Scottish Sanitary Survey Report

Sanitary Survey Report
North Uyea
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Partner Organisations

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

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I. Executive Summary

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

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

The North Uyea production area is situated on the northeastern side of the island of Uyea which itself is located off the southern coastline of the island of Unst in Shetland. A sanitary survey was undertaken for North Uyea on the basis of a risk ranking of those production areas that had not yet received a sanitary survey.

The fishery comprises a mussel farm of eight double-headed longlines with 6 m droppers. Harvesting is undertaken from August to May inclusive.

The main sources of human faecal contamination are community and private discharges located around the bay at the northern end of Uyea Sound, to the northwest of the mussel farm. There is boating activity in the area, including an anchorage in the immediate vicinity of the mussel farm, and this may constitute an additional source of human contamination. Other inputs in the vicinity of the farm are sheep on the island of Uyea, seabirds and ducks, and seals. The latter have been observed hauled out on the pier south of the mussel farm.

The main tidal currents flow east to west over most of the tidal cycle with flows in the opposite direction only occurring around low water. Except within the bay at the head of Uyea Sound, the currents are expected to follow the topography of the shoreline. It is therefore expected that contamination arising at the head of Uyea Sound will only impact on the mussel farm after travelling south on the currents and then returning around low tide. That contamination is expected to be well mixed. Any spatial differences are therefore expected to arise from sources on the island of Uyea, more local to the mussel farm.

It is recommended that the production area be expanded slightly at its northwestern extent in order to fully encompass the extent of the mussel farm lease area. It is also

recommended that the RMP be relocated towards the southeastern extent of the mussel farm in order to better reflect the local sources of contamination on the island of Uyea.

II. Sampling Plan

Production Area	North Uyea
Site Name	North
SIN	SI-230-453-08
Species	Common mussels
Type of Fishery	Long-line
NGR of RMP	HU 6025 9983
East	460250
North	1199830
Tolerance (m)	40
Depth (m)	1-3
Method of Sampling	Hand
Frequency of Sampling	Monthly
Local Authority	Shetland Islands Council
Authorised Sampler(s)	Sean Williamson Marion Anderson Gwen Williamson Vicki Smith
Production area	The area bounded by lines drawn from HP 5993 000 to HP 6000 0020 to HP 6090 0000 to HU 6136 9926 extending to MHWS

III. Report

1. General Description

The North Uyea production area is in the Shetland Isles, in a strait separating Unst, the most northerly inhabited island in the group, from the smaller island of Uyea.

The strait is comprised of two bodies of water. Skuda Sound, in which the production area lies, is on the northeastern side of Uyea. Uyea Sound lies to the west and northwest of Uyea.. Skuda Sound has a NW-SE orientation while Uyea Sound has a NE-SW orientation. The strait has an overall length of approximately 4 km and is approximately 500 m wide at its narrowest, expanding to approximately 1.3 km at the mouth of Skuda Sound. The depth ranges from 5.6 m to 16.2 m.

There are two small population centres, on the Unst coastline north of Uyea: these are Uyeasound and Clivocast. The island of Uyea is uninhabited.

A sanitary survey was undertaken on the classified fishery at North Uyea on the basis recommended in the European Union Reference Laboratory publication: “Microbiological Monitoring of Bivalve Mollusc Harvesting Area Guide to Good Practice: Technical Application”. This production area was selected for survey based on a risk-based ranking of the area amongst those in Scotland that had yet to receive sanitary surveys.

Figure 1.1 Location of North Uyea

2. Fishery

North Uyea is a common mussel (*Mytilus edulis*) fishery, comprised of a single mussel farm. Information on the site given in the 2014-2015 classification listing is presented in Table 2.1.

Table 2.1 North Uyea shellfish farm

Production area	Site	SIN	Species
North Uyea	North	SI-230-453-08	Common Mussels

The shoreline survey identified that the site is licenced for eight 220m twin-headline longlines. At the time of the survey, the farm did consist of eight 220m double headed longlines: these had 6 m droppers. Harvesting is conducted from August to May inclusive.

The production area is currently defined as the area bounded by lines drawn between HP 5993 000 and HP 6090 0000 and from HP 6090 0000 to HU 6136 9926. The RMP is located at HU 6011 9997. The northwestern extent of the mussel lines, as recorded during the shoreline survey, appears on the map to lie just outside the northern production area boundary. However, the discrepancy, of less than 10 m, is likely to be within the error of the GPS used for recording the mussel farm position. However, the northwestern extent of the lease area extends significantly beyond the production area boundary.

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

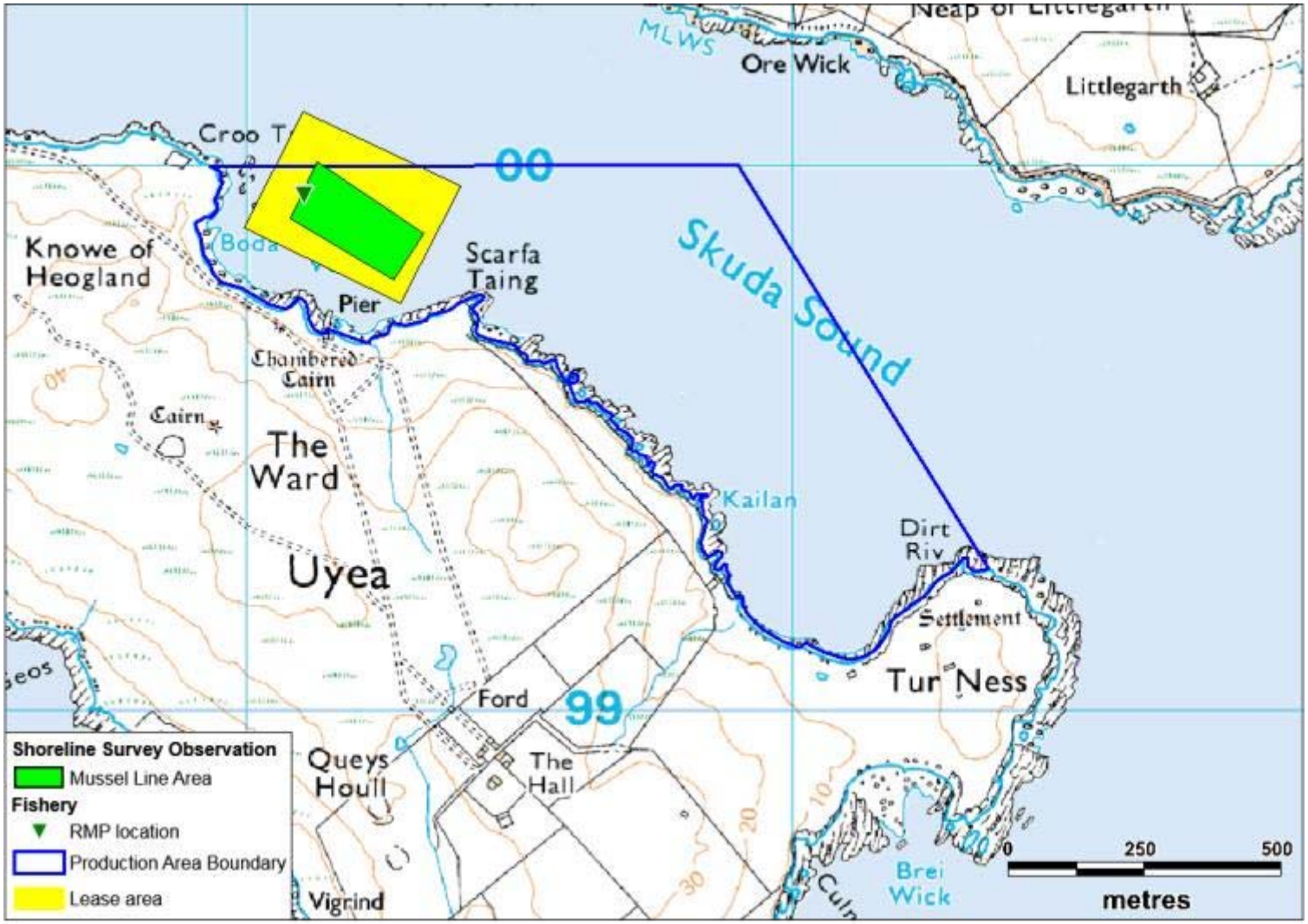


Figure 2.1 North Uyea Fishery

3. Human Population

Information was obtained on the population within the vicinity of the North Uyea production area from the General Register Office for Scotland. The last census was undertaken in 2011. The census output areas immediately surrounding the shellfish farm at North Uyea are shown in Figure 3.1 thematically mapped by the 2011 population densities. The population density is low < 3 people per km^2 within the output areas bordering the fishery. The census output areas vary in size and population within them will not be evenly distributed.

Table 3.1 Census output area and population – North Uyea

Census Output Area ID	Population	Area (km^2)	Population density (people/ km^2)
S00057232	88	32	2.78
S00059492	79	28	2.83

The two settlements of Clivocast and Uyeasound are located on the southern shoreline of Unst. A small number of dwellings are also located along the road between these. The island of Uyea, immediately south of the mussel farm, is uninhabited and only accessible by boat.

A youth hostel and campsite is located on the western coastline of Uyea Sound. In Clivocast there is a bed and breakfast and one self-catering unit. There are several B&B and self-catering holiday properties in the surrounding area.

There is a pier on Uyea adjacent to the mussel farm. There are also two piers on the eastern shoreline of the bay at the northern end of Uyea Sound, one near Cockle Point and one near Cliva Skerries, and a small harbour is located on the western shoreline of that bay. There is one anchorage within that bay and a second anchorage north of the pier on the island of Uyea, adjacent to the mussel farm (Clyde Cruising Club, 2005). Three workboats, a voe boat, two rigid inflatable boats (RIBs) and two pleasure yachts were observed at the pier north of Cockle Point during the shoreline survey. Two boats were also observed moored at the harbour on the western shoreline. A workboat was observed on site at one of the salmon farms in Uyea Sound.

Overall, the local population in the area is low and is mainly concentrated in the small communities of Uyeasound and Clivocast.

