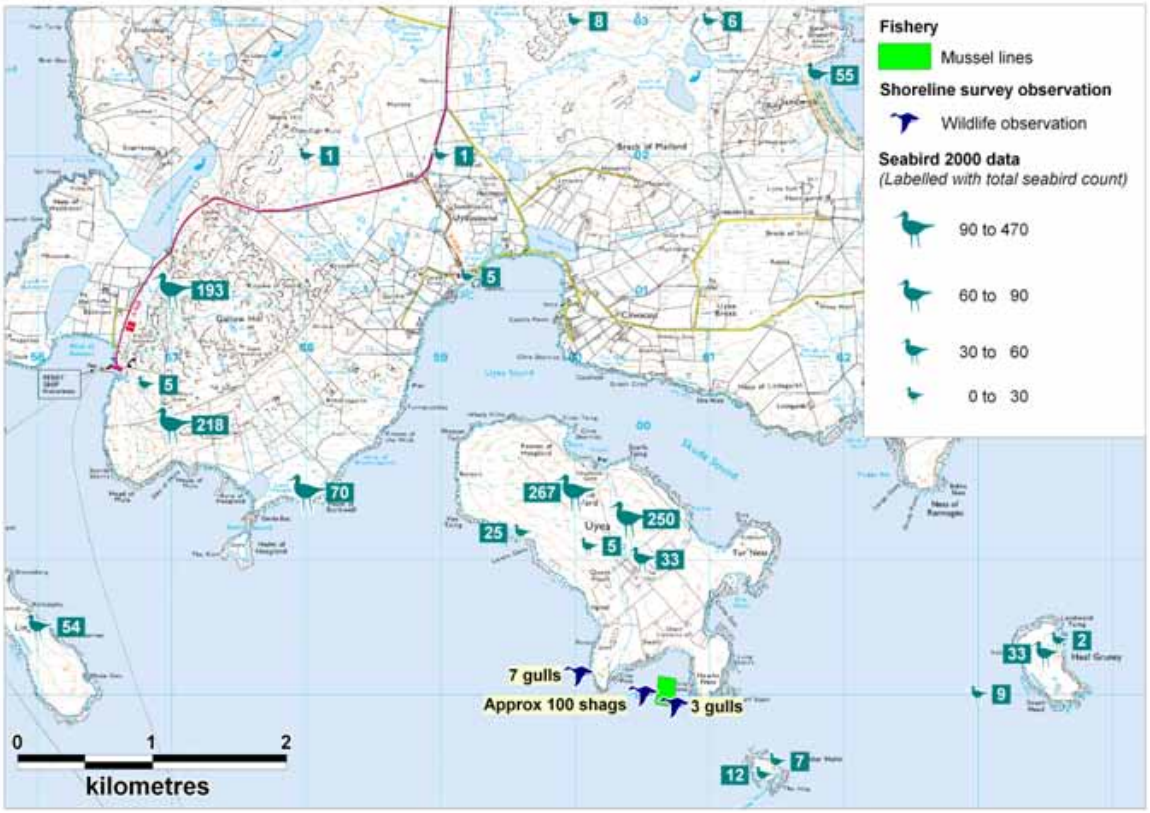

Figure 8.1 Map of seabird distributions at South Uyea

9. Meteorological data

The nearest weather station is located at Unst: Uyeasound No. 3, which lies approximately 3 km north of the production area. Rainfall data was obtained for 2003-2010, however data was missing for the months of November and December 2010. The nearest wind station is Sumburgh, which lies approximately 92 km to the south of the production area. Due to the distance and differences in topography between these locations, wind patterns at Basta Voe may differ significantly from Sumburgh. However, this data is still shown as it can be useful in identifying seasonal variation in wind patterns.

Data for theses stations were purchased from the Meteorological Office and unless stated otherwise, further analysis of this section e.g. graphs were conducted by Cefas. This section aims to describe the local rain and wind patterns and how they may affect the bacterial quality of shellfish at South Uyea.

9.1 Rainfall

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

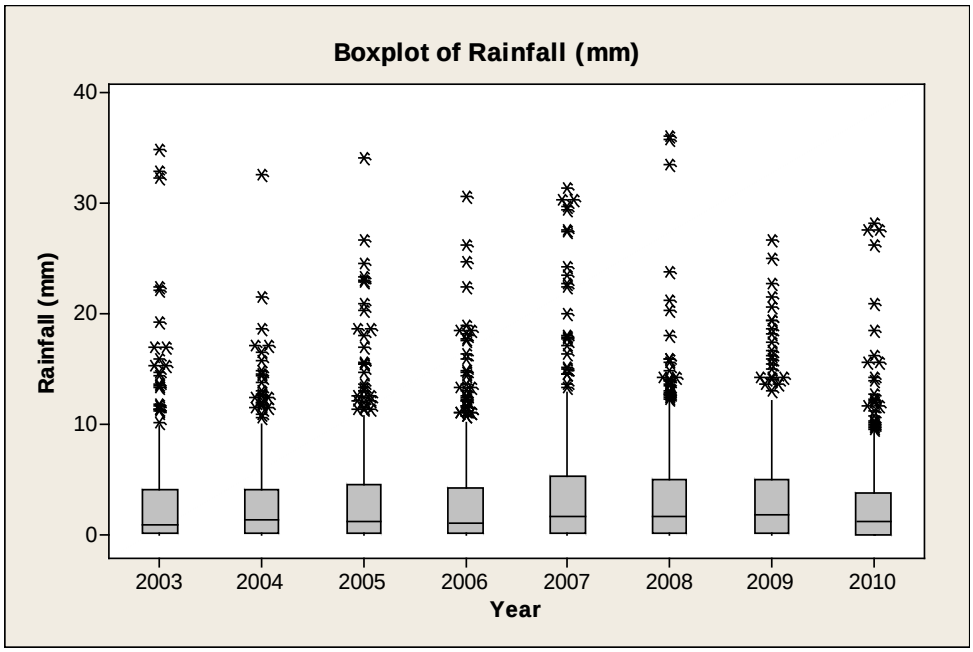

Figure 9.1 Box plot of daily rainfall values by year at Unst: Uyeasound (2003 – 2010)

Annual rainfall varied slightly over the years examined. The wettest year was 2007 and the driest 2006. Although 2010 appeared to be relatively dry, data for November and December were missing and therefore this year cannot be compared on the same terms with previous years.

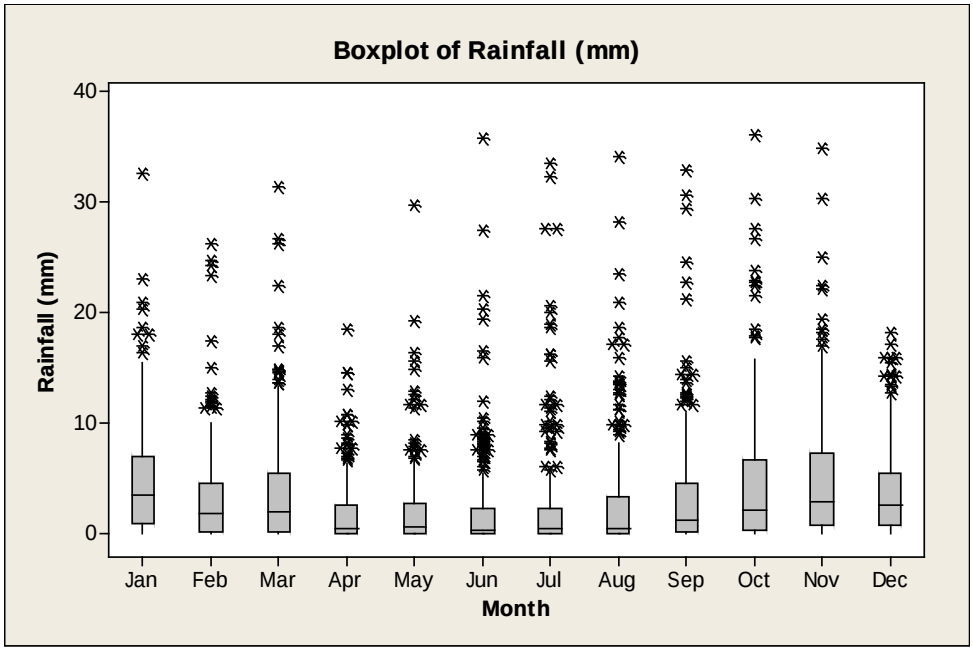

Figure 9.2 Box plot of daily rainfall values by month at Unst (2003 – 2010)

Daily rainfall was higher from October to January and in March. The driest months were April to July. Days with extreme rainfall events (>20 mm) occurred in all months except for April, May and December. However, caution should be used in interpreting data for November and December as no data was recorded for these months in 2010. For the period considered here, 45% of days experienced rainfall less than 1 mm and 8% of days experienced rainfall of 10mm or more.

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

9.2 Wind

Wind data collected at Sumburgh is summarised by seasonal wind roses as shown in Figure 9.3 and annually in Figure 9.4.

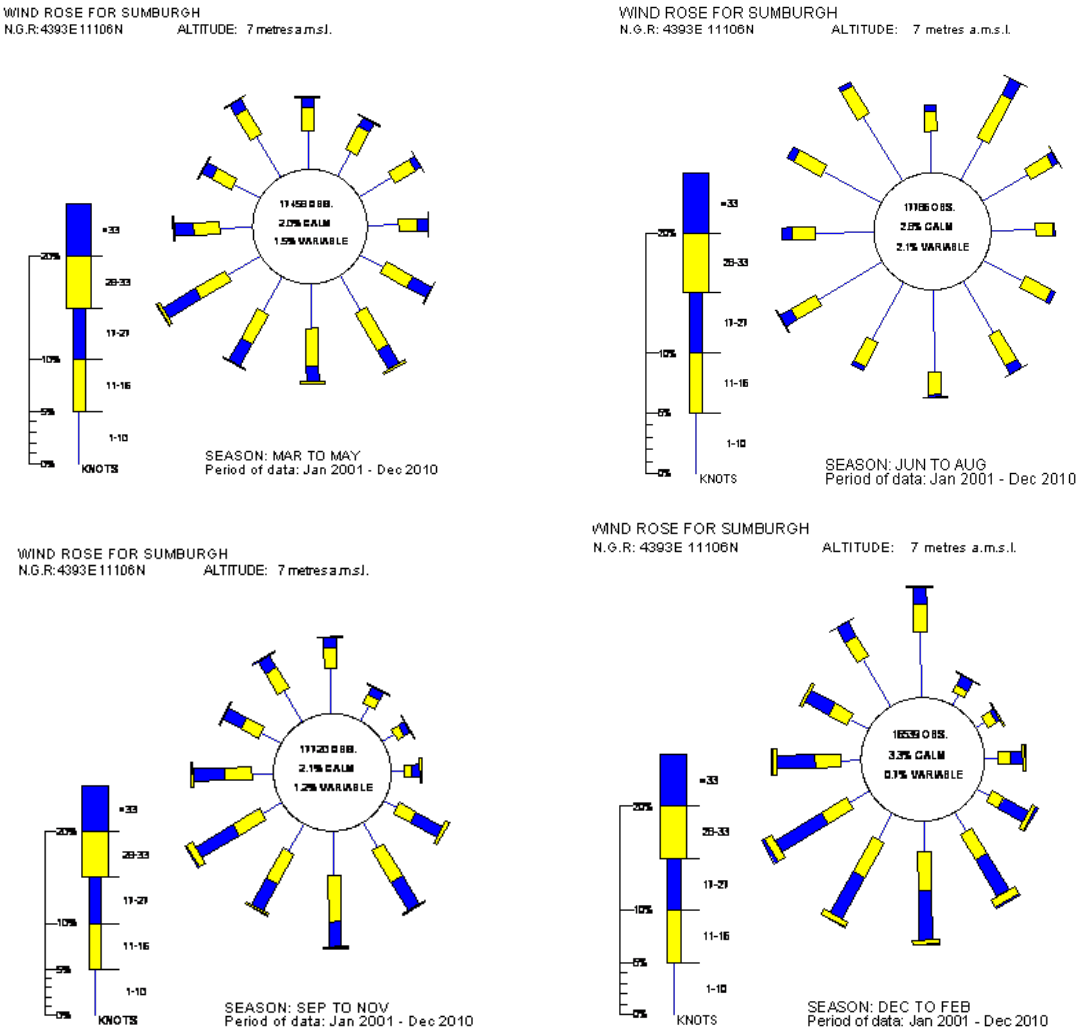

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Figure 9.3 Seasonal wind roses for Sumburgh

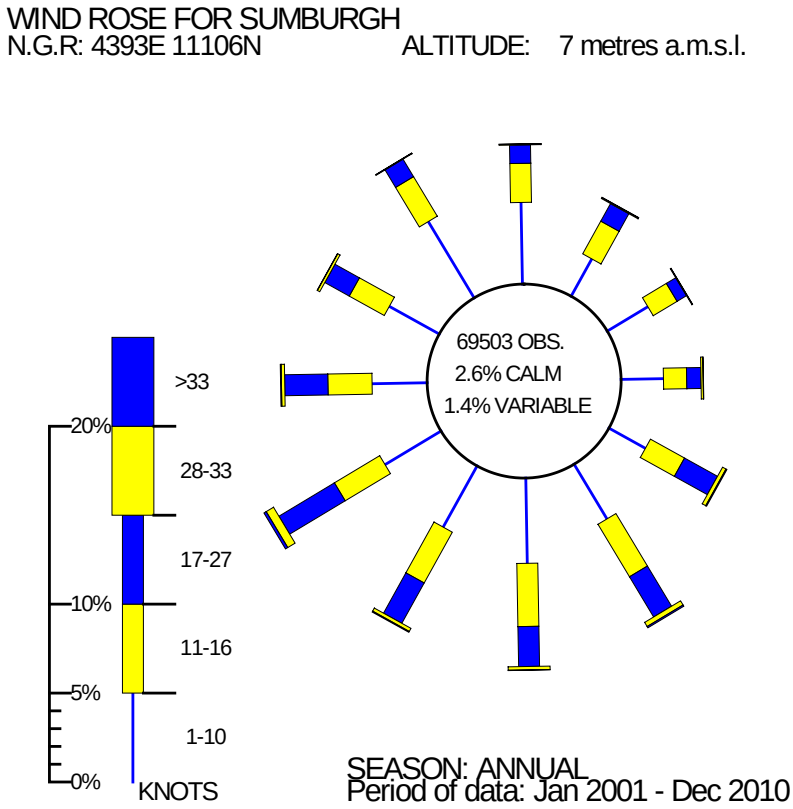

Figure 9.4 Annual wind rose for Sumburgh

Shetland is one of the more windy areas of Scotland with a much higher frequency of gales than the country as a whole. The wind roses show that the overall prevailing direction of the wind is from the south and west, and when it is blowing from this direction it is likely to be stronger than when blowing from other directions. Winds are generally lighter during the summer months and strongest in the winter.