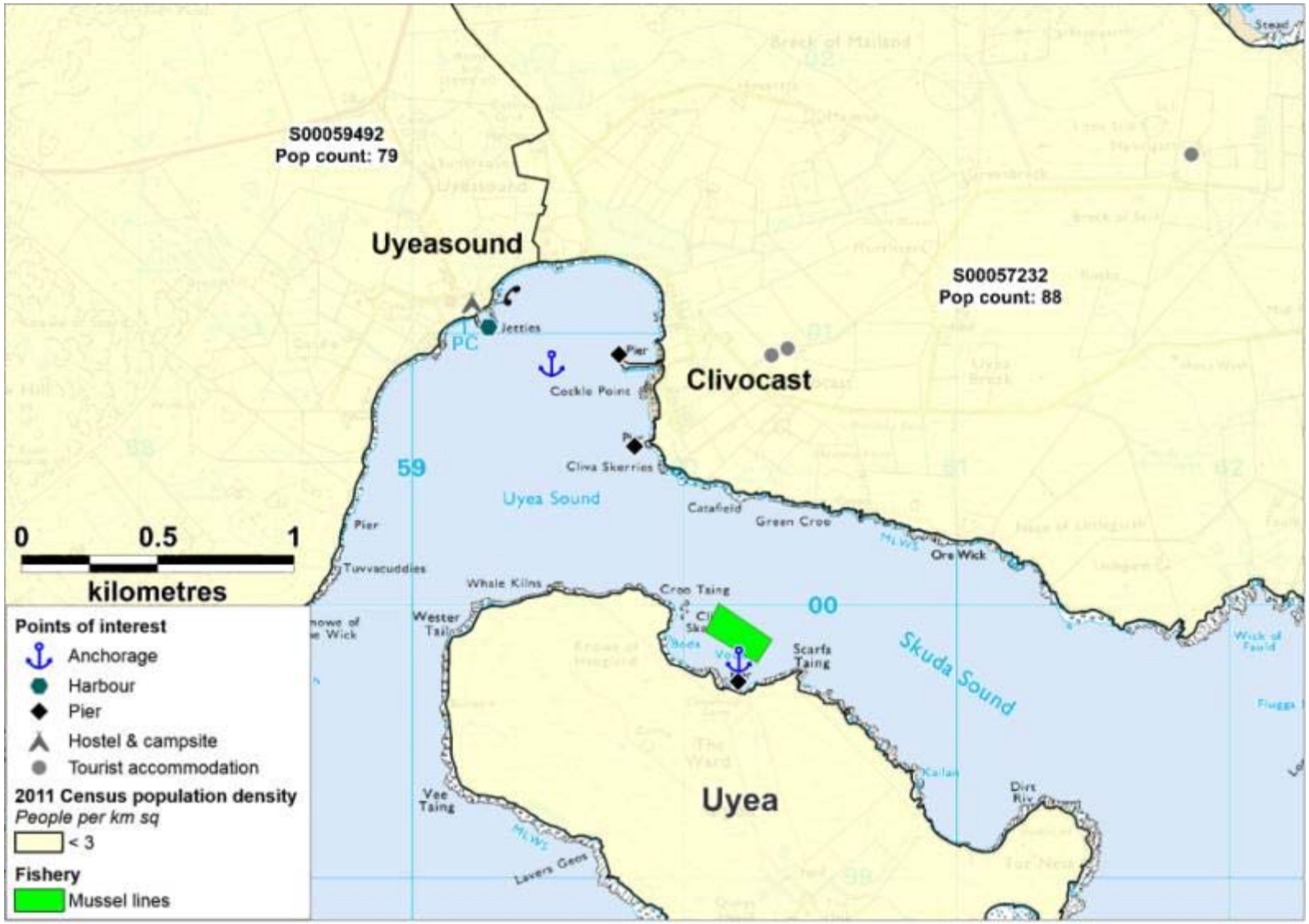


Figure 3.1 Population map for the area around North Uyea

4. Sewage Discharges

Information on sewage discharges within an area 4 km around the point HU 6011 9997 (the North Uyea RMP) was sought from Scottish Water and the Scottish Environment Protection Agency (SEPA). Data requested included the name, location, type, size (in either flow or population equivalent), level of treatment, sanitary or bacteriological data, spill frequency, discharge destination (to land, watercourse or sea), any available dispersion or dilution modelling studies, and whether improvements were in work or planned. No information was provided on sanitary or bacteriological content, any available dispersion or dilution modelling studies or whether any improvements were in work or planned. Information on spill frequency was not relevant as no intermittent discharges were identified.

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

Consents for discharges located in more open water, west of British Grid Easting 458000 (the western end of Uyea Sound), has not been included in the assessment. Additional consents related to abstraction and impoundment by fish farms, and hatcheries, were deemed unlikely to contribute to faecal contamination in the area and were also excluded from assessment. The full set of discharge information reported by SEPA is given in Appendix 6.

4.1 Community Discharges

Scottish Water and SEPA both provided information about one community discharge within the assessment area. A summary of the SEPA information is given in Table 4.1 below.

4.1 Community Discharge

Licence No.	Discharge Location	Discharge Name	Discharge Type	Receiving Body	Design PE
CAR/L/1004026	HP 59872 00853	Uyeasound septic tank, East Road, Uyeasound	Primary FE	Uyea Sound	250

FE=Final Effluent, PE=Population Equivalent

The locations given by Scottish Water and SEPA for the community septic tank differed slightly, but the location given by SEPA was given to a greater level of accuracy (1 m instead of 100 m) and is that shown in Figure 4.1.

4.2 Consented Private Discharges - SEPA

SEPA provided information on 18 private sewage discharge consents. The associated discharges were mainly located around the shoreline at the village of Uyeasound at the head of Uyea Sound. A summary of the consents is listed in Table 4.2 and the locations are shown in Figure 4.1.

Table 4.2 Consented private discharges

Licence Number	National Grid Reference	Discharge Type	Discharging to	PE
CAR/R/1016089	HP 58908 01753	Sewage (Private) Primary	Land	6
CAR/R/1047362	HP 62950 00679	Sewage (Private) Primary	Soakaway	5
CAR/R/1047371	HP 62980 00710	Sewage (Private) Primary	Soakaway	5
CAR/R/1047372	HP 58840 01100	Sewage (Private) Primary	Soakaway	5
CAR/R/1047435	HP 60227 01850	Sewage (Private) Primary	Soakaway	5
CAR/R/1057768	HP 58750 00990	Sewage (Private) Primary	Soakaway	5
CAR/R/1057783	HP 62980 01300	Sewage (Private) Primary	Soakaway	5
CAR/R/1057845	HP 58770 00630	Sewage (Private) Primary	Soakaway	5
CAR/R/1057847	HP 58660 00770	Sewage (Private) Primary	Soakaway	5
CAR/R/1057899	HP 60513 01767	Sewage (Private) Primary	Soakaway	5
CAR/R/1059213	HP 59150 01230	Sewage (Private) Primary	Soakaway	5
CAR/R/1067217	HP 59810 01856	Sewage (Private) Primary	Soakaway	5
CAR/R/1067232	HP 58614 01843	Sewage (Private) Primary	Soakaway	5
CAR/R/1067314	HP 60270 00630	Sewage (Private) Primary	Land	6
CAR/R/1069757	HP 63047 01049	Sewage (Private) Primary	Soakaway	5
CAR/R/1078688	HP 59160 01210	Sewage (Private) Primary	Soakaway	15
CAR/R/1082617	HP 59480 01380	Sewage (Private) Primary	Soakaway	5
CAR/R/1105195	HP 60310 00860	Sewage (Private) Primary	Land	6

All of the septic tanks were consented to soakaway or land. The effectiveness of soakaway systems depends on location and maintenance, and SEPA have identified previously that in remote areas, consents originally registered as discharging to land may be diverted to sea or watercourses upon failure of the soakaway fields.

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

SEPA provided information of nine marine cage fish farms (MCFF) within the assessment area. Working facilities on these may include toilets and sewage treatment facilities, but no information of any were given.

Shoreline Survey Discharge Observations

Twelve observations of sewage discharges or infrastructure were observed during the shoreline survey. These are shown in Table 4.3.

Table 4.3 Discharge-associated observations made during the shoreline survey

No.	Date	NGR	*E. coli* (cfu/100ml)	Description
1	20/11/2014	HP 59053 00925		Pipe across beach into sea, end not visible underwater, below 1 dwelling house above beach.
2	20/11/2014	HP 59076 00947		Ceramic pipe onto pebbled beach, no outflow noted.
3	20/11/2014	HP 59084 00954		Concrete pipe on beach below 1 dwelling house and 1 derelict house. No discharge from pipe.
4	20/11/2014	HP 59097 00989		1 dwelling house above beach. Piped outlet on beach, end of pipe visible, no outflow.
5	20/11/2014	HP 59176 01065	5	Public toilets on upper side of road. Associated septic tank and outlet pipe to sea identified. Additional sea water sample taken near outlet pipe.
6	20/11/2014	HP 59530 01267		Community Hall and 2 dwelling houses above road. Pipe to sea below road, no outflow to sea.
7	20/11/2014	HP 59630 01284		2 dwelling houses on upper side of road. Piped outlet to sea, no discharge. Pebbled/Sandy beach.
8	20/11/2014	HP 59906 01184		Possible sewage pipe draining to sea, end of pipe not visible. Pebbled/sandy beach. Photo taken. Empty Polar Cirkel salmon cages moored just off beach.
9	20/11/2014	HP 59927 01042		1 dwelling house on upper side of road. Redundant outlet pipe onto beach.
10	20/11/2014	HP 59940 01010		Septic tank pipe observation cover recorded below old school building. 2 outlet pipes onto beach with ends visable, neither in use. 2 photos taken.
11	20/11/2014	HP 59886 00749	41	Additional seawater sample collected from near where community discharge outlet pipe enters sea. Photos taken.
12	20/11/2014	HP 59923 00758		Community Discharge - Uyeasound STW. Photos taken.

Observation five reports a public toilet block and its associated septic tank. No corresponding consent was received from either SEPA or Scottish Water. The Shetland Islands Council identifies that these toilets are administered and maintained by Gardiesfauld Youth Hostel (Shetland Island Council, 2014). A seawater sample taken from the outfall location returned a low result of 5 *E.coli* cfu/100ml.

Observation eleven and twelve relate to the Uyeasound community septic tank (CAR/L/1004026). Observation twelve is the septic tank location while observation eleven represents the outfall location. A seawater sample taken from here returned a relatively low result of 41 *E. coli* cfu/100ml.

Summary

The majority of sewage input to the area is associated with the settlement of Uyeasound, to the northwest of the fishery. Only one community discharge is present. With a consented PE of 250, it is the largest discharge in the area. This discharge does to the marine environment and is located approximately 400 m from the fishery. It will therefore present the greatest potential impact upon the fishery.

All private discharges reported by SEPA are given as discharging to land or soakaway. Those consented to discharge to soakaway are unlikely to have an impact

on water quality in the area if they have not been diverted to watercourses or the marine environment and if the soakaway is working properly.

Several pipes were observed going through the intertidal zone to the sea during the shoreline survey. These may be unconsented private discharges. A discharge associated with a set of public toilets was also observed: this is operated by the youth hostel and this its use may vary seasonally.

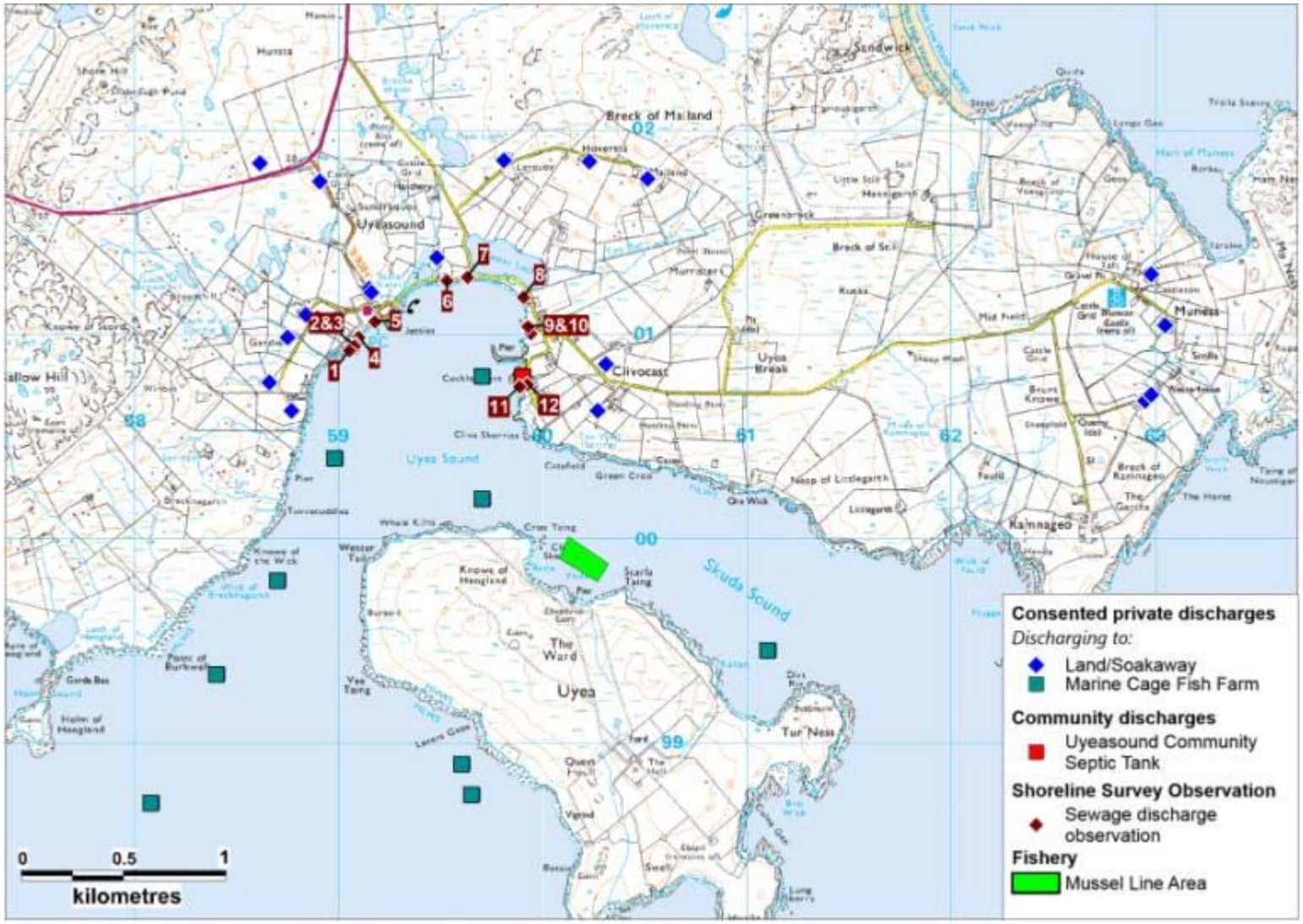


Figure 4.1 Discharges in the vicinity of North Uyea

5. Agriculture

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

Table 5.1 Livestock numbers in the Unst agricultural parish

	Unst (123 km^2)	
	Holdings	Numbers
Pigs	*	*
Poultry	15	179
Cattle	11	286
Sheep	94	23920
Horses used in Agriculture	0	-
Other horses and ponies	26	237

* data withheld

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

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

The majority of the land observed around the production area was rough grazing. During the shoreline survey. In total approximately 55 sheep were observed along the north coast of Uyea adjacent to the mussel farm, all with access to the shoreline. Sheep faeces and approximately 29 sheep in total were observed on the southern shoreline of Unst. Pony prints and faeces were also observed along the same stretch of shoreline, although

no ponies were observed at the time of the shoreline survey. No other livestock were observed during the shoreline survey.

A field cut for silage was recorded near the shoreline to the south of Clivocast.

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

Numbers of sheep are expected to be approximately double during the spring and summer months when lambs are present. Any contributions of faecal contamination from livestock are expected to be low but principally associated with animals located on the northeast side of Uyea, with the greatest potential impact on the mussel lines closest to the shoreline.

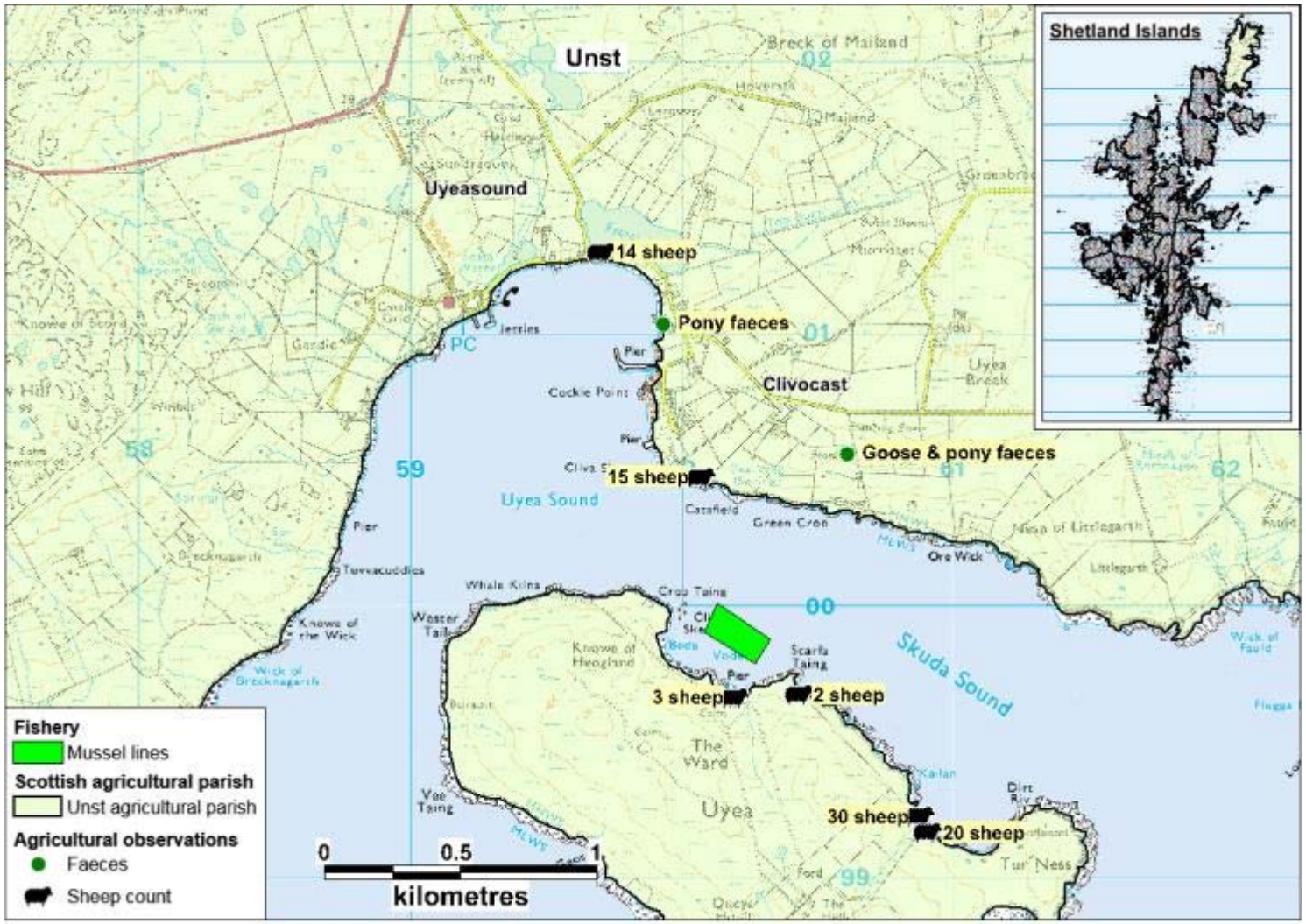


Figure 5.1 Livestock observations at North Uyea

6. Wildlife

Wildlife species present in and around the production area will contribute to background levels of faecal contamination at the fishery, and large concentrations of animals may constitute significant sources when they are present. Seals (pinnipeds), whales (cetaceans) and some seabirds may deposit faecal wastes directly into the sea, whilst birds and mammals present on land will contribute a proportion of any faecal indicator loading carried in diffuse runoff or watercourses.

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

Pinnipeds

The Special Committee on Seals report (Special Committee on Seals, 2013) did not identify any harbour or grey seals within the North Uyea area during surveys undertaken in August between 2007 and 2011. There were reports of both species in Basta Voe, which lies more than 5 km southwest of North Uyea. The Marine and Spatial Plan for Shetland identified that areas containing suitable harbour seal habitat lay to the south and southeast of Uyea Island. The report also identified that a large amount grey seal habitat was situated to the south of Uyea Island.