Winds typically 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 may significantly alter the surface movement at South Uyea. Strong winds may affect tide height depending on wind direction and local hydrodynamics. A strong wind from the south combined with a spring tide may result in higher than usual tides, which will carry accumulated faecal matter from livestock, in and above the normal high water mark, into the production area. Strong winds will increase the circulation of water and hence dilution of contamination from sources arising in areas near the fishery.

10. Current and historical classification status

South Uyea was first given a classification for common mussels (*Mytilus edulis*) in 2003. The historical and current classifications for the area are shown below in Table 10.1.

Table 10.1 South Uyea Common Mussels

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	A	A	A	A	B	B	B	B	B	A	A	A
2004	A	A	A	A	B	B	B	B	B	B	A	A
2005	A	A	A	A	A	A	A	A	A	A	A	A
2006	A	A	A	A	A	A	A	A	A	A	A	A
2007	A	A	A	A	A	A	A	A	B	B	A	A
2008	A	A	A	A	A	A	A	A	B	B	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									

The South Uyea production area has held an A classification year-round since 2009. Prior to that, some years received seasonal A/B classifications, with B months tending to occur during summer and/or autumn.

11. Historical *E. coli* data

11.1 Validation of historical data

The results for all samples assigned against South Uyea from 1st January 2007 up to the 31st December 2011 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 in April 2012. All *E. coli* results were reported as most probable number per 100 g of shellfish flesh and intravalvular fluid.

One sample was recorded on the database as "Rejected" and were deleted. Two samples were reported as having invalid MPN results (-1 *E. coli*/100 g) and were deleted. Samples collected during the first three months of 2007 did not have a sample time recorded (all show 00:00:00). Of these samples, one was received at the laboratory on the day after it was collected. The sample collection time was obtained from the sample submission form and the dataset amended accordingly. The sample collection time for one of these was obtained from the sample submission form.

All samples were reported as received in the laboratory within 24 hours. The reported coolbox temperatures were all ≤8°C. Six samples were recorded from a location that fell outwith, but within 20 metres of the production area boundary. These were included in the analysis. Twenty-four samples had the result reported as <20, and were assigned a nominal value of 10 for statistical assessment and graphical presentation. No sample had a result reported as >18000.

11.2 Summary of microbiological results

Table 11.1 Summary of historical sampling and results

Sampling Summary	
Production area	South Uyea
Site	South
Species	Common mussels
SIN	SI 263 454 08
Location	HU 606 983, HU 6073 9814
Total no of samples	48
No. 2007	8
No. 2008	9
No. 2009	10
No. 2010	11
No. 2011	10
Results Summary	
Minimum	<20
Maximum	490
Median	15
Geometric mean	20.76
90 percentile	80
95 percentile	123
No. exceeding 230/100g	1 (2%)
No. exceeding 1000/100g	0
No. exceeding 4600/100g	0
No. exceeding 18000/100g	0

11.3 Overall geographical pattern of results

Prior to January 2011, all sampling locations were recorded on the database to 100 m accuracy. After this time, sampling locations were recorded to 10 m accuracy however no 'drift' was evident in the recorded grid references which suggests that the location may not have been recorded using GPS on each sampling occasion.

The reported sampling locations are plotted on the map shown in Figure 11.1.

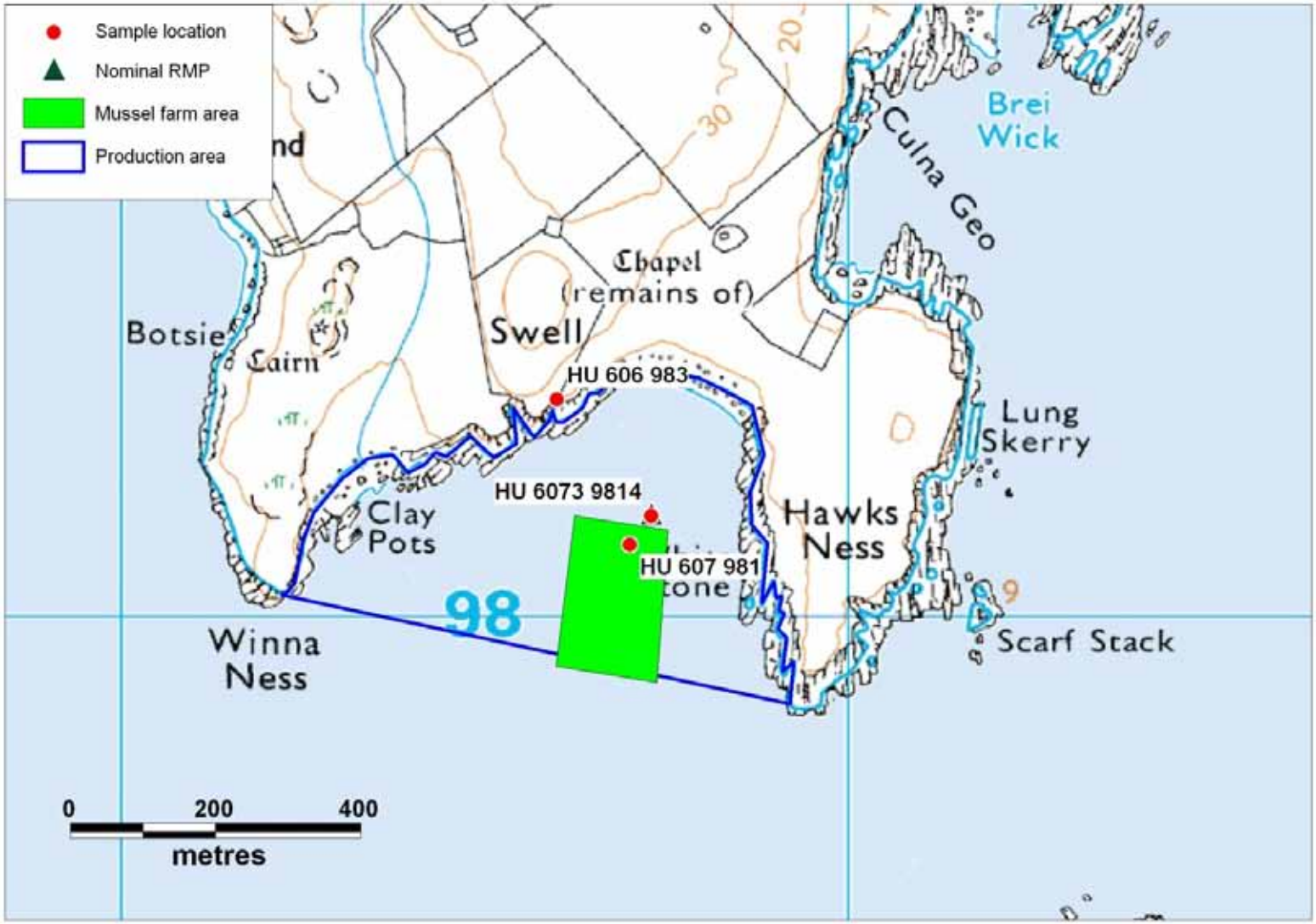

Figure 11.1 Historical sampling locations at South Uyea

11.4 Overall temporal pattern of results

The scatterplot in Figure 11.2 represent individual *E. coli* results against date, fitted with a loess smoother line. Loess stands for 'locally weighted regression scatter plot smoothing'. At each point in the data set an estimated value is fit 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 loess line is influenced more by the data close to it (in time) and less by the data further away. The smoother line helps to highlight any apparent underlying trends or cycles.

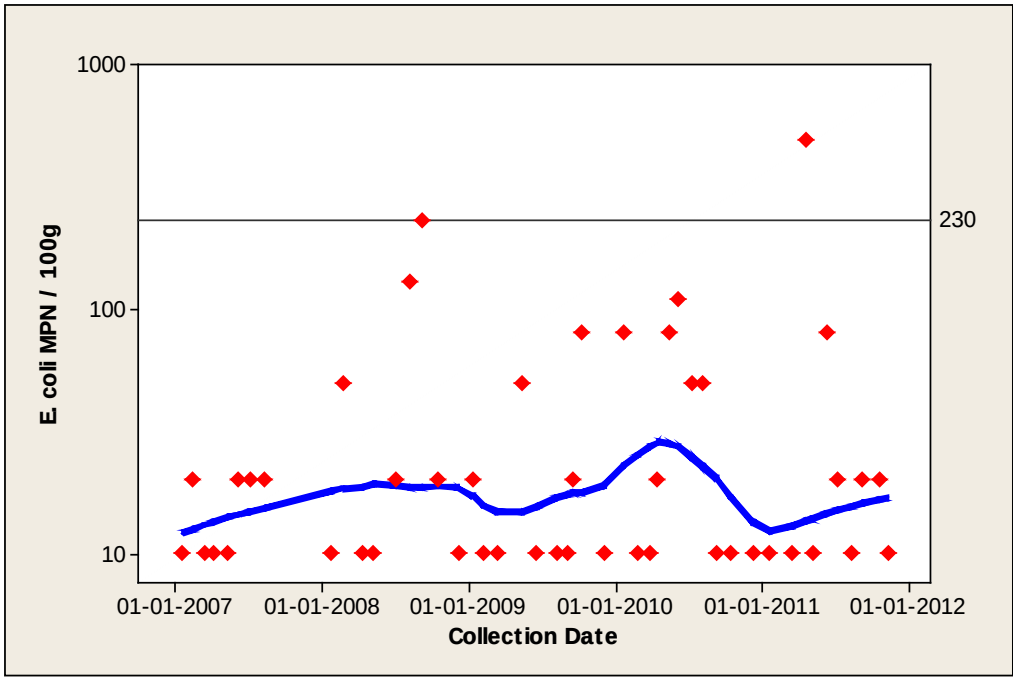

Figure 11.2 Scatterplot of *E. coli* results by date.

Results overall have tended to be at or below the limit of detection of the MPN test. A slight increase in results was seen in early 2010. This was followed by a period of results that were all below the limit of detection of the test, causing a steep drop in the trend line. A single result >230 MPN/100g followed immediately after series of very low results.

11.5 Seasonal pattern of results

Several seasonal factors can affect *E. coli* concentrations in water and in shellfish. These include seasonal variations in environmental factors such as rainfall and water temperature. Other factors such as livestock numbers and their grazing patterns, the presence of wild animals and patterns of human occupation can also influence microbial contamination and seasonal patterns of results. Figure 11.3 presents a scatterplot of *E. coli* result by month, superimposed with a loess smoother line.

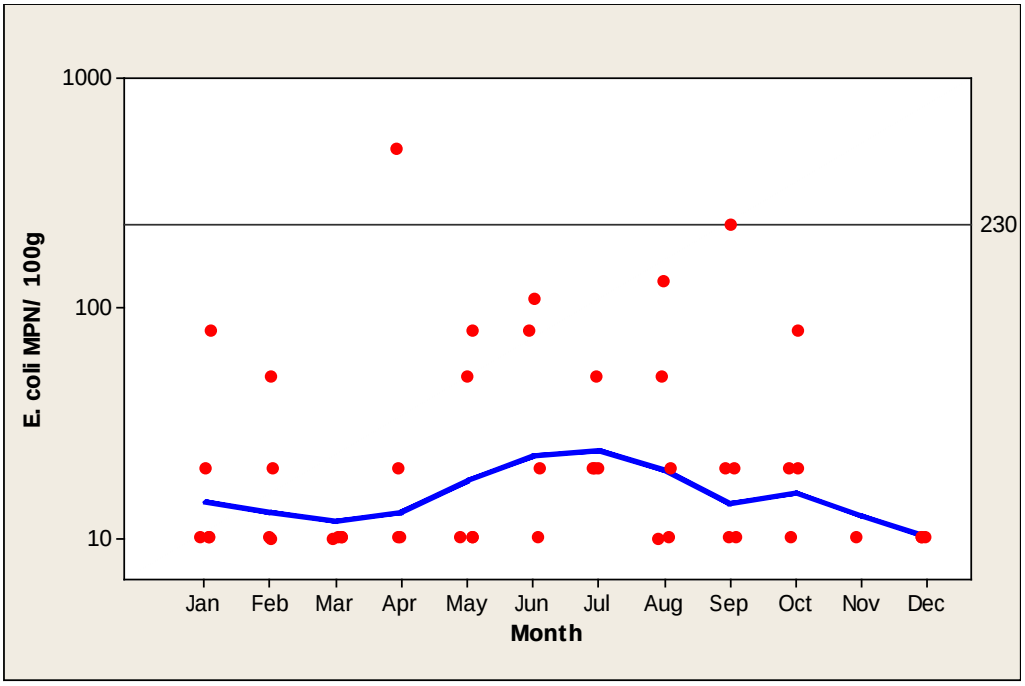

Figure 11.3 Scatterplot of *E. coli* results by month.

A slight tendency toward higher results from June to August is apparent in Figure 11.3. However, the highest results occurred in April and September, however. Only one result exceeded 230 *E. coli* MPN/100 g.

A box plot of the results by season is presented in figure 11.4. For statistical evaluation, seasons were split into spring (March - May), summer (June - August), autumn (September - November) and winter (December - February).