Three seals were observed at Uyea Island during the shoreline survey. Two were hauled out by the pier and the third was in the water.

Cetaceans

Two bottle-nosed dolphins were noted in Uyea Sound in 1998 (Nature in Shetland, 1998). There were also reportedly five white-sided dolphins in Uyea Sound in 2002 (Nature in Shetland, 2002). No cetaceans were noted in waters around North Uyea during the shoreline survey.

Birds

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

Table 6.1 Seabird counts within 5 km of the North Uyea

Common name	Species name	Count*	Qualifier	Accuracy
Black Guillemot	*Cepphus grylle*	111	Individuals on land	Accurate
Arctic Skua	*Stercorarius parasiticus*	10	Occupied territory	Accurate
Great Skua	*Stercorarius skua*	30	Occupied territory	Accurate
European Storm-petrel	*Hydrobates pelagicus*	10	Occupied sites	Estimate
Common Gull	*Larus canus*	2	Occupied territory	Accurate
Great Black-Backed Gull	*Larus marinus*	70	Individuals on land, occupied nests and territory	Accurate
Arctic Tern	*Sterna paradisaea*	399	Individuals on land and occupied nests	Accurate
Kittiwake	*Rissa tridactyla*	350	Occupied nests	One accurate, one unknown

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

The JNCC dataset indicates that there large numbers of Arctic terns and a large breeding colony of kittiwakes on Uyea Island. Arctic terns are only resident in the area during summer months from May to August, when they come to the area to breed before migrating back to the Antarctic. Other species were present in much smaller numbers, with black guillemots and great black-backed gulls most common. These other species were mostly noted on the Unst mainland, north of the fishery.

The Marine and Spatial Plan for Shetland (NAFC Marine Centre, 2012) indicates that there is an area of Arctic tern habitat in Skuda Sound and over parts of Uyea. It also identifies that eider habitat is located over the south of Uyea Island. Extensive areas of habitat for seabirds, eiders, other ducks and black guillemot are located to the west of Uyea.

Birds were the most common wildlife observed during the shoreline survey. Species included; common gulls which were observed most frequently, ravens, fulmar, crows, snipe, greylag geese, ducks and swans. Bird faeces were noted on buoys to the east of the fishery, with 23 common gulls also noted along the northern side of the fishery.

Otters

The Eurasian otter (*Lutra lutra*) is common in Shetland, which holds approximately 12% of the UK population (Shetland Otters, 2014). The Marine and Spatial Plan for Shetland identified that there was suitable otter habitat located within 5 km to the southwest around the island of Linga. No otters were observed during the shoreline survey.

Overall

The main wildlife species expected to contribute to contamination levels at the North Uyea mussel lines are Arctic terns, gulls and ducks, including eiders. Inputs from Arctic terns are expected to be restricted to the breeding season from May to August. Localised impacts may arise from seals using the haulout area at the pier on Uyea..

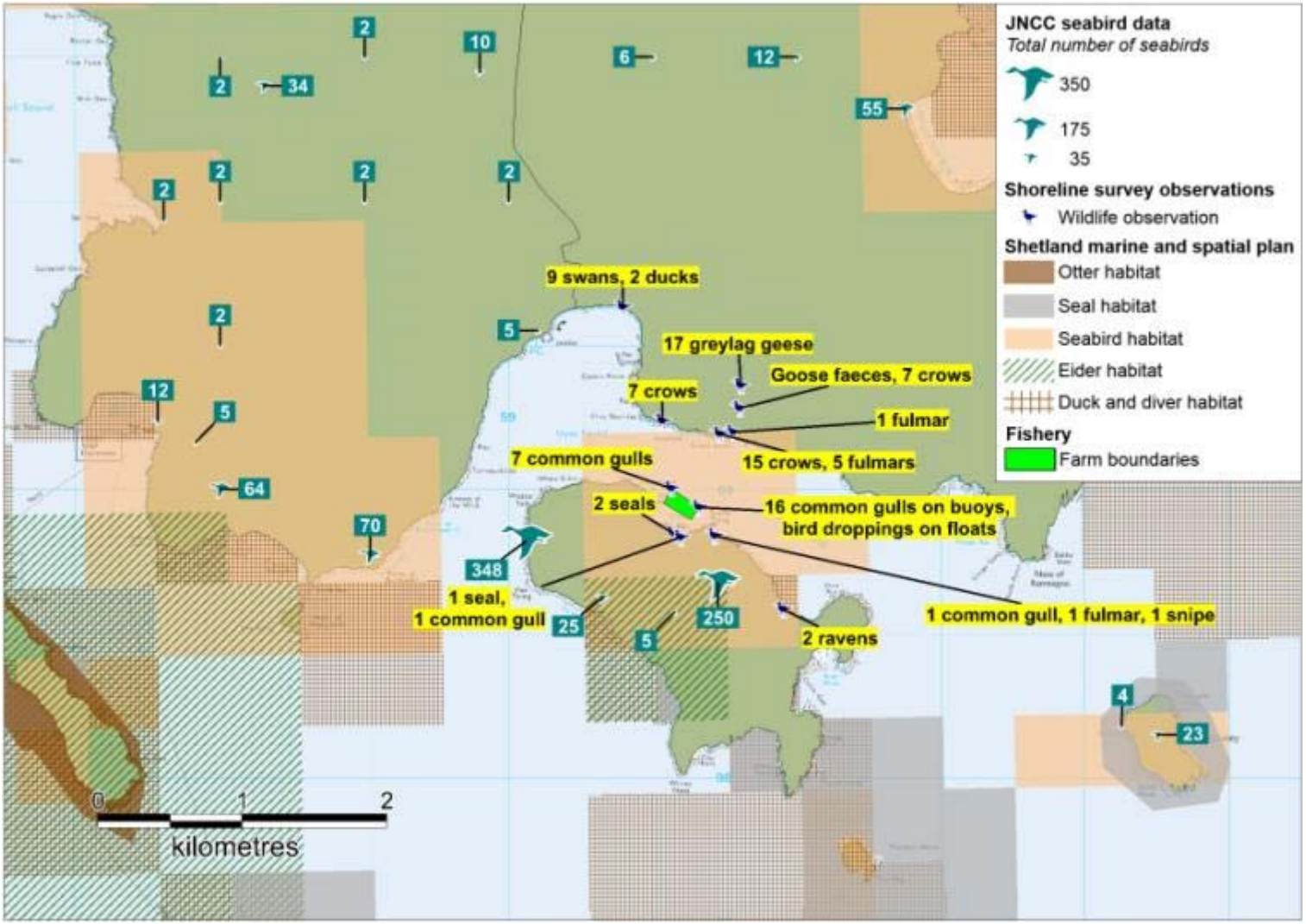


Figure 6.1 Map of wildlife around North Uyea

7. Land Cover

The Land Cover Map 2007 data for the area is shown in Figure 7.1. The predominant land cover type on the north coats of Uyea adjacent to the shellfish farm is dwarf shrub heath with some littoral sediment also shown in the embayment. Rough grassland with some areas of improved grassland predominates on the southern coast of Unst opposite the mussel farm. The majority of the land on the western side of Uyea Sound is composed of neutral grassland with areas of rough and improved grassland also present. A number of areas have been identified as built-up areas/gardens, including some around the settlement of Clivocast, one southwest of Uyeasound jetties, and three others to the north and west of Uyeasound. Some of these may be erroneously classified, as there are only very small areas of concentrated housing at Clivocast and Uyeasound.

Faecal indicator organism export coefficients for faecal coliform bacteria have been found to be approximately 1.2 – 2.8x10^{9} cfu km^{-2} hr^{-1} for urban catchment areas, 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., 2008a). 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., 2008a).

The potential contribution from contaminated run-off in the area of the mussel farm is therefore low to moderate. Any impact is likely to be greatest on long lines situated closest to this shoreline. This contribution would be expected to increase after rainfall events.

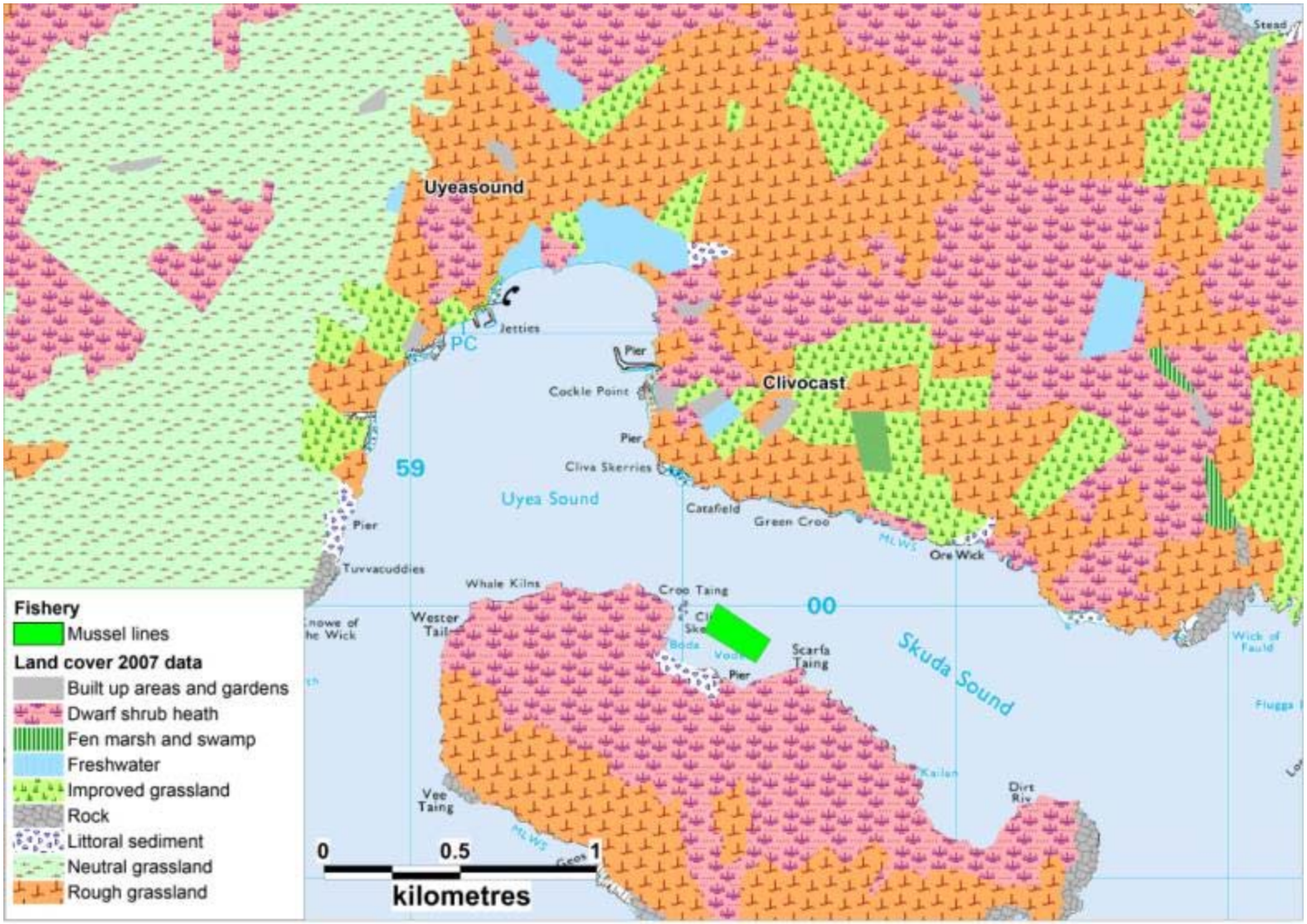


Figure 7.1 LCM2007 land cover data for the area around North Uyea

8. Watercourses

There are no gauging stations on watercourses entering North Uyea.

Spot measurements of flow and microbial content were obtained during the shoreline survey conducted on the 20th November 2014. The weather was mainly dry over the two days prior to the survey and was dry on the day of the survey. The watercourses listed in Table 8.1 are those recorded during the shoreline survey. In addition, four areas of land drainage were observed on the southern coastline north of Unst and three areas of land drainage were observed on the northern coastline of Uyea, two of which were adjacent to the fishery. The locations and loadings of measured watercourses are shown in Figure 8.1.

Table 8.1 Watercourses entering North Uyea

No.	Eastings	Northings	Description	Width (m)	Depth (m)	Flow (m^3/d)	Loading (*E. coli* per day)
1	459011	1200929	Burn of Gardie	0.65	0.05	1466	2.3×10^8
2	459103	1201017	Watercourse	NA			Not determined*
3	459306	1201182	Culvert	2.80	0.04	3174	7.3×10^8
4	459700	1201302	Culvert	0.80	0.14	4713	6.1×10^8
5	459943	1199971	Watercourse	NA			Not determined*
6	460234	1199675	Watercourse	0.12	0.04	87	3.0×10^6
7	460903	1199169	Watercourse	0.10	0.10	167	1.2×10^7

*Not sampled, therefore loading not determined.

In total seven watercourses were recorded along the coastline surrounding the fishery. Not all of these were sampled and it was therefore only possible to calculate loadings for five of these watercourses (see Table 8.1). Three watercourses were observed on the northern shoreline of Uyea. Two watercourses were located in the embayment where the fishery is situated: one of these was stagnant and therefore not measured or sampled and the second had a low estimated *E. coli* loading of 3.0×10^6. A further four watercourses were observed along the south shoreline of Uyea, all more than 1 km from the mussel farm. Three of these had low estimated *E. coli* loadings ranging from 2.3×10^8 to 7.3×10^8 while the other had minimal flow and was not measured or sampled.

Overall, freshwater inputs would be expected to provide low levels of contamination to the production area at North Uyea, with the greatest impact expected from the watercourses that discharge adjacent to the shellfish farm on the northern coastline of Uyea. The loadings would be expected to be higher after rainfall.

Figure 8.1 Map of watercourse loadings at North Uyea

9. Meteorological Data

The nearest weather station for which a nearly complete rainfall data set was available is located at Baltasound, situated approximately 8 km to the north of the production area. Rainfall data was available for January 2008 – December 2013. The nearest wind station is Lerwick, 62 km to the south. Conditions may differ between this station and the mussel farm due to the distances between them. However, this data is still shown as it can be useful in identifying seasonal variation in wind patterns.

Data for these stations was purchased from the Meteorological Office. Unless otherwise identified, the content of this section (e.g. graphs) is based on further analysis of this data undertaken by Cefas. This section aims to describe the local rain and wind patterns in the context of the bacterial quality of shellfish at North 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 (Mallin, et al., 2001; Lee & Morgan, 2003). The box and whisker plots in Figures 9.1 and 9.2, present a summary of the distribution of individual daily rainfall values by year and by month. The grey box represents the middle 50% of the observations, with the median at the midline. The whiskers extend to the largest or smallest observations up to 1.5 times the box height above or below the box. Individual observations falling outside the box and whiskers are represented by the symbol *.

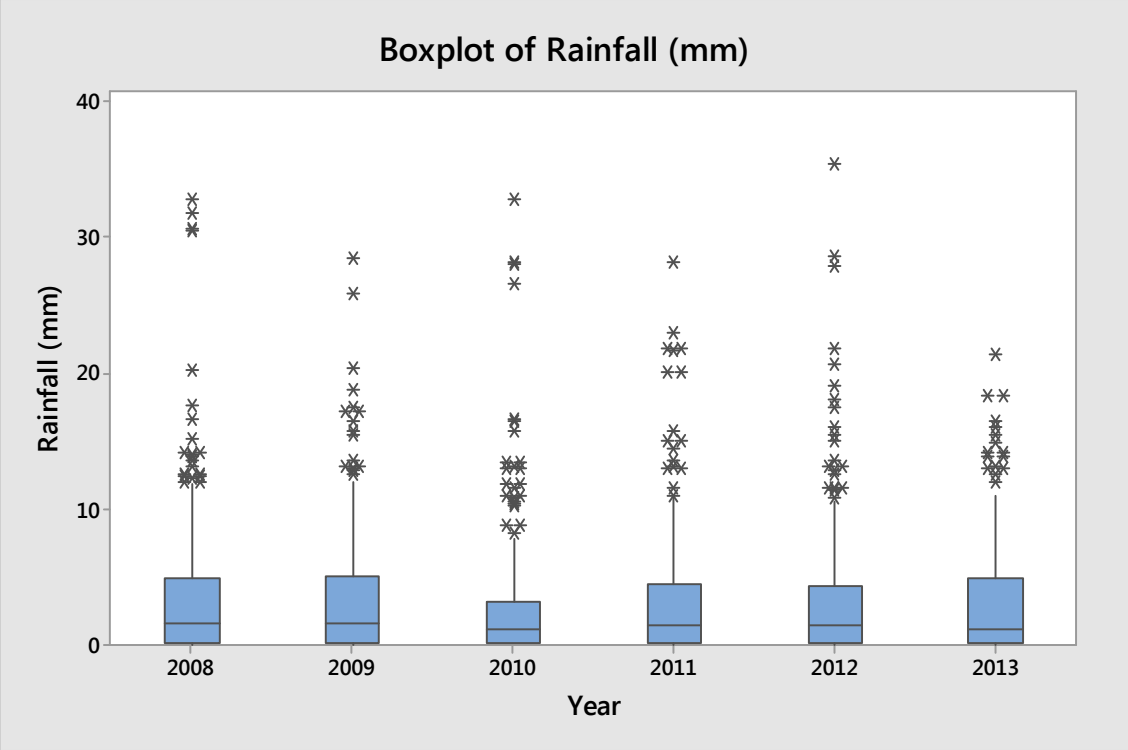


Figure 9.1 Box plot of daily rainfall values by year at Baltasound (2008 – 2013)

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

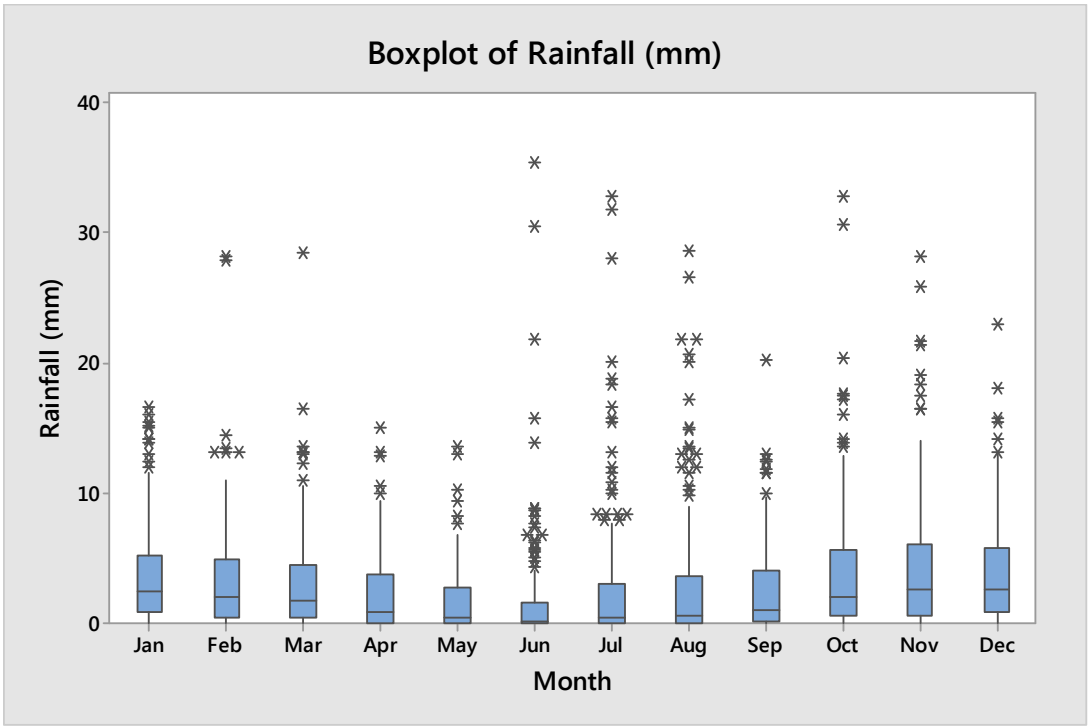


Figure 9.2 Box plot of daily rainfall values by month at Baltasound (2008 – 2013)

Daily rainfall values were higher during the autumn and winter. Total rainfall by month was greatest in November (745 mm) and least in April (304 mm). Rainfall

values exceeding 30 mm/d occurred in June, July and October. This needs to be taken into account when considering the annual and monthly rainfall figures (with 2010 and April apparently showing the lowest annual and monthly totals over the period considered here).