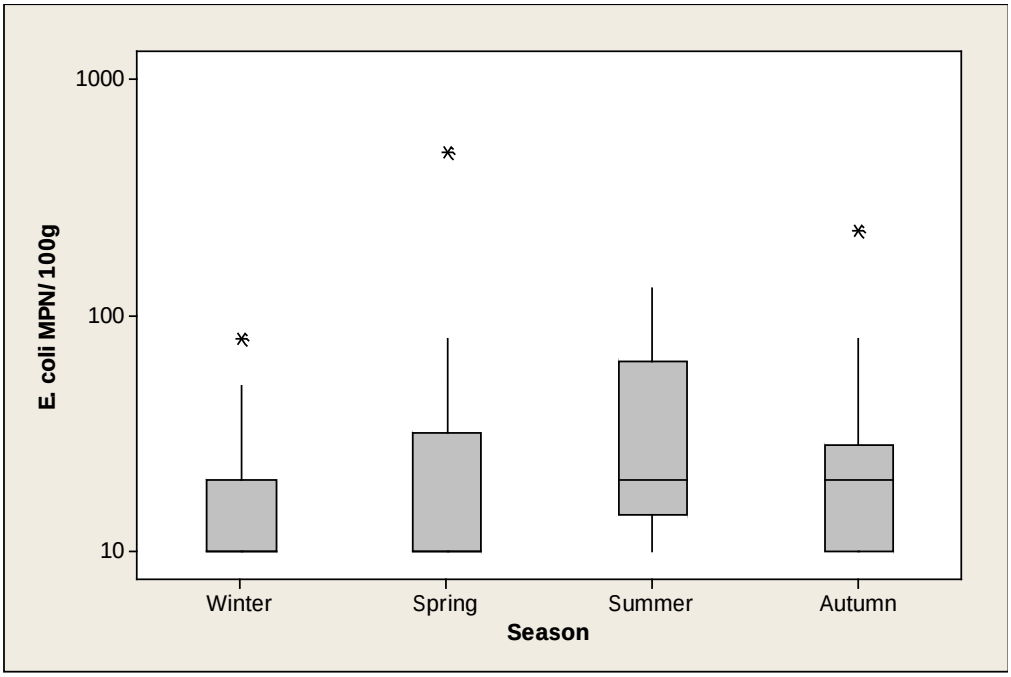

Figure 11.4 Box plot of results by season.

A one way analysis of variance showed no statistically significant difference in *E. coli* results by season. (One-way ANOVA, P= 0.437, Appendix 4).

11.6 Analysis of results against environmental factors

11.6.1 Analysis of results by recent rainfall

The nearest Meteorological office weather station is Unst: Uyea Sound No 3, approximately 3 km north of the production area. Rainfall data was purchased from the Meteorological office for the period up to 31/10/2010 (total daily rainfall in mm). Daily rainfall data was not available for November and December 2010. Therefore only samples collected up to 31/10/2010 were included in the this analysis.

Two-day antecedent rainfall

A scatter plot of *E. coli* results against two day rainfall is presented in Figure 11.5. A Spearman's rank correlation was carried out between *E. coli* result and rainfall recorded in the two days prior to sampling. No statistically significant correlation was found (Spearman's rank correlation = -0.04, p =0.810).

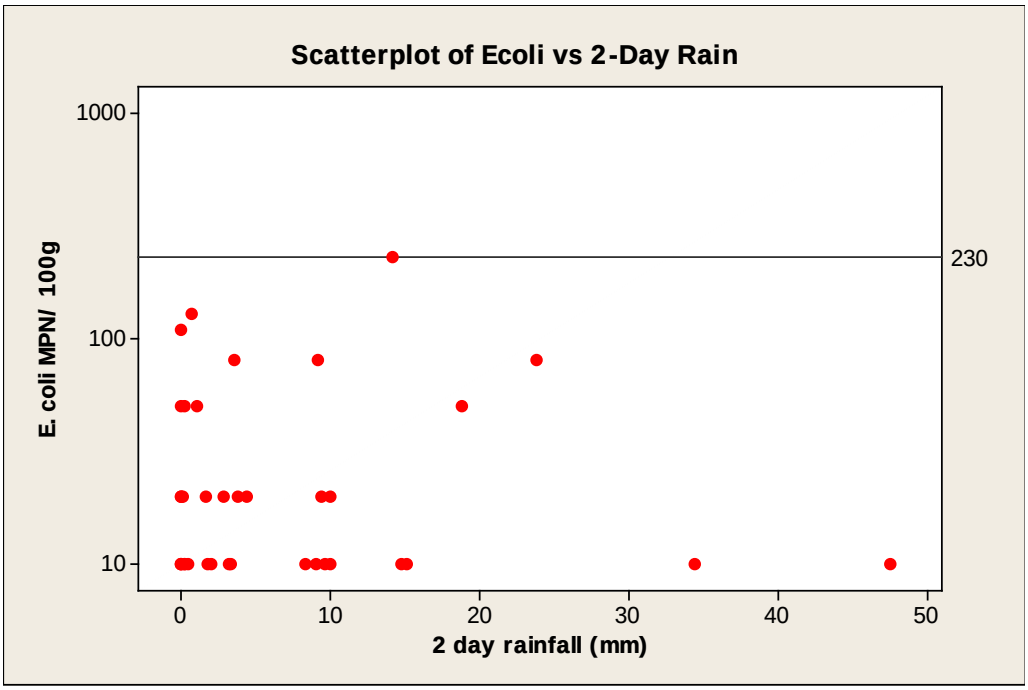

Figure 11.5 Scatterplot of result against rainfall in previous 2 days

Seven-day antecedent rainfall

As the effects of heavy rain may take differing amounts of time to be reflected in shellfish sample results in different systems, the relationship between rainfall in the previous 7 days and sample results was investigated in an identical manner to the above.

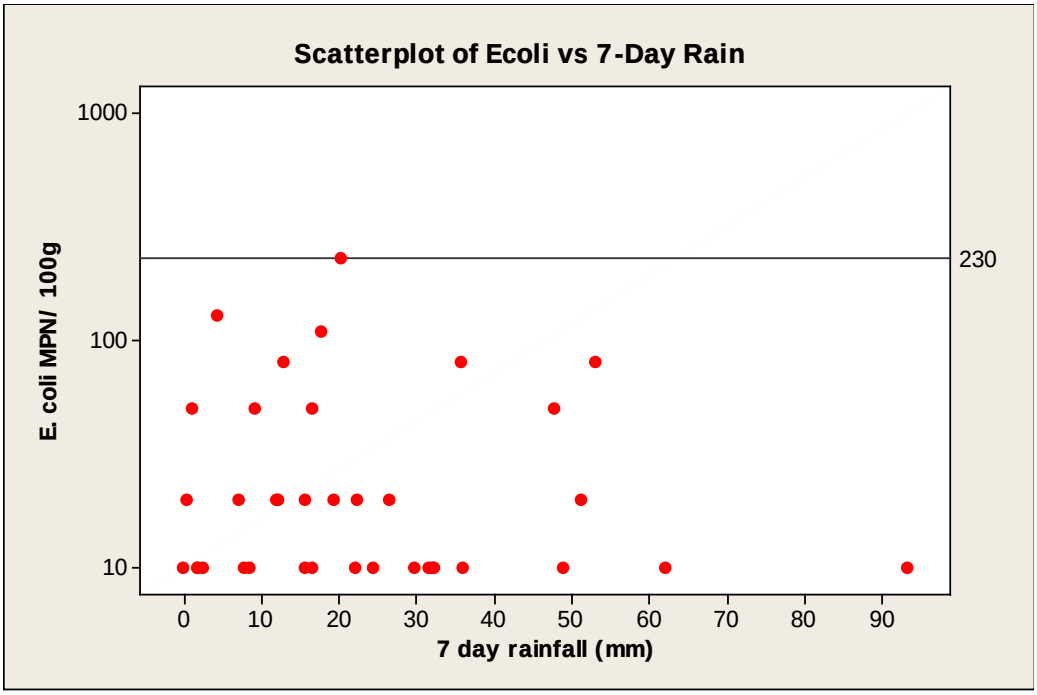

Figure 11.6 Scatterplot of result against rainfall in previous 7 days

No significant correlation was found between E. coli result and 7-day rainfall (Spearman's rank correlation = -0.063, p= 0.713).

11.6.2 Analysis of results by tidal height and state

Spring/ Neap Cycle

When the larger (spring) tides occur every two weeks, circulation of water and particle transport distances will increase, and more of the shoreline will be covered at high water, potentially washing more faecal contamination from livestock into the area. Figure 11.7 presents a polar plot of $\log_{10}$ *E. coli* results on the lunar spring/neap tidal cycle. Full/new moons are located at 0º, and half moons at 180º. The largest (spring) tides occur about 2 days after the full/new moon, or at about 45º, then decrease to the smallest (neap tides) at about 225º, then increase back to spring tides. It should be noted that local meteorological conditions such as wind strength and direction can influence the height of tides and this is not taken into account.

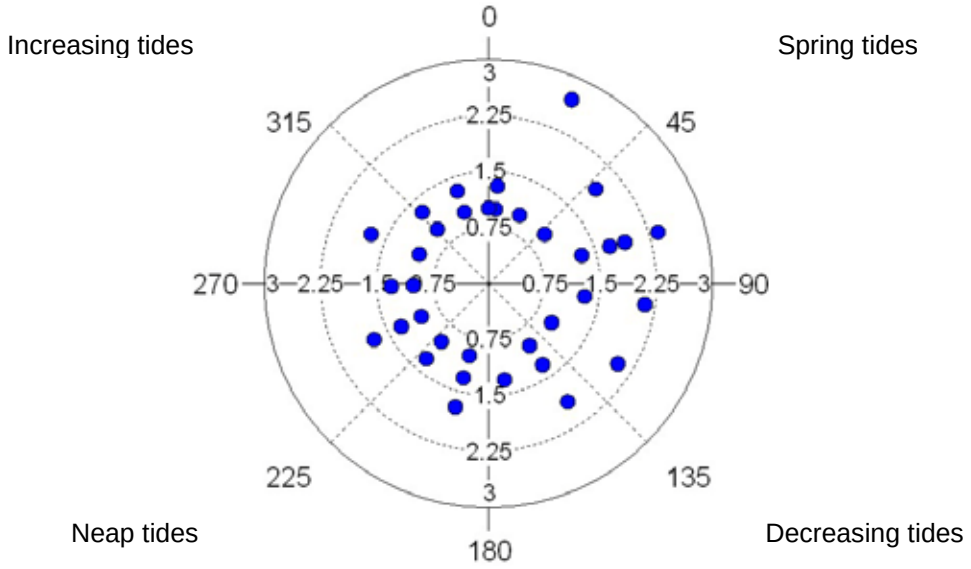

Figure 11.7 Polar plot of log_{10} *E. coli* results on the spring/neap tidal cycle

A statistically significant correlation was found between *E. coli* results and the spring/neap tidal cycle (circular- linear correlation = 0.432, p =<0.001). Highest results tended to occur during spring tides.

High/Low Cycle

Direction and strength of flow around the production areas will change according to tidal state on the (twice daily) high/low cycle, and, depending on the location of sources of contamination, this may result in marked changes in water quality in the vicinity of the farms during this cycle. As *E. coli* levels in some shellfish species can respond within a few hours or less to changes in *E. coli* levels in water, tidal state at time of sampling (hours post high water) was compared with *E. coli* results. Figure 11.8 presents a polar plot of log_{10} *E. coli* results on the lunar high/low tidal cycle. High water is located at 0º, and low water at 180º.

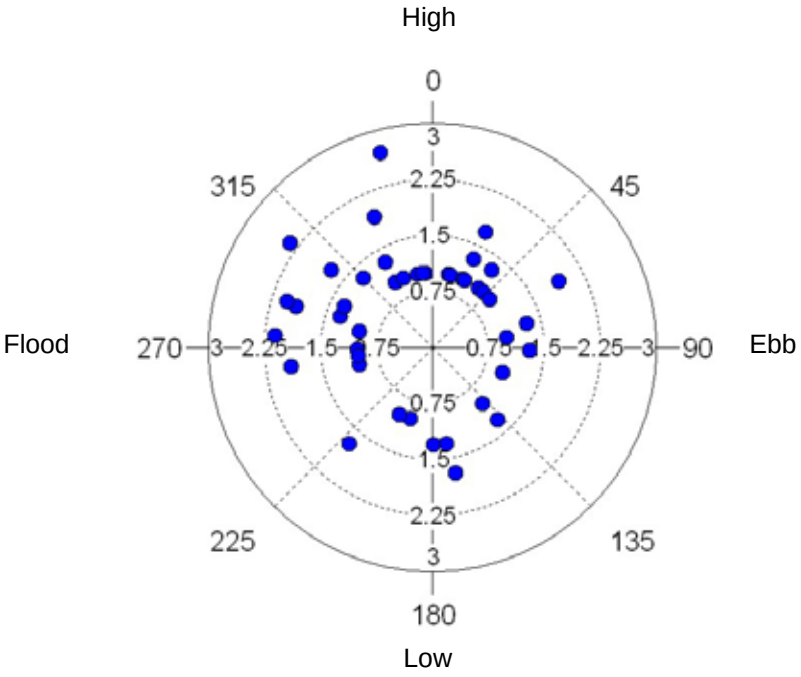

Figure 11.8 Polar plot of log_{10} E. coli results on the high/low tidal cycle

A statistically significant correlation was found between *E. coli* results and the high/low tidal cycle (circular-linear correlation, p = 0.031). Higher results tended to occur during the later half of the flood, toward high tide.

11.6.3 Analysis of results by water temperature

Water temperature is likely to affect the survival time of bacteria in seawater (Burkhardt *et al*, 2000) and the feeding and elimination rates of shellfish and therefore may be an important predictor of *E. coli* levels in shellfish flesh. It is of course closely related to season, and so any correlation between temperatures and *E. coli* levels in shellfish flesh may not be directly attributable to temperature, but to other factors such as seasonal differences in livestock grazing patterns. Water temperature was recorded for 39 out of the 48 samples analysed. Figure 11.9 represents a scatterplot of *E. coli* against water temperature.