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

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

9.2 Wind

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

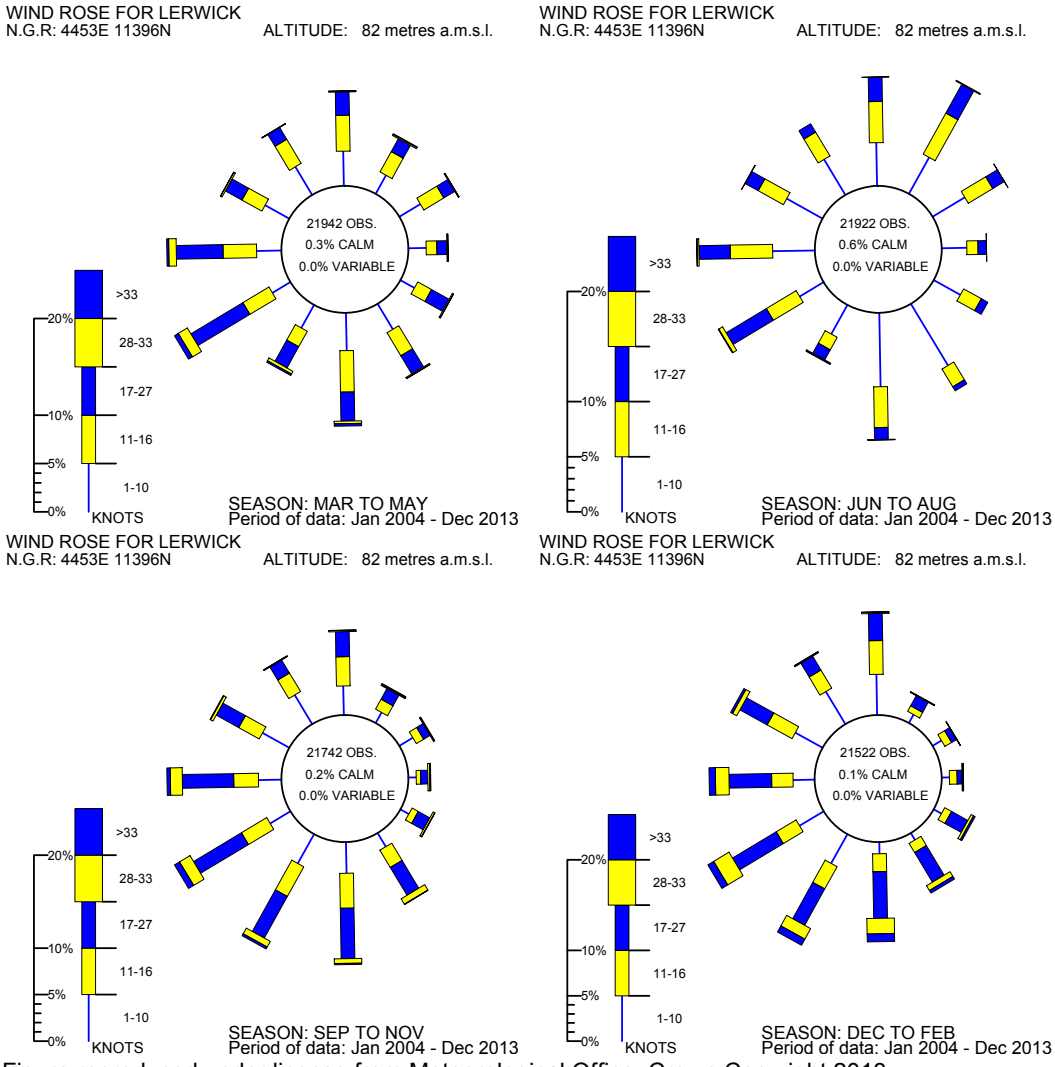


Figure 9.3 Seasonal wind roses for Lerwick

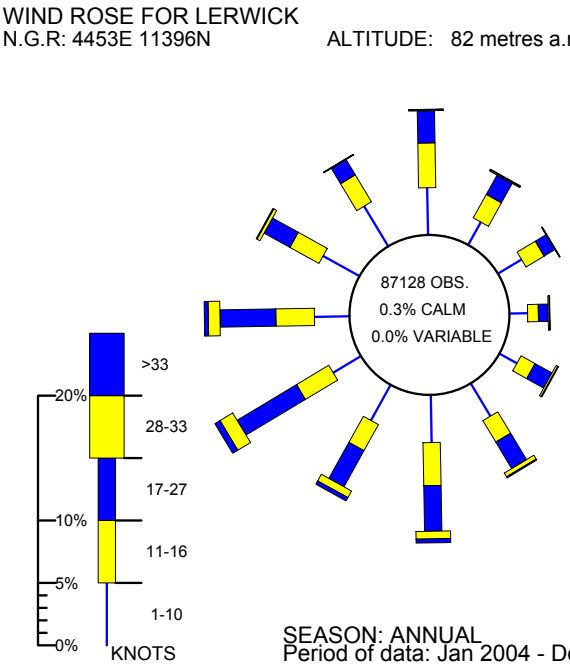


Figure 9.4 Annual wind rose for Lerwick

Overall the annual wind direction showed that wind was stronger when coming from the west than the east, and winds from the southerly direction were stronger than those from the north. The strongest winds tended to come to from the southwest quarter although winds from the north occurred relatively frequently. During the summer, winds were also often seen from the north-northeast. Winds were strongest during the winter and were weakest during the summer.

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

10. Classification Information

North Uyea has been classified for production of common mussels (*Mytilus edulis*) since 2003. The classification history since 2006 is listed in Table 10.1.

Table 10.1 North Uyea classification history

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

The North Uyea production area has been given a year-round A classification over the whole period.

11. Historical *E. coli* Data

11.1 Validation of historical data

Results for all samples assigned against North Uyea production area for the period 01/01/2009 to the 19/01/2015 were extracted from the FSAS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. The data was extracted on 19/01/2015. All *E. coli* results were reported as most probable number (MPN) per 100 g of shellfish flesh and intravalvular fluid.

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

One sample yielded an improbable MPN combination and was omitted from further analysis. The remaining 70 samples were all identified as valid, received at the laboratory within 48 hours of collection and had box temperatures of ≤8^{o}C. The OS grid square identifier was incorrectly reported for the first 20 samples (HP instead of HU). This was corrected and the locations then fell within the production area.

11.2 Summary of microbiological results

Sampling and results summaries for North Uyea are shown in Table 11.1.

Table 11.1 Summary of historical sampling and results

Sampling Summary	
Production area	North Uyea
Site	North
Species	Common mussels
SIN	SI-230-453-08
Location	Various
Total no of samples	70
No. 2009	9
No. 2010	12
No. 2011	12
No. 2012	12
No. 2013	12
No. 2014	1
Results Summary	
Minimum	<18
Maximum	1400
Median	20
Geometric mean	32
90 percentile	230
95 percentile	858
No. exceeding 230/100g	5 (7%)
No. exceeding 1000/100g	2 (3%)
No. exceeding 4600/100g	0
No. exceeding 18000/100g	0

The majority of results have been <230 *E. coli* MPN/100 g although two results exceeded 1000 *E. coli* MPN/100 g.

11.3 Overall geographical pattern of results

The reported geographical locations of all samples assigned to the North Uyea production area are shown in Figure 11.1. The symbol sizes are shown proportional to the magnitude of the *E. coli* results.

Samples taken up to mid-2012 were reported against one of two locations. The location for the earliest samples was reported to 100 m accuracy while that for samples reported from late 2010 to mid-2012 was reported to 10 m accuracy. These two locations plot to the southeast of the current mussel farm area. Since mid-2012, the reported sampling locations have tended to vary and the majority plot within approximately 50 m of the RMP. Of those later samples, the highest results have

been seen in the vicinity of the RMP. However, the highest results overall were associated with the earlier two reported sampling locations.