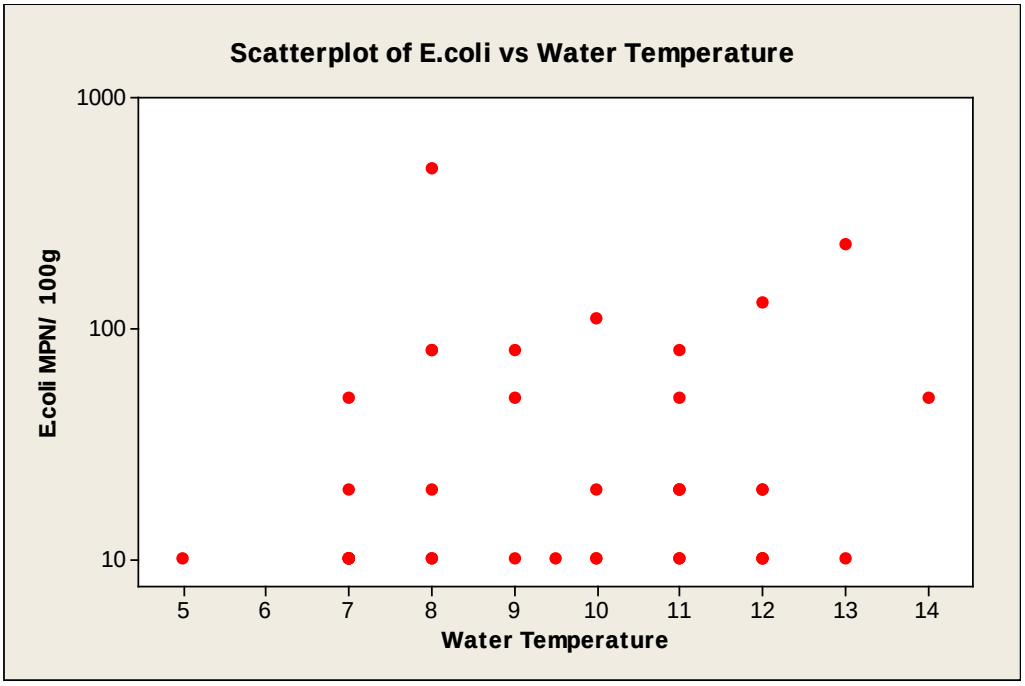

Figure 11.9 Scatterplot of result by water temperature

No significant correlation was found between the *E. coli* result and seawater temperature at the time of sampling (Spearman's Rank = 0.209, p = 0.202).

11.6.4 Analysis of results by salinity

Salinity will give a direct measure of freshwater influence, and hence freshwater-borne contamination at the site. Figure 11.10 presents a scatter plot of *E. coli* result against salinity.

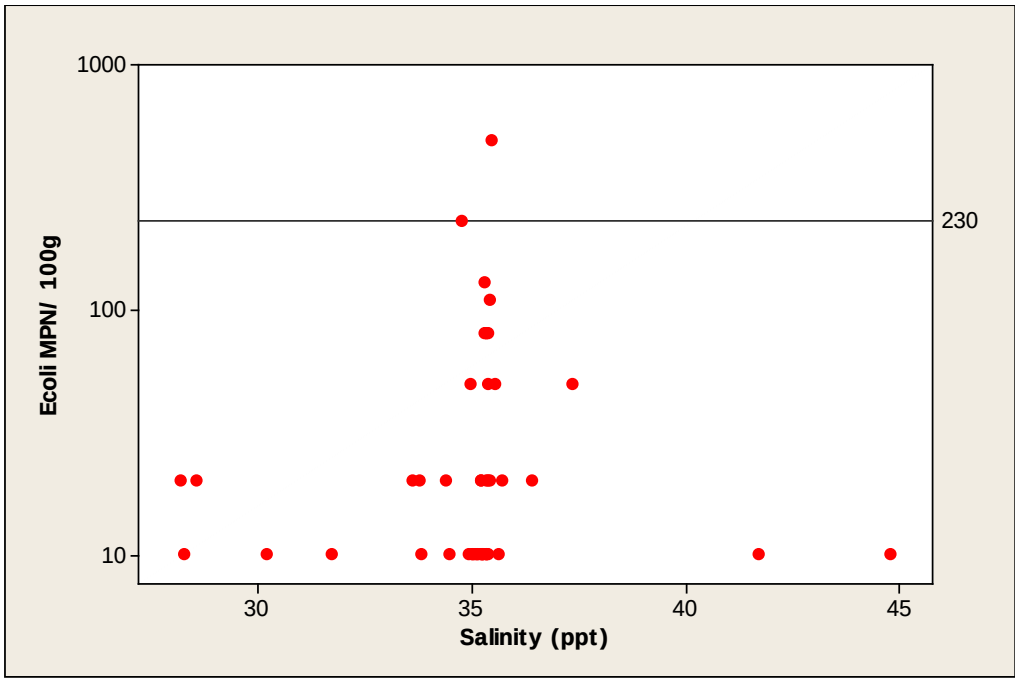

Figure 11.10 Scatterplot of result by salinity

No significant correlation was found between *E. coli* result and salinity (Spearman's Rank Correlation = 0.246, p = 0.092). Most salinity values clustered around 35 ppt, the expected value of full-strength seawater in the area. It should be noted that a small number of salinity results of 40 and above were recorded: it is unlikely that these represent valid values.

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

Only one of the 48 samples contained results over 230 *E. coli* MPN/ 100g, details of which are presented in Table 11.2.

Table 11.2 Historic *E. coli* sampling results over 230 *E. coli* MPN/100g

Collection date	*E. coli* (MPN/100g)	Location	2 day rainfall (mm)	7 day rainfall (mm)	Water Temp (ºC)	Salinity (ppt)	Tidal state (high/low)	Tidal state (spring/ neap)
19/04/2011	490	HU 6073 9814	NA	NA	8	35	High	Spring

This sample was taken during 2011, therefore rainfall data related to that period was not available. The sample was taken at a high tide and during a spring tide; both tidal parameters were found to be positively correlated with higher results.

11.8 Summary and conclusions

Overall, *E. coli* monitoring results at the South Uyea production area have been historically been low. Although there was a slight increase in results during 2010, results over time have been relatively low and stable.

A very slight seasonal increase in results appeared to occur from June to August, although the highest historical results occurred outside that period. Only one result exceeded 230 *E. coli* MPN/100 g, and that was taken in April 2011.

No statistically significant relationship was found between sampling result and rainfall, salinity or water temperature. A statistically significant relationship was found between *E. coli* result and both the spring/neap and high/low tidal cycles, with higher results tending to occur at spring tides and during the latter half of the flood tide.

11.9 Sampling frequency

When a production area holds a non-seasonal classification, and where at least 24 results are available over the past 3 years, and the geometric mean of those results falls within a certain range, consideration may be given to reducing the sampling frequency from monthly to bimonthly. For South Uyea, 31 results were available for the 3-year period from January 2009 to December 2011. The geometric mean of these results was 21.4. This is

greater than the class A limit of 13 given in the EURL Good Practice Guide and so it is not recommended that the sampling frequency be reduced.

12. Designated Shellfish Growing Waters Data

The waters of South Uyea are not currently designated under the either the European Community Shellfish Waters Directive (2006/113/EC) or the EC Bathing Water Directive (2006/7/EC).

13. River Flow

There are no river gauging stations on rivers or burns on the island of Uyea or the southern coastline of Unst. The Ordnance Survey map of South Uyea indicates there is a small watercourse discharging west of the fishery, however this was not flowing at the time of the shoreline survey and no other streams were observed on the southern coastline of Uyea. There had been heavy rain on the day prior to the survey and light showers fell during it. Any watercourses that would only flow after rainfall would have been expected to be running. Freshwater impact to the fishery is therefore expected to be minimal.

14. Bathymetry and Hydrodynamics

The bathymetry at South Uyea and the surrounding area is shown in Figure 14.1.

The mussel farm is located in a bay at the southern end of the island of Uyea. The headland of Hawks Ness is immediately east of the mussel farm. The headland of Winna Ness is located at the western end of the bay. Within the bay, there is a narrow drying area that is largely rocky. The seabed within the bay slopes relatively gently to a maximum of 10 m at the outer edge (which coincides with the southern end of the mussel farm). Depths at the mussel farm range from approximately 5 to 10 m.

Outside the bay, depths increase fairly rapidly to more than 30 m. However, extending south-east from Hawks Ness is a shallow area (mostly <10 m) which extends for approximately 1.5 km. The islands of Wedder Holm and The Hog lie within this shallow area.

14.1 Tidal Curve and Description

The two tidal curves shown in Figure 14.2 are for Bluemull Sound located on the north-east coast of Yell, approximately 8 km from the mussel farm. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 BST on 18/10/11 and the second is for seven days beginning 00.00 BST on 25/10/00. This two-week period covers the date of the shoreline survey. Together they show the predicted tidal heights over high/low water for a full neap/spring tidal cycle.

The following is the summary description for Bluemull Sound from TotalTide:

The tide type is Semi-Diurnal.

HAT	3.3 m
MHWS	2.6 m
MHWN	1.9 m
MLWN	1.0 m
MLWS	0.5 m
LAT	-0.1 m

Predicted heights are in metres above chart datum. The average tidal range at spring tide is 2.4 m and at neap tide 0.9 and so the area is mesotidal (moderate tidal range).

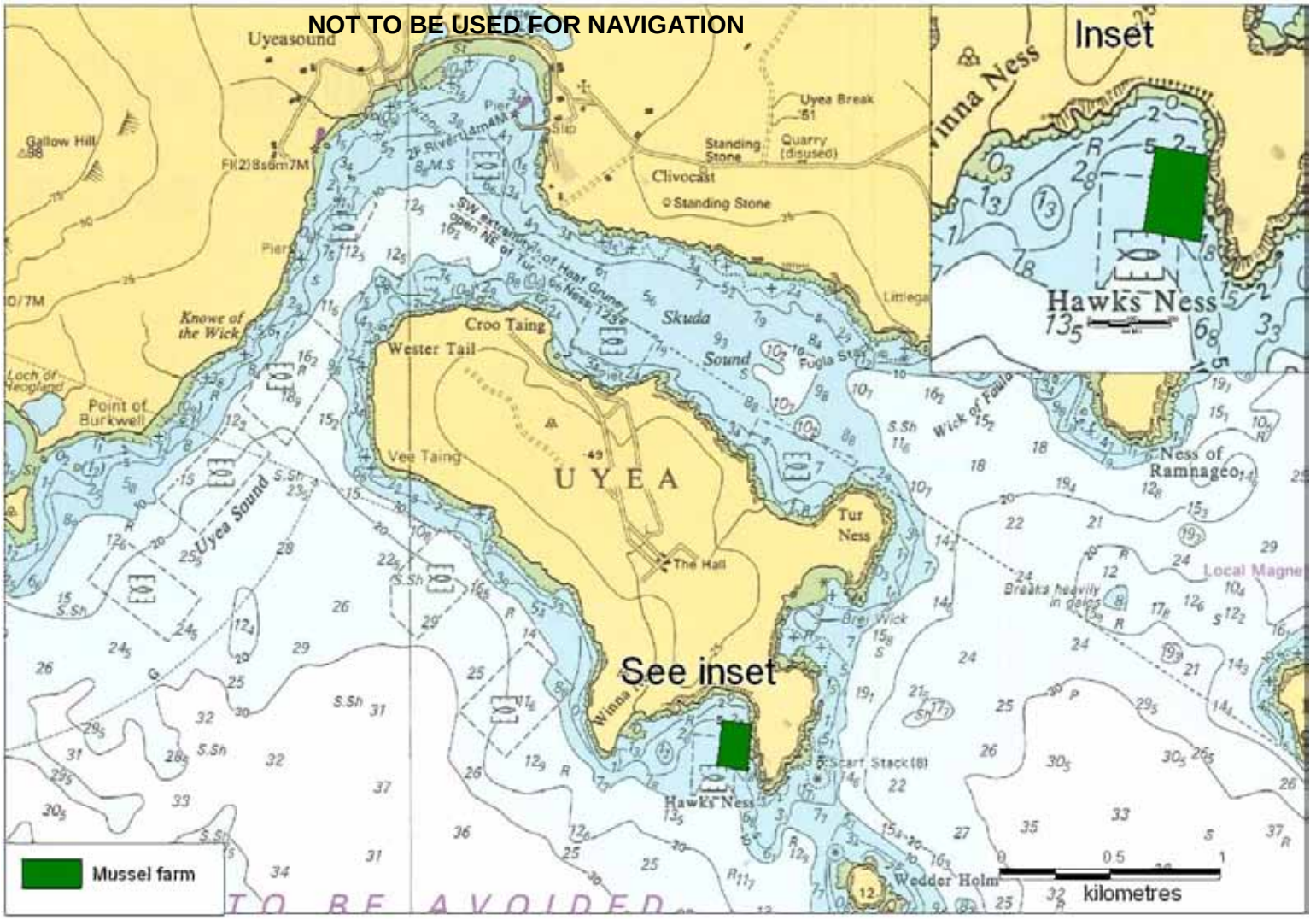

Figure 14.1 Bathymetry at South Uyea

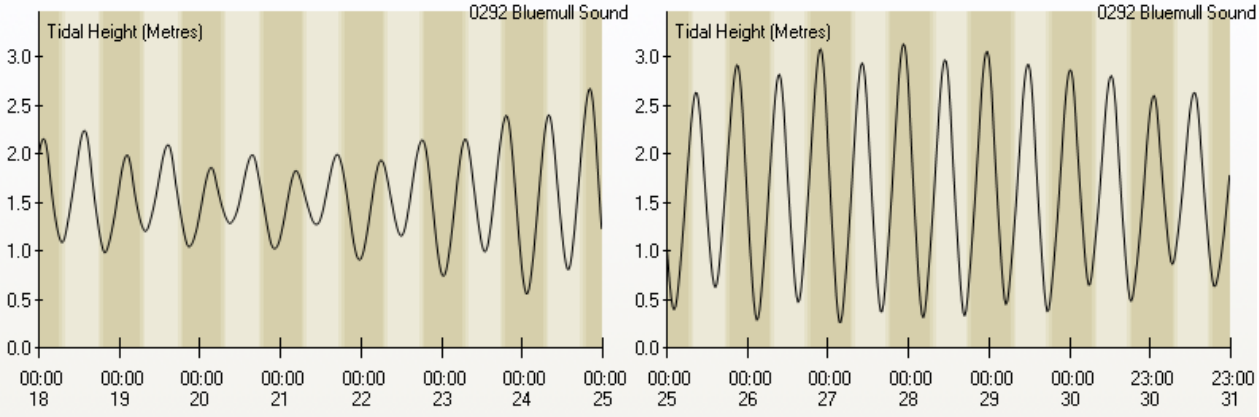

Figure 14.2 Tidal curves for Bluemull Sound

14.2 Currents

There is no tidal stream information for the immediate vicinity of South Uyea. Shetland Seafood Quality Control (SSQC) had undertaken seven current meter studies in the area in support of discharge consent applications for fish farms. The data was made available to Cefas with the consent of the owners (as at June 2011; Turness, Vee Taing & Winna Ness South: Northern Isles Salmon Ltd.; Uyeasound Sites 1 to 4: Uyeasound Salmon Company). The location and survey period is given in Table 14.1 and the position is shown on the map in Figure 14.3. Plots of the current directions and speeds, together with the wind direction and speeds over the relevant period, are shown in Figures 14.4 and 14.5.

None of the locations were within, or immediately outside, the bay where the mussel farm is located, the nearest being Winna Ness South, located off the west coast of the island. However, the data does give general information on the currents flowing around Uyea.

Table 14.1 Survey period for the current meter studies

Location	NGR	Survey period
Turness	HU 6116 9947	02/11/2004 - 26/11/2004
Uyeasound Site 1	HP 5960 0029	03/05/2002 - 30/05/2002
Uyeasound Site 2	HP 5950 0069	20/02/2002 - 21/03/2002
Uyeasound Site 3	HP 5906 0047	04/02/2002 - 20/02/2002
Uyeasound Site 4	HU 5867 9962	18/12/2006 - 16/01/2007
Vee Taing	HU 5928 9879	06/10/2004 - 02/11/2004
Winna Ness South	HU 5958 9842	09/09/2004 - 06/10/2004

Figure 14.3 Current meter locations

Currents speeds shown in Figures 14.4 and 14.5 are measured in cm/s. Wind speeds are measured in m/s. As per convention, currents are plotted against the direction towards which they are travelling while winds are plotted against the direction from which they are travelling. The length of each segment in a plot relates to the proportion of observations lying in that direction. The speed relates to the colour key beneath each plot. The proportion that each colour takes up in an individual segment relates to the proportion of observations in that direction having speed in that range. Directions are in degrees true.

Turness

Currents at near-bottom and near-surface (mid-depth data was not supplied) were bimodal, flowing in approximately easterly and westerly directions. The easterly flow occurs on the flood tide and the westerly flow on the ebb tide. The westerly currents predominated and were stronger than the easterly currents. The near-surface currents were somewhat more variable in direction that the near-bottom currents and this may have been an influence of wind.

Uyeasound Site 1

Currents at all three depths were strongly bimodal. Ebb flows were almost directly south and flood flows to the north-north west. The southerly flows were stronger at depth but this effect became less towards the surface. This may have been affected by the wind as this mainly blew from the south and south-south-west during the period of the study.

Uyeasound site 2

Flows tended to be relatively variable but those to the south-west predominated. These effects did not appear to be related to wind direction.

Uyeasound site 3

At depth, current directions varied between westerly and northerly with those between north-west and north being strongest. At mid-depth and near-surface, the currents were somewhat bimodal, with westerly and north-easterly components. The latter may have been due to the influence of wind as it predominantly blew from the west-south-west during the survey period.

Uyeasound site 4, Vee Taing and Winna Ness South

Currents at all three locations were strongly bimodal at all depths and generally followed the line of the nearest coast. Flows were towards Uyea Sound on the flood tide and away from Uyea Sound on the ebb tide.

Overall

Maximum current speeds at the different locations and depths vary from approximately 30 to 70 cm/s (0.3 to 0.7 m/s; 0.6 to 1.4 kn) which is moderate. Winna Ness South was the nearest current meter location to the mussel farm and the median and maximum current speeds for this site are shown in Table 14.2.

Table 14.2 Median and maximum current speeds for Winna Ness South

Depth	Current speed (cm/s)	
	Median	Maximum
Near-bottom	10.6	52.8
Mid-depth	11.6	69.7
Near-surface	12.1	72.6

At the maximum current speed, the maximum excursion over an ebb or flood tide would be in the order of 10 km, ignoring any dilution or dispersion. However, much of the time the distance potentially travelled by contaminants is likely to be less than 10 km.

In general, flows appear to circulate around much of the island of Uyea in a clockwise direction on the flood tide and an anticlockwise direction on the ebb tide. However, the tidal stream atlas for the area shows that flows to the south of the island will be generally to the south-east during the flood tide and to the north-west during the ebb tide (UKHO, 1986). This would be expected to apply in general at the bay in which the mussel farm is located but with additional flow complexities caused by the presence of the headlands at each end of the bay (and the shallow area to the south-east of Hawks Ness). Given the flows, it is unlikely that sources elsewhere on Uyea or in Uyea Sound or Skuda Sound will impact at the shellfishery: the main impacts will tend to arise from any sources within the bay.

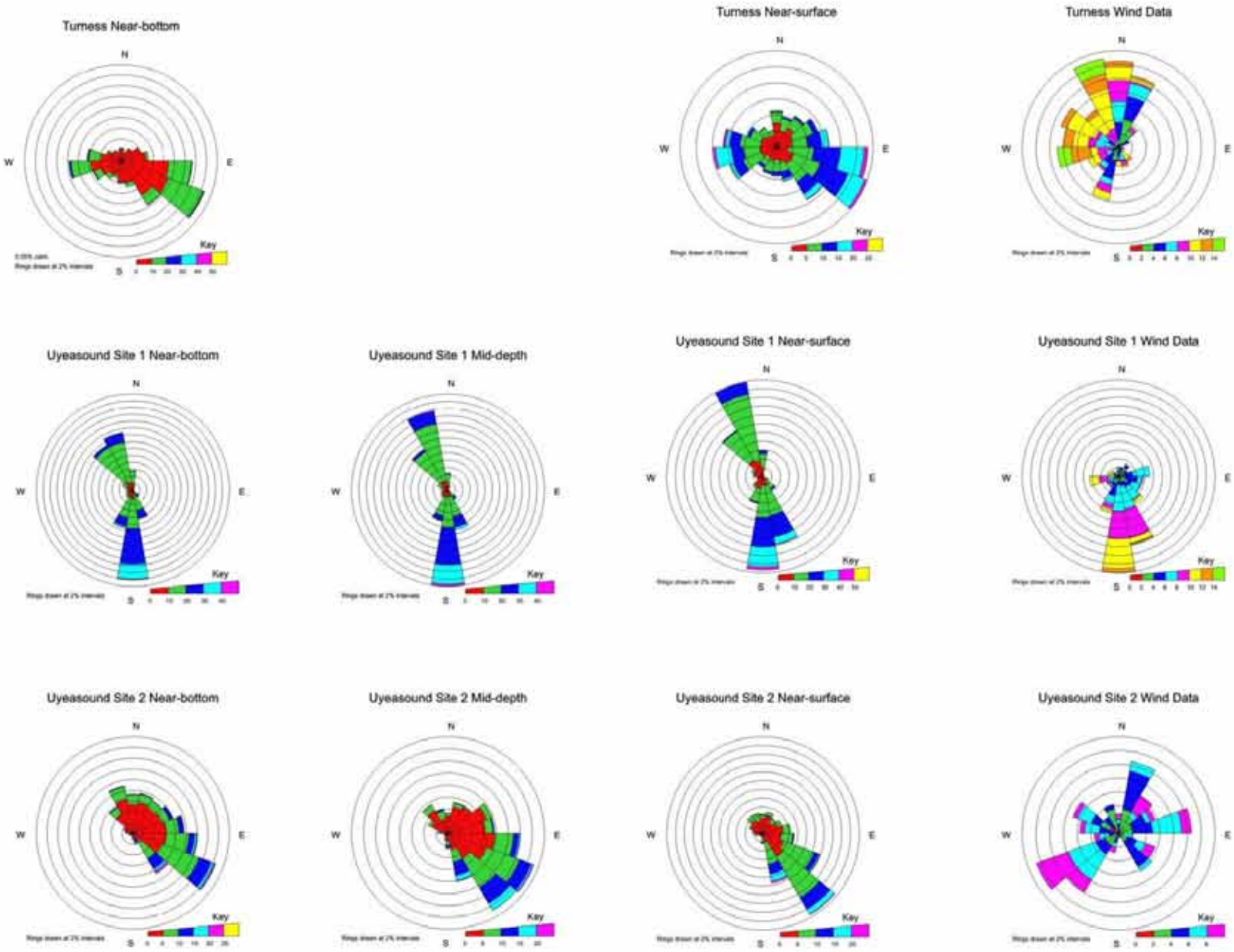

Figure 14.4 Current plots for South Uyea

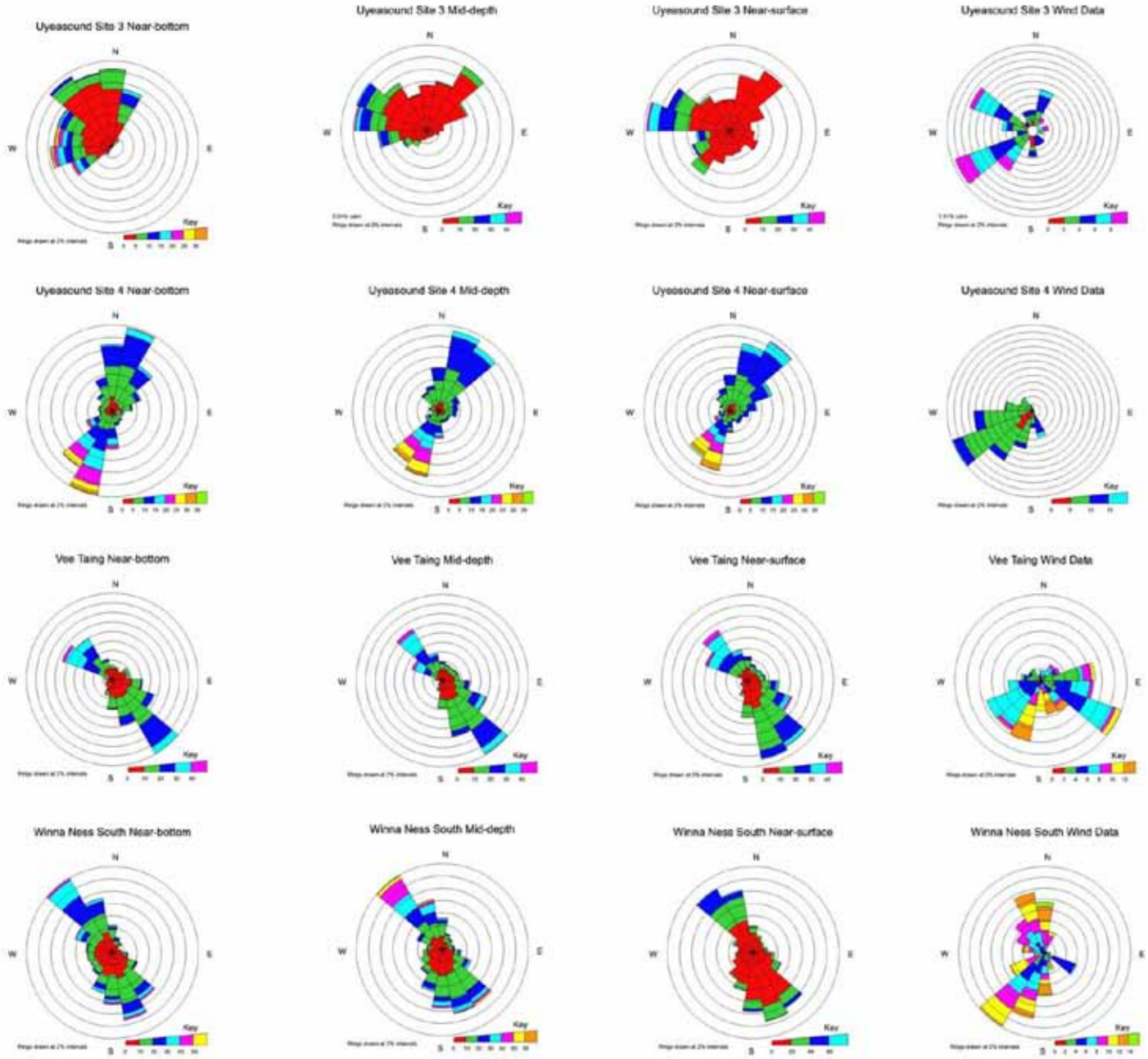

Figure 14.5 Current plots for South Uyea

14.3 Conclusions

The bay in which the mussel farm is located is relatively shallow and contamination arising from within the bay will be subject to low to moderate dilution. Outside of the bay, depths are much greater and thus dilution of any contamination will also be greater. Current speeds within the area are moderate and contamination could be carried a significant distance on springs tides. However, the expected direction of current at the south of Uyea island means that sources outside the bay are unlikely to significantly impact on the microbiological quality of the seawater at the mussel farm.

15. Shoreline Survey Overview

The shoreline survey was conducted on the 18th October 2011 under mainly dry and calm weather conditions. Observations made during the shoreline survey were recorded from a boat due to the shoreline being inaccessible.

The fishery was visited on the day of the shoreline survey. The fishery consists of a longline mussel farm consisting of seven long lines, 200 m in length with 5 – 8 m droppers The fishery had sufficient stock on site for sampling during the survey and the site is harvested all year round.

The area surrounding the South Uyea fishery is sparsely populated and the island of Uyea itself is uninhabited. Uyea is accessible via a small pier on the northern shoreline of the island and there is an old abandoned farm in the centre of the island. The shoreline at South Uyea is inaccessible as there are no footpaths or tracks on the southern side of the island. The nearest settlements are located on the neighbouring island of Unst to the north of the island of Uyea.