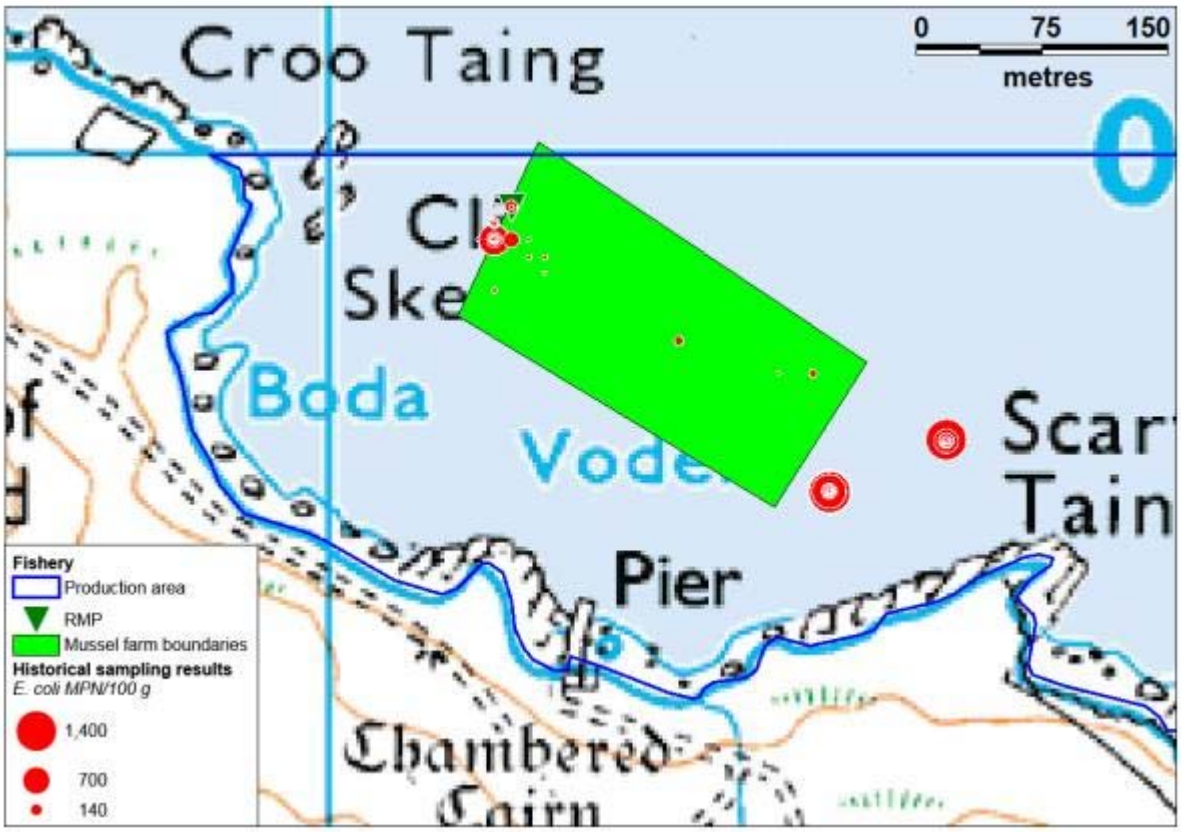


Figure 11.1 Map of reported sampling locations for common mussels at North Uyea

11.4 Overall temporal pattern of results

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

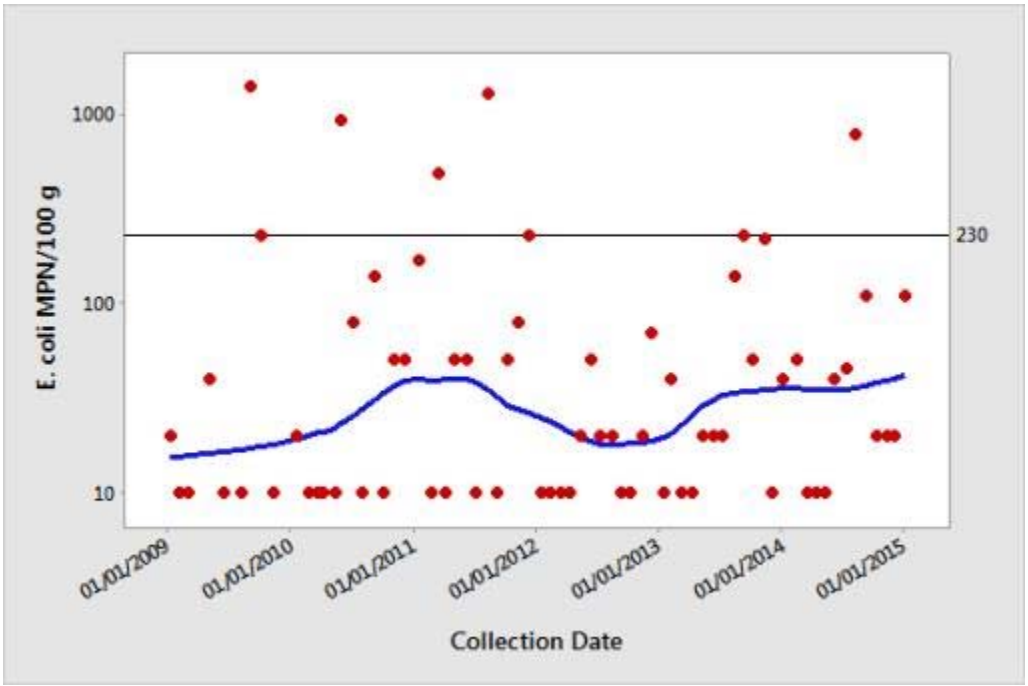


Figure 11.2 Scatterplot of *E. coli* results by collection date at North Uyea, fitted with a lowess line

E. coli levels have stayed generally low over the sampling period. Although there appears to be a small upward trend in average levels over the period, as represented by the trend line, a greater proportion of samples prior to mid-2011 yielded results >230 *E. coli* MPN/100 g than those taken since then.

11.5 Seasonal pattern of results

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

A greater proportion of low results were seen in spring and early summer than at other times of the year.

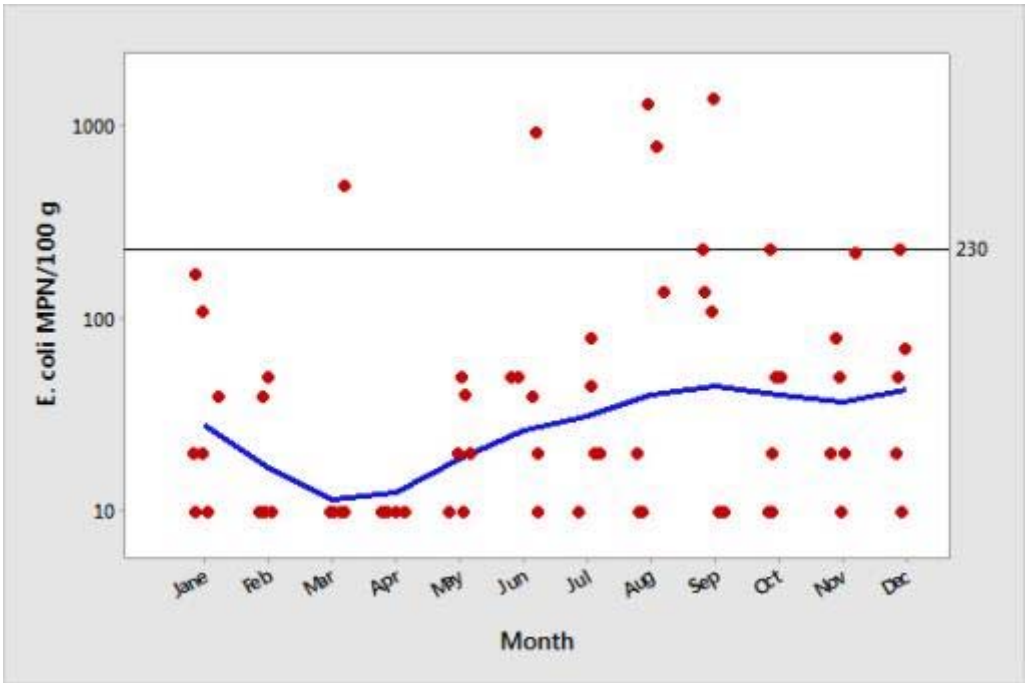


Figure 11.3 Scatterplot of *E. coli* results by month at North Uyea, fitted with a lowess line

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

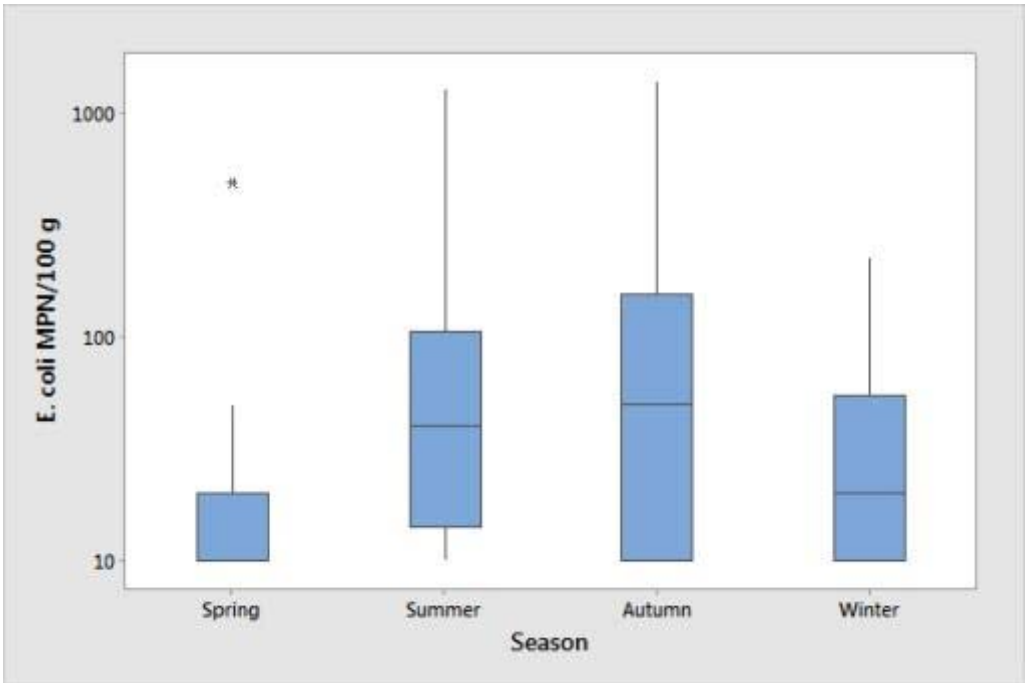


Figure 11.4 Boxplot of *E. coli* results by season at North Uyea

A significant difference was found between $\log_{10}$-transformed *E. coli* results for North Uyea by season (one-way ANOVA, p = 0.045) (Appendix 4). A post-ANOVA comparison of means undertaken using Tukey's method showed no significant difference between the four seasons but a comparison using Fisher's method

showed that the means for summer and autumn were significantly higher than those for spring.

11.5.1 Analysis of results against environmental factors

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

11.5.2 Analysis of results by recent rainfall

The nearest weather station with available rainfall data was at Baltasound approximately 8 km north of North Uyea. Rainfall data was purchased from the Meteorological Office for the period of 01/01/08 - 31/12/2013 (total daily rainfall in mm). Data was extracted from this for all sample results at North Uyea between 01/01/2009 – 31/12/2013.

Two-day rainfall

A scatterplot of *E. coli* results against total rainfall recorded on the two days prior to sampling for North Uyea is displayed in Figure 11.5. Rainfall data was available for 52 out of the 70 sample results and jittering was applied to points at 0.02 (x-axis) and 0.001 (y-axis) respectively.