Sheep were observed grazing along the southern shoreline of the island of Uyea on the day of the shoreline survey. Some of the livestock appeared to be fenced off from the shoreline whilst others roamed free. A total of approximately 16 sheep were observed.

During the shoreline survey approximately 100 shags were disturbed on the water close to the fishery. An additional 3 gulls were observed on the mussel lines and 7 more gulls were observed nesting on the shoreline west of the Winna Ness headland to the west of the fishery.

Sea water samples taken in the close vicinity of the fishery contained little *E. coli* (<1-1 cfu/100 ml) in all cases. Salinity profiles taken close to the mussel fishery indicated little or no significant freshwater influence at the time of the survey.

Figure 15.1 shows a summary map of the most significant findings from the shoreline survey for South Uyea.

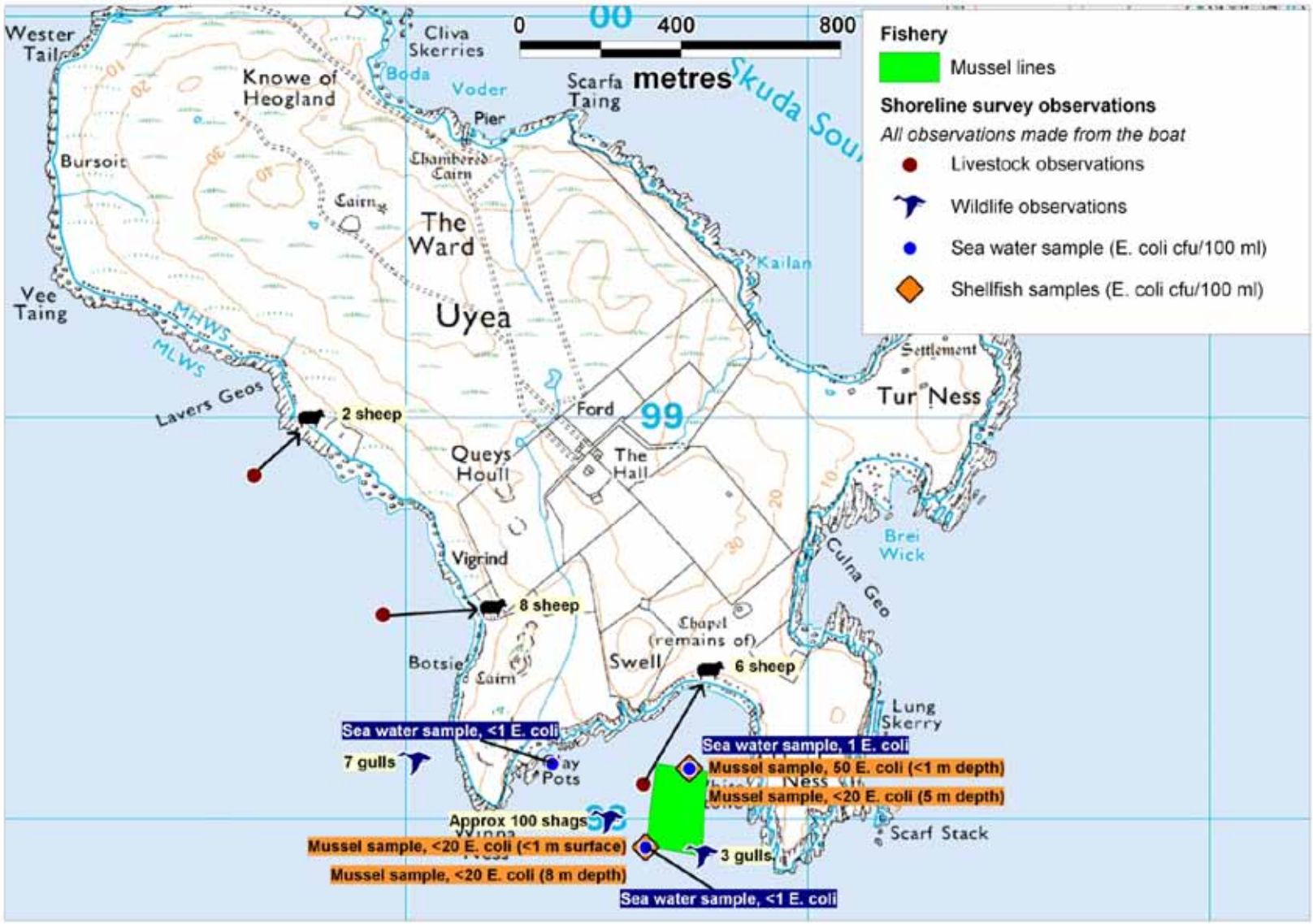

Figure 14.1 Summary of shoreline survey findings for South Uyea

16. Overall Assessment

Human sewage impacts

The island of Uyea adjacent to the fishery is uninhabited. Although there is a small septic tank discharge at Uyeasound, to the north of the fishery, given the predicted currents and potential for dilution it is unlikely that this discharge will have a significant impact on water quality at the mussel farm.

Agricultural impacts

Sheep are grazed on Uyea and a small number of animals were observed on the shoreline adjacent to the fishery. Faecal contamination from sheep droppings can reach the fishery from either land runoff or direct deposition to the shoreline and is likely to impact water quality at the shellfish farm. The part of the farm nearest the shore is most likely to be affected. Although there is a farm on Uyea, it has been abandoned.

More sheep are likely to be present in summer, when there are lambs with the ewes. It is not known whether the sheep observed on Uyea during the shoreline survey are only present there during the summer months.

Wildlife impacts

Seabirds, seals, and potentially otters are the wildlife species most likely to contribute faecal contamination to the waters at the shellfish farm. Seabirds are present in very large numbers around Fetlar, to the south of the fishery and in significant numbers around Uyea itself. These animals are present in highest numbers during the summer, when they nest in the area. Although most of these birds will disperse or return to sea after nesting, some species, such as certain gulls, will remain year-round. The greatest impact is likely to be from birds swimming, feeding, and resting on mussel floats.

Seals are present in the area and are likely to pass near or through the mussel farm during foraging. There are haulout areas to the south on Fetlar, though these are over 3 km from the mussel farm. Seals are likely to contribute to background levels of contamination seen at the fishery.

Otters may be present in the area, and tend to leave faeces adjacent to watercourses. However, it is not known whether they are present on Uyea, and if so any impact is likely to be minimal.

Seasonal variation

Numbers of both seabirds and sheep near the fishery are likely to be higher in summer.

Seasonal variation was also observed in rainfall, with higher rainfall overall tending to occur during the autumn and winter. A slight increase in *E. coli*

monitoring results was observed from July to September, though the variation between season was not found to be statistically significant.

Rivers and streams

There are minimal freshwater impacts to the fishery. The Ordnance Survey map of South Uyea indicates there is a small watercourse discharging west of the fishery, however this was not flowing at the time of the shoreline survey and no other streams were observed on the southern coastline of Uyea.

Movement of contaminants

The predicted high current speeds in the channel between Uyea and Unst and between Unst and Yell suggest significant water movement through the area and substantial opportunity for dispersion and dilution of contaminants. Analysis of current meter studies showed that flows appear to circulate around much of the island of Uyea, moving in a clockwise direction on the flood tide and an anticlockwise direction on the ebb. Water movement within the bay in which the mussel farm is located is likely to be complex, as tidal streams passing south of the island may form gyres as they pass the headlands located at either side of the bay in which the fishery is located. Strong winds from the south may drive the tide higher up the shore and wash any droppings deposited there into the waters around the mussel farm.

Temporal and geographical patterns of sampling results

Very little variation in results was seen over time, with a very slight increase occurring in 2010. Results were low over the time period examined, with only a single result exceeding 230 *E. coli* MPN/100 g.

The majority of sampling results were reported against the nominal RMP and therefore no meaningful assessment of geographic variation in results was possible. During the shoreline survey, samples of mussels were taken at two depths from both the north and south end of the mussel farm. All results but one were below the limit of detection for the test. The sample taken from near the surface at the northern end of the farm (nearest shore) returned a result of 50 *E. coli* MPN/100g. This suggests that contamination levels were marginally higher nearer shore, but still very low.

Conclusions

Overall, the fishery is subject to only low level, diffuse sources of faecal contamination primarily from sheep and wildlife. There is limited seasonal variation in results, and this appears to coincide with increases in both the local sheep and seabird populations.

Currently, the farm on Uyea is abandoned. If it were to come back into productive use, the amount of diffuse contamination from agricultural activity would be expected to increase.

Overall, the assessment of movement of contaminants suggests sources outside the immediate vicinity of the mussel farm are unlikely to impact at the shellfishery and that the main impacts will tend to arise from any sources within the bay.

17. Recommendations

Production area

As the current fishery and its underlying seabed lease area extend beyond the current production area boundary, it is recommended that the boundary be extended southward to encompass the entire lease area. The recommended boundary is described as the area bounded by lines drawn between HU 6022 9803 and HU 6022 9780 and between HU 6022 9780 and HU 6092 9780 and between HU 6092 9780 and HU 6092 9788 and extending to MHWS.

RMP

It is recommended that the RMP be retained at the northeastern end of the mussel farm, though the location was amended 20 metres southward to HU 6073 9812 in order to place it on the location of the farm as measured during the shoreline survey.

Depth of sampling

There is no specific evidence to suggest variation in contamination levels with depth. Therefore it is recommended that the sampling depth be set between 1 and 3 metres depth.

Tolerance

Sampling tolerance recommended to be 40 metres to allow for some movement of the mussel lines.

Frequency

An assessment of sampling results for stability did not suggest the area was suitable for reduced sampling frequency, therefore the recommended sampling frequency is monthly.

The locations of the recommended production area, RMP and the mussel farm are shown in Figure 17.1.

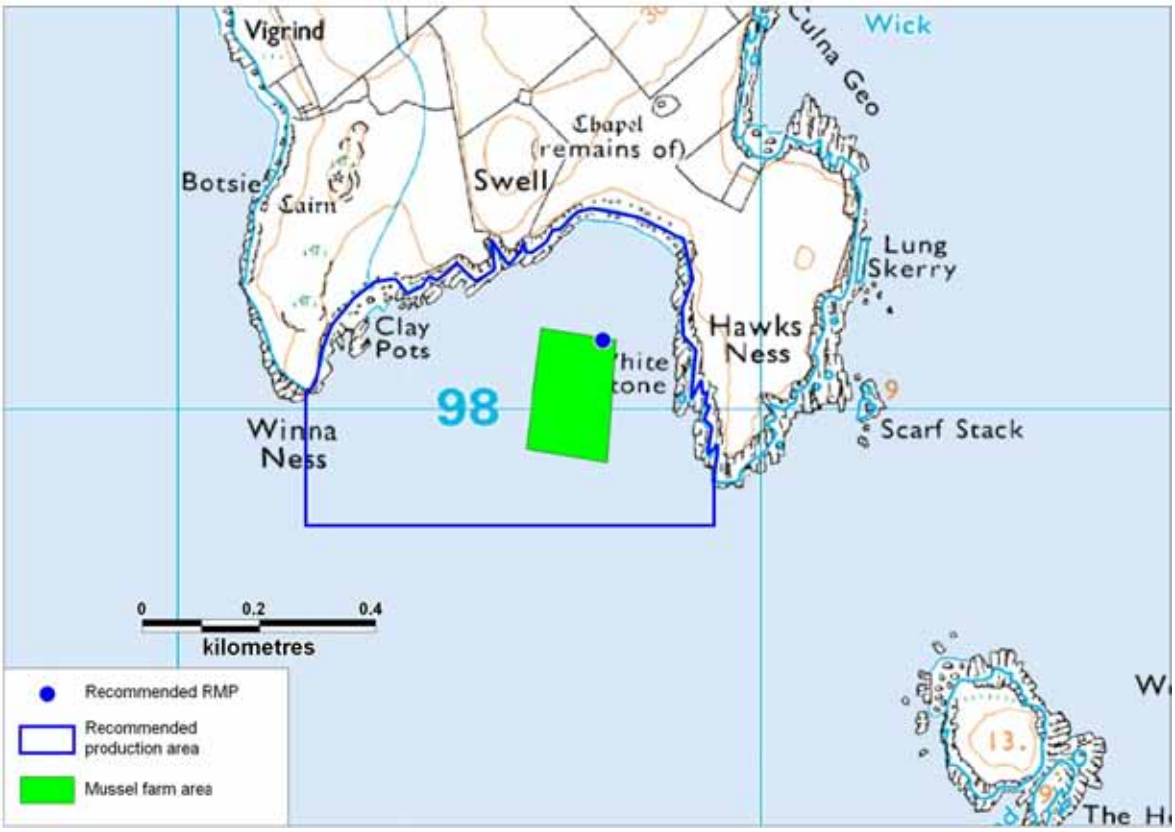

Figure 16.1 Map of recommendations at South Uyea

18. References

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19. List of Figures and Tables

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1. **Geology and Soils Assessment Method**
2. **General Information on Wildlife Impacts**
3. **Tables of Typical Faecal Bacteria Concentrations**
4. **Statistical Data**
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Geology and Soils Assessment Method

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

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

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

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

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

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

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

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

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

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

Glossary of Soil Terminology

Calcareous: Containing free calcium carbonate.

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

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

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

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

General Information on Wildlife Impacts

Pinnipeds

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

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

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

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

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

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

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

Cetaceans

As mammals, whales and dolphins would be expected to have resident populations of *E. coli* and other faecal indicator bacteria in the gut. Little is known about the concentration of indicator bacteria in whale or dolphin

faeces, in large part because the animals are widely dispersed and sample collection difficult.

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

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

Birds

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

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

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

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

Deer

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

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

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

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

Other

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

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

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Tables of Typical Faecal Bacteria Concentrations

Summary of faecal coliform concentrations (cfu 100ml-1) for different treatment levels and individual types of sewage-related effluents under different flow conditions: geometric means (GMs), 95% confidence intervals (Cis), and results of t-tests comparing base- and high-flow GMs for each group and type.

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

Source: Kay, D. et al (2008) Faecal indicator organism concentrations in sewage and treated effluents. *Water Research* 42, 442-454.

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

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

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

Statistical Data

One-way ANOVA: Log EC versus Season

```
Source  DF     SS     MS     F      P
Season   3  0.504  0.168  0.92  0.437
Error   44  8.005  0.182
Total   47  8.509

S = 0.4265   R-Sq = 5.93%   R-Sq(adj) = 0.00%


                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level    N    Mean   StDev  ---+---------+---------+---------+------
autumn  10  1.3469  0.4508        (------------*-------------)
spring  13  1.2764  0.5211      (-----------*-----------)
summer  13  1.4586  0.3913               (-----------*-----------)
winter  12  1.1837  0.3134  (-----------*------------)
                           ---+---------+---------+---------+------
                            1.00      1.20      1.40      1.60

Pooled StDev = 0.4265
```

Hydrographic Methods

The new EU regulations require an appreciation of the hydrography and currents within a region classified for shellfish production with the aim to "determine the characteristics of the circulation of pollution, appreciating current patterns, bathymetry and the tidal cycle." This document outlines the methodology used by Cefas to fulfil the requirements of the sanitary survey procedure with regard to hydrographic evaluation of shellfish production areas. It is written as far as possible to be understandable by someone who is not an expert in oceanography or computer modelling. A glossary at the end of the document defines commonly used hydrographic terms e.g. tidal excursion, residual flow, spring-neap cycle etc.

The hydrography at most sites will be assessed on the basis of bathymetry and tidal flow software only. Selected sites will be assessed in more detail using either: 1) a hydrodynamic model, or 2) an extended consideration of sources, available field studies and expert assessment. This document will consider the more basic hydrographic processes and describes the common methodology applied to all sites.

Background processes

Currents in estuarine and coastal waters are generally driven by one of three mechanisms: 1) Tides, 2) Winds, 3) Density differences.

Tidal flows often dominate water movement over the short term (approximately 12 hours) and move material over the length of the *tidal excursion*. Tides move water back and forth over the tidal period often leading to only a small net movement over the 12 hours tidal cycle. This small net movement is partly associated with the *tidal residual* flow and over a period of days gives rise to persistent movement in a preferred direction. The direction will depend on a number of factors including the bathymetry and direction of propagation of the main tidal wave.

Wind and density driven current also lead to persistent movement of water and are particular important in regions of relatively low tidal velocities characteristic of many of the water bodies in Scottish waters. Whilst tidal flows generally move material in more or less the same direction at all depths, wind and density driven flows often move material in different directions at the surface and at the bed. Typical vertical profiles are depicted in Figure 1. However, it should be understood that in a given water body, movement will often be the sum of all three processes.

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

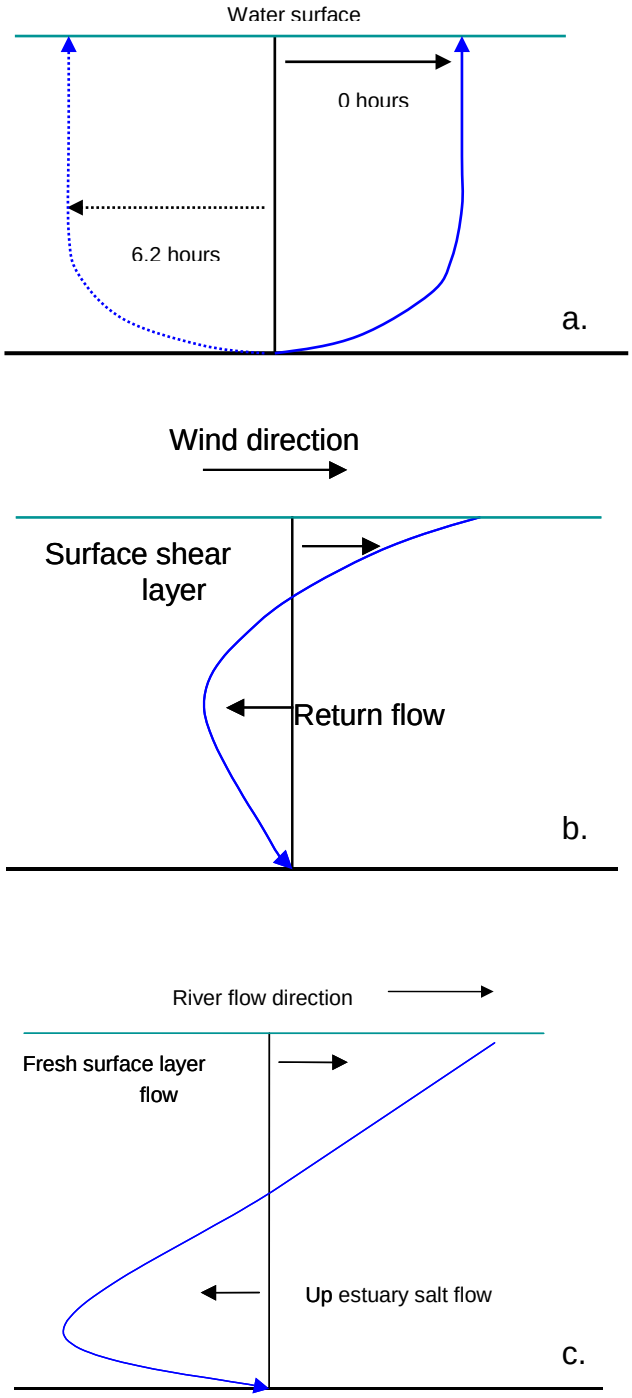

Figure 1. Typical vertical profiles for water currents. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction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

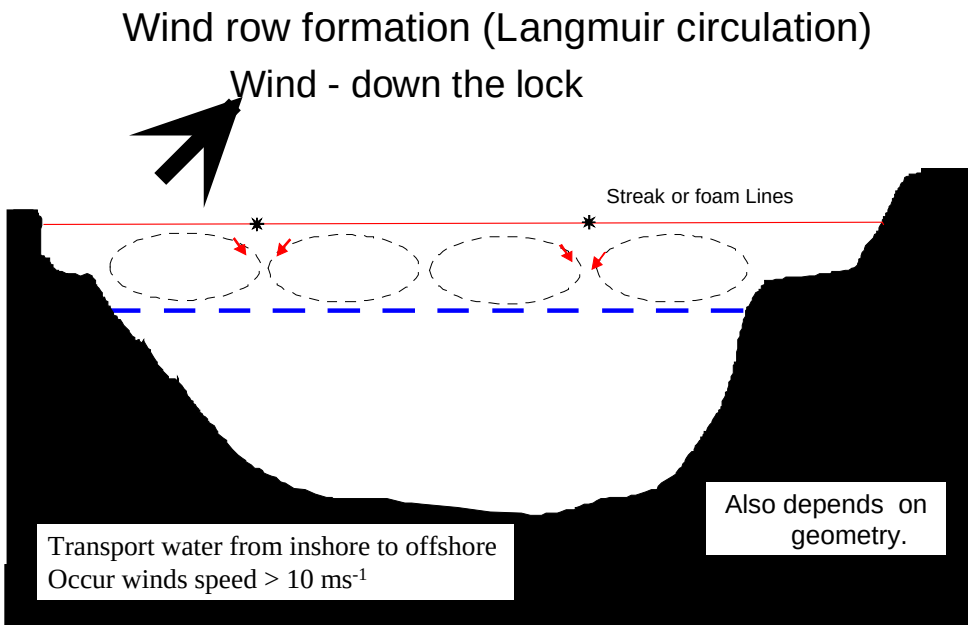

Figure 2. Schematic of wind driven 'wind row' currents. The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

Non-modelling Assessment

In this approach the assessment requires a certain amount of expert judgment and subjectivity enters in. For all production areas, the following general guidelines are used:

1. Near-shore flows will generally align parallel to the shore.
2. Tidal flows are bi-directional, thus sources on either side of a production area are potentially polluting.
3. For tidal flows, the tidal excursion gives an idea of the likely main 'region of influence' around an identified pollutant source.
4. Wind driven flows can drive material from any direction depending on the wind direction. Wind driven current speeds are usually at a maximum when the wind direction is aligned with the principle axis of the loch.
5. Density driven flows generally have a preferred direction.
6. Material will be drawn out in the direction of current, often forming long thin 'plumes'.

Many Scottish shellfish production areas occur within sea lochs. These are fjord-like water bodies consisting of one or more basins, deepened by glacial activity and having relatively shallow sills that control the mixing and flushing processes. The sills are often regions of relatively high currents, while the basins are much more tranquil often containing higher density water trapped below a fresh lower density surface layer. Tidal mixing primarily occurs at the sills.

The catalogue of Scottish Sea Loch produced by the SMBA is used to quantify sills, volume fluxes and likely flow velocities. Because the flow is so constrained by the rapidly varying bathymetry, care has to be used in the extrapolation of direct measurements of current flow. Mean flow velocities can be estimated at the sills by using estimates of the sill area and the volume change through a tidal cycle. This in turn can be used to estimate the maximum distance travelled in a tidal cycle in the sill area. Away from the sill area, tidal velocities are general low and transport events are dominated by wind or density effects. Sea Lochs

generally have a surface layer of fresher water; the extent of this depends on freshwater input, sill depth and quantity of mixing.

In addition to movement of particles by currents, dilution is also an important consideration. Dilution reduces the effect of an individual point source although at the expense of potentially contaminating a larger area. Thus class A production areas can be achieved in water bodies with significant faecal coliform inputs if no transport pathway exists and little mixing can occur. Conversely a poor classification might occur where high mixing causes high and permanent background concentrations arising from many weak diffuse sources.

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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.

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. The strongest tides in a month are called spring tides and the weakest are called neap tides. Spring tides occur every 14 days with neaps tides occurring 7 days after springs. Both tidal range and tidal currents are strongest at Spring 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. Often a surface flow at the surface is accompanied by a compensating flow in the opposite direction at the bed (see figure 1).

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.

Shoreline Survey Report

Production area:	South Uyea
Site name:	South
SIN:	SI 263 454 08
Species:	Common mussels
Harvester:	David Niven (Unst Shellfish)
Local Authority:	Shetland Islands Council
Status:	Existing site
Date Surveyed:	18/10/2011
Surveyed by:	Jessica Larkham – Cefas Sean Williamson – NAFC
Nominal RMP:	HU 606 983
Sampling Point:	HP 607 981
Area Surveyed:	See Figure 1.

Weather observations

18/10/2011 – Cloudy with light rain showers in the morning and calm and dry in the afternoon. Wind 2.2 knots, 8.7˚C. Heavy rain previous day.

Site Observations

Specific observations made on site are mapped in Figure 1 and listed in Table 1. Water and shellfish samples were collected at sites marked on Figures 2 and 3. Bacteriology results are given in Tables 2 and 3. Salinity profiles are presented in Table 4. Photographs are presented in Figures 4 – 8.

Fishery

The South Uyea mussel fishery is a longline mussel farm consisting of seven long lines, 200 m in length with 5 – 8 m droppers. The fishery had sufficient stock on site for sampling at the time of the shoreline survey and the site is harvested all year round.

Sewage/Faecal Sources

Human
The island of Uyea is accessible via a small pier on the northern shoreline of the island, however the island is uninhabited. There is an old farm in the centre of the island though this is abandoned. The shoreline at South Uyea is inaccessible as there are no footpaths or tracks on the southern side of the island. The nearest settlements are located on the neighbouring island of Unst to the north of the island of Uyea.

Livestock
All livestock observations were made from the boat as access to shoreline was not possible. Sheep were observed grazing along the southern shoreline

of the island of Uyea on the day of the shoreline survey. Some of the livestock appeared to be fenced off from the shoreline whilst others roamed free.

Seasonal Population
There are no hotels or B&B's on the island of Uyea. The neighbouring island of Unst is popular with wildlife enthusiasts and walkers so there is likely to be holiday accommodation available there.

Boats/Shipping
No boats were observed during the shoreline survey. The closest ferry route from Belmont, Feltar to Hamarsness, Unst is located approximately 3 km to the south west of the fishery. There is a small pier on the northern shoreline of the island of Uyea.

Land Use
The land observed on Uyea appeared to mostly rough grassland.

Wildlife/Birds
During the shoreline survey approximately 100 shags were disturbed on the water close to the fishery and 3 gulls were observed on the mussel lines. A further 7 gulls were observed nesting on the shoreline west of the Winna Ness headland to the west of the fishery.

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.

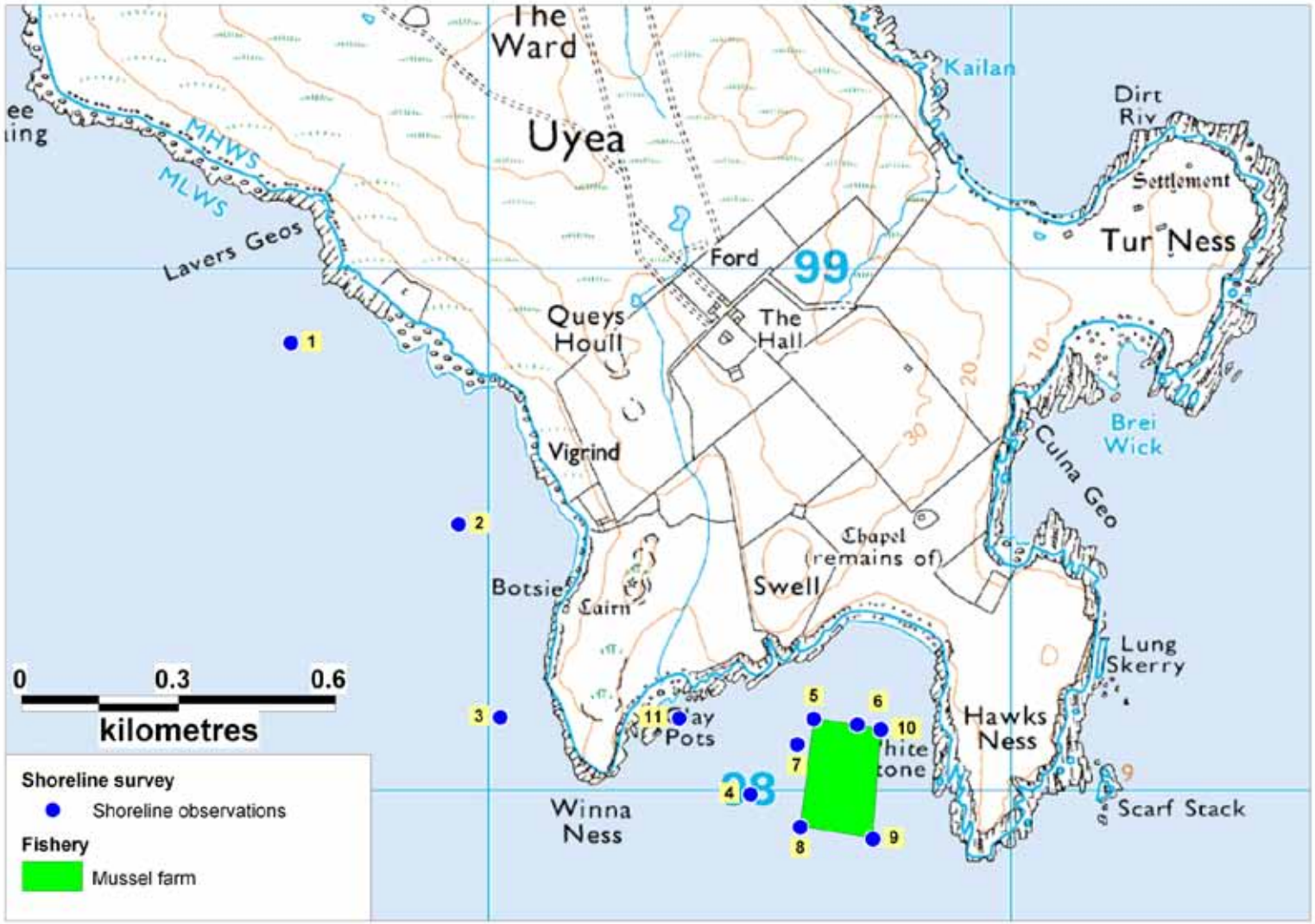

Figure 1. Shoreline Observations

Table 1 Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	18/10/2011	09:04	HU 59623 98859	459623	1198859	Figure 4		2 sheep on the shore. Abandoned farm buildings and house visible from boat.
2	18/10/2011	09:05	HU 59944 98512	459944	1198512			8 sheep in field with wall next to the shoreline
3	18/10/2011	09:06	HU 60024 98142	460024	1198142			7 gulls nesting on the shoreline
4	18/10/2011	09:08	HU 60503 97995	460503	1197995			Approx 100 shags disturbed near the mussel lines
5	18/10/2011	09:08	HU 60624 98139	460624	1198139	Figure 5		Corner of lines (South Uyea farm consists of 7 longlines, 200 m length, 5-8 m droppers
6	18/10/2011	09:11	HU 60707 98128	460707	1198128		SUSW1, SUMUSSEL1, SUMUSSEL 2	Location of seawater sample SUSW1 (09:11) and mussel samples SUMUSSEL1 (<1 m depth) and SUMUSSEL2 (5 m depth) Salinity profile 5 m 36.26 ppt/11C, 4 m 36.27 ppt/11C, 3 m 36.26 ppt/11C, 2 m 36.24 ppt/11C, 1 m 36.23 ppt/11.1C, <1 m 36.26 ppt/11.1C
7	18/10/2011	09:21	HU 60592 98090	460592	1198090	Figure 6		6 sheep on shore
8	18/10/2011	09:22	HU 60598 97932	460598	1197932		SUSW2, SUMUSSEL3, SUMUSSEL4	Corner of lines. Location of seawater sample SUSW2 (09:22) and mussel samples SUMUSSEL3 (<1 m depth) and SUMUSSEL4 (8 m depth)
9	18/10/2011	09:29	HU 60737 97909	460737	1197909	Figure 7		Corner of lines, 3 gulls on buoys
10	18/10/2011	09:30	HU 60752 98119	460752	1198119			Corner of lines
11	18/10/2011	09:34	HU 60366 98140	460366	1198140	Figure 8	SUSW3	Location of seawater sample SUSW3 (09:34), close to freshwater input shown on OS map, no visible flow at time of shoreline survey

Photographs referenced in the table can be found attached as Figures 4 – 8.

Sampling

Water and shellfish samples were collected at sites marked on the maps in Figures 2 and 3 respectively. Bacteriology results follow in Tables 2 and 3. Samples were transferred to a cool box with ice packs after sampling then delivered by hand on the same day to the SSQC laboratory at the NAFC Marine College in Scalloway. Samples were then processed the day after sampling.

Samples of seawater were tested for salinity by the laboratory using a salinity meter under controlled conditions. These results are shown in Table 2, given in units of grams salt per litre of water. Note that this is equivalent to ppt.

Table 2. Water sample *E. coli* results

No.	Sample Ref.	Date	Position	Type	*E. coli* (cfu/100 ml)	Salinity (g/L)
1	SUSW1	18/10/2011	HU 60707 98128	Seawater	1	35.21
2	SUSW2	18/10/2011	HU 60598 97932	Seawater	<1	35.24
3	SUSW3	18/10/2011	HU 60366 98140	Seawater	<1	35.31

Table 3. Shellfish sample *E. coli* results

No.	Sample Ref.	Date	Position	Species	Depth (m)	*E. coli* MPN/100 g
1	SUMUSSEL1	18/10/2011	HU 60707 98128	Common mussels	<1 (Surface)	50
2	SUMUSSEL2	18/10/2011	HU 60707 98128	Common mussels	5	<20
3	SUMUSSEL3	18/10/2011	HU 60598 97932	Common mussels	<1 (Surface)	<20
4	SUMUSSEL4	18/10/2011	HU 60598 97932	Common mussels	8	<20

Table 4. Salinity profiles

Profile	Date	Time	Position	Depth (m)	Salinity (ppt)	Temperature ˚C
1	18/10/2011	09:11	HU 60707 98128	Surface	36.26	11.1
				1	36.23	11.1
				2	36.24	11.1
				3	36.26	11.1
				4	36.27	11
				5	36.26	11

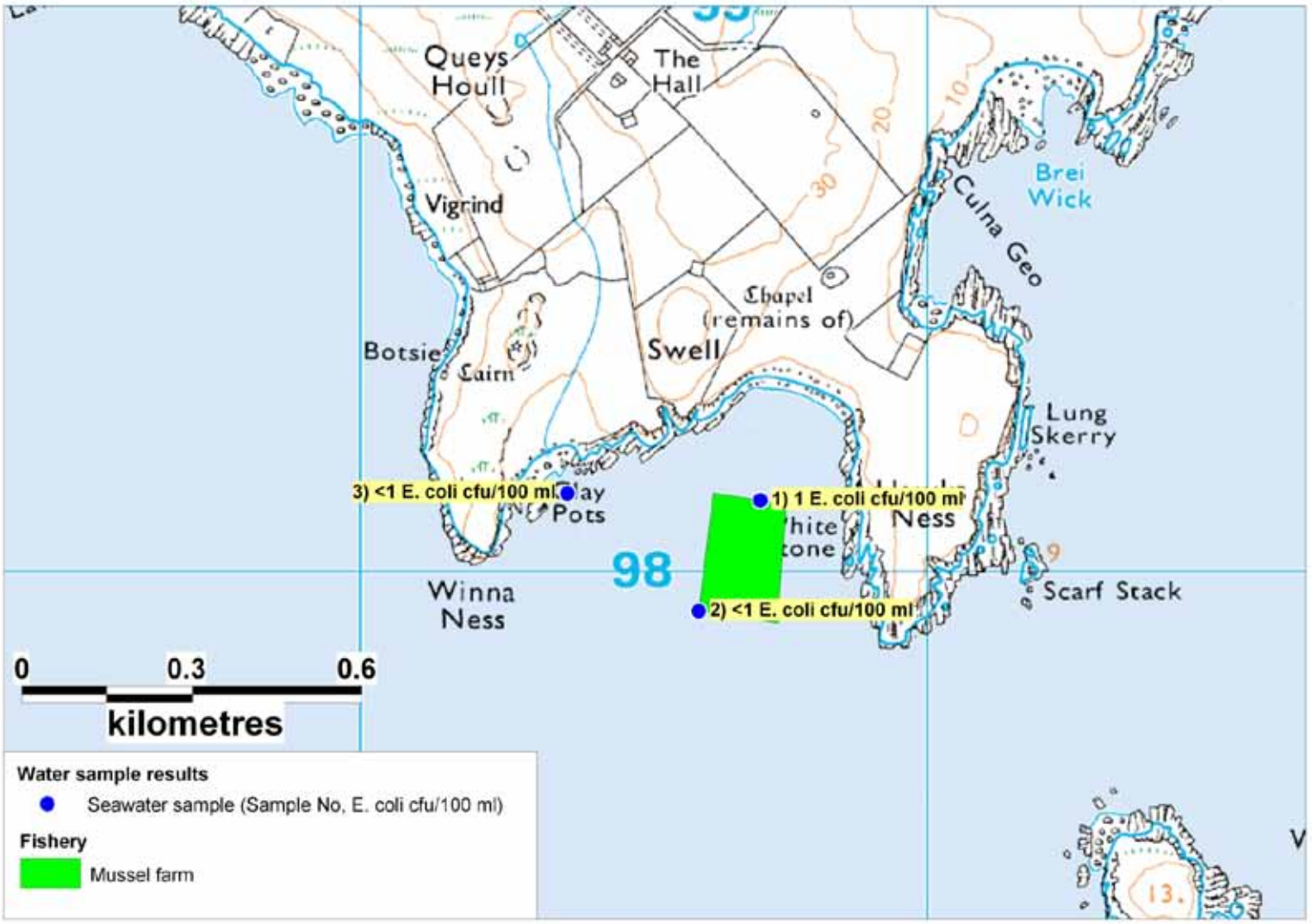

Figure 2. Water sample results

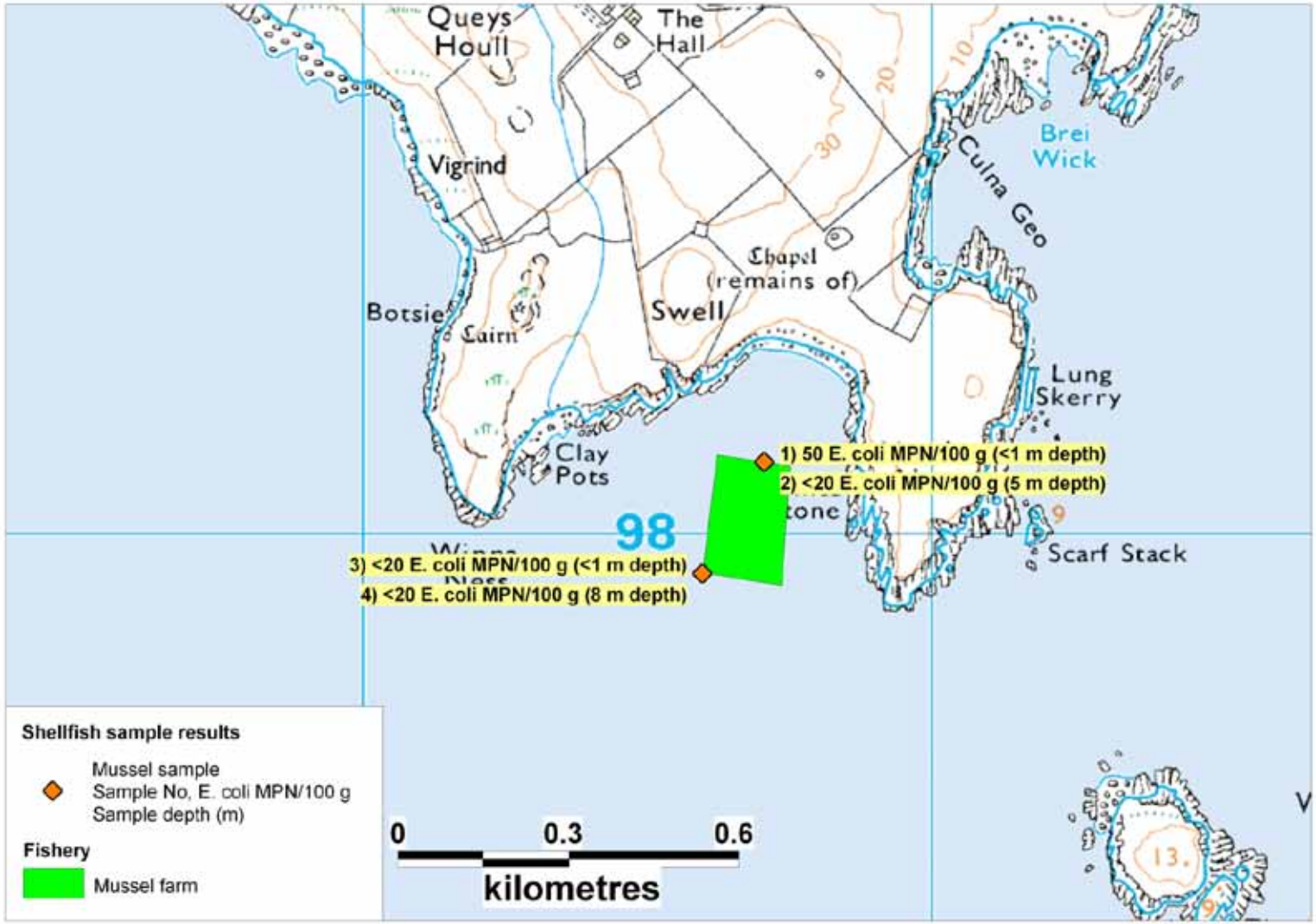

Figure 3. Shellfish sample results

Photographs

Figure 4. Abandoned farm buildings and house visible from boat

Figure 5. South Uyea mussel farm

Figure 6. Sheep on the island of Uyea shoreline

Figure 7. 3 gulls on mussel buoys

Figure 8. Location of seawater sample SUSW3