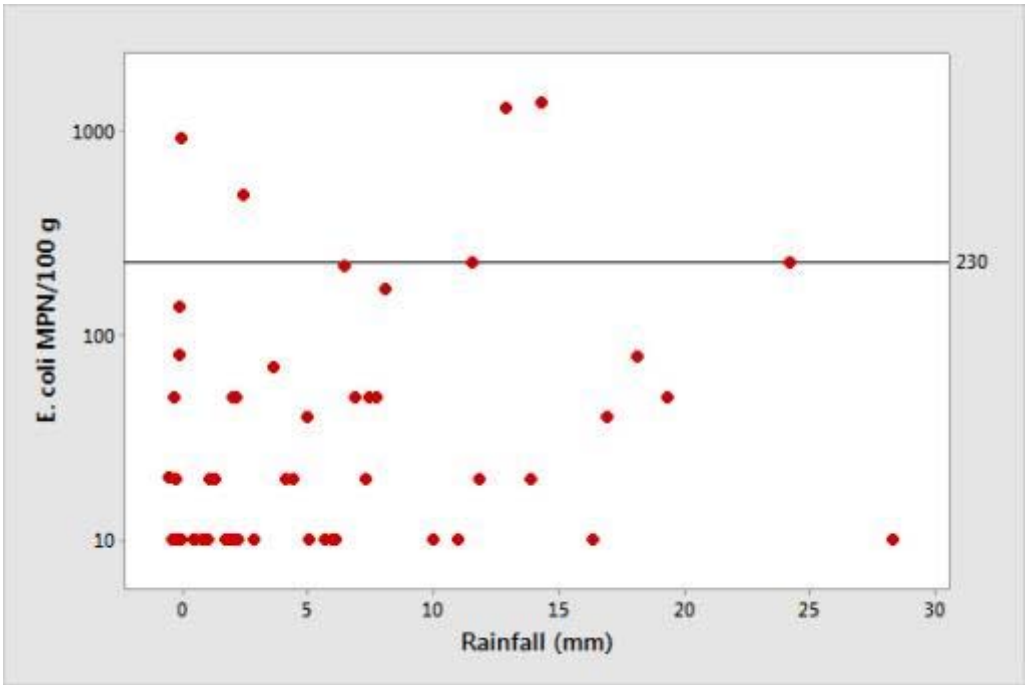


Figure 11.5 Scatterplot of *E. coli* results against rainfall in the previous two days at North Uyea

No significant correlation was found between *E. coli* results and the previous two day rainfall (Spearman's rank correlation r = 0.223, p = 0.112).

Seven-day rainfall

The effects of heavy rainfall may take differing amounts of time to be reflected in shellfish sample results in different system, the relationship between rainfall in the previous seven days and sample results was investigated in an identical manner to the above. A scatterplot of *E. coli* results against total rainfall recorded for the seven days prior to sampling at North Uyea is shown in Figure 11.6. Rainfall data was available for 50 out of the 70 sampling results. Jittering was applied to points at 0.02 (x-axis) and 0.001 (y-axis) respectively.

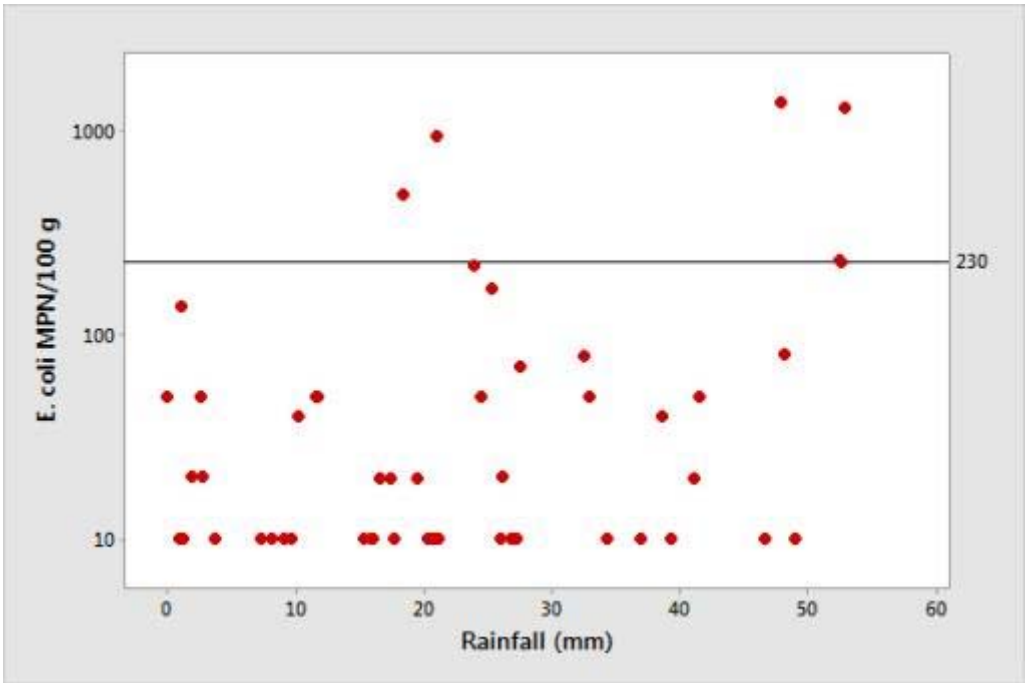


Figure 11.6 Scatterplot of *E. coli* results against rainfall in the previous seven days at North Uyea

No significant correlation was found between *E. coli* results and the previous seven day rainfall (Spearman's rank correlation r = 0.279, p = 0.050).

11.5.3 Analysis of results by tidal height

Spring/neap tidal cycle

Spring tides are large tides that occur fortnightly and are influenced by the state of the lunar cycle. They reach above the mean high water mark and therefore increase circulation and particle transport distances from potential contamination sources on the shoreline. The largest (spring) tides occur approximately two days after the full/new moon, at about 45º on a polar plot. The tides then decrease to the smallest (neap) tides, at about 225º, before increasing back to spring tides. A polar plot of *E. coli* results against the lunar cycle is shown for North Uyea in Figure 11.7. It

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

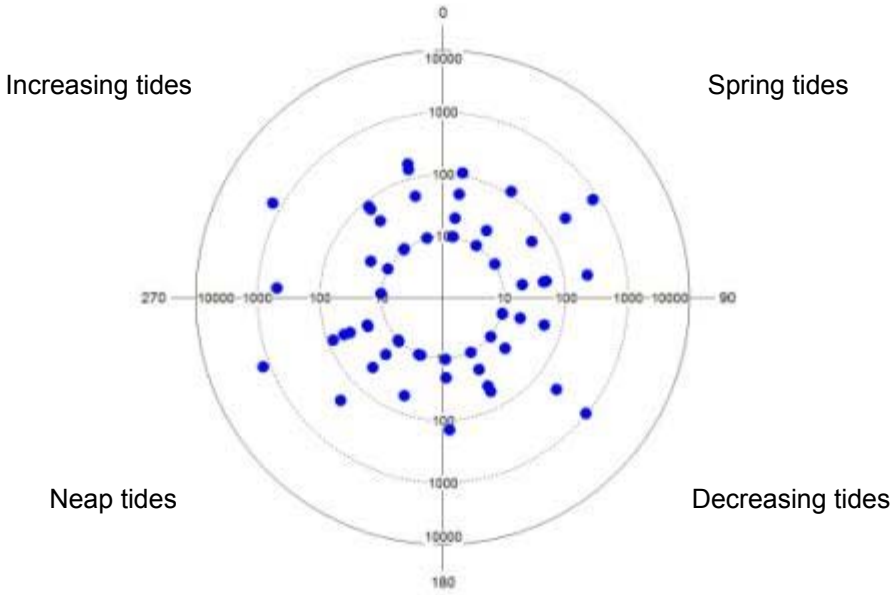


Figure 11.7 Polar plots of E. coli results on the spring/neap tidal cycle at North Uyea

No significant correlation was found between $\log_{10}$ *E. coli* results and the spring/neap tidal cycle (circular-linear correlation r = 0.152, p = 0.214).

High/low tidal cycle

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

High and low water data from Bluemull Sound was extracted from POLTIPS-3 in January 2015. This site was the closest to the production area (approximately 7 km to the northwest) and it is assumed that the tidal state will be similar between sites.

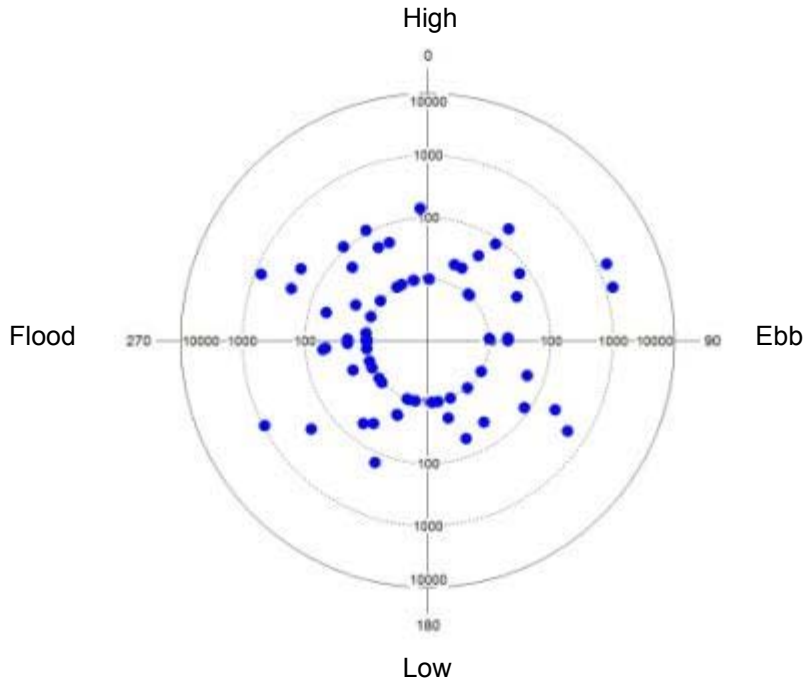


Figure 11.8 Polar plots of *E. coli* results on the high/low tidal cycle at North Uyea

No significant correlation was found between $\log_{10}$ *E. coli* results and the high/low tidal cycle (circular-linear correlation r = 0.177, p = 0.123).

11.5.4 Analysis of results by water temperature

Water temperature can affect survival time of bacteria in seawater (Burkhardt, *et al*., 2000). It can also affect the feeding and elimination rates in shellfish and therefore may be an important predictor of *E. coli* levels in shellfish flesh. Water temperature is obviously closely related to season. Any correlation between temperatures and *E. coli* levels in shellfish flesh may therefore not be directly attributable to temperature, but to the other factors e.g. seasonal differences in livestock grazing patterns. A scatterplot of *E. coli* results against water temperature for North Uyea is shown in Figures 11.9. Water temperature was recorded for all 70 sampling occasions. Jittering was applied to points at 0.02 (x-axis) and 0.001 (y-axis) respectively.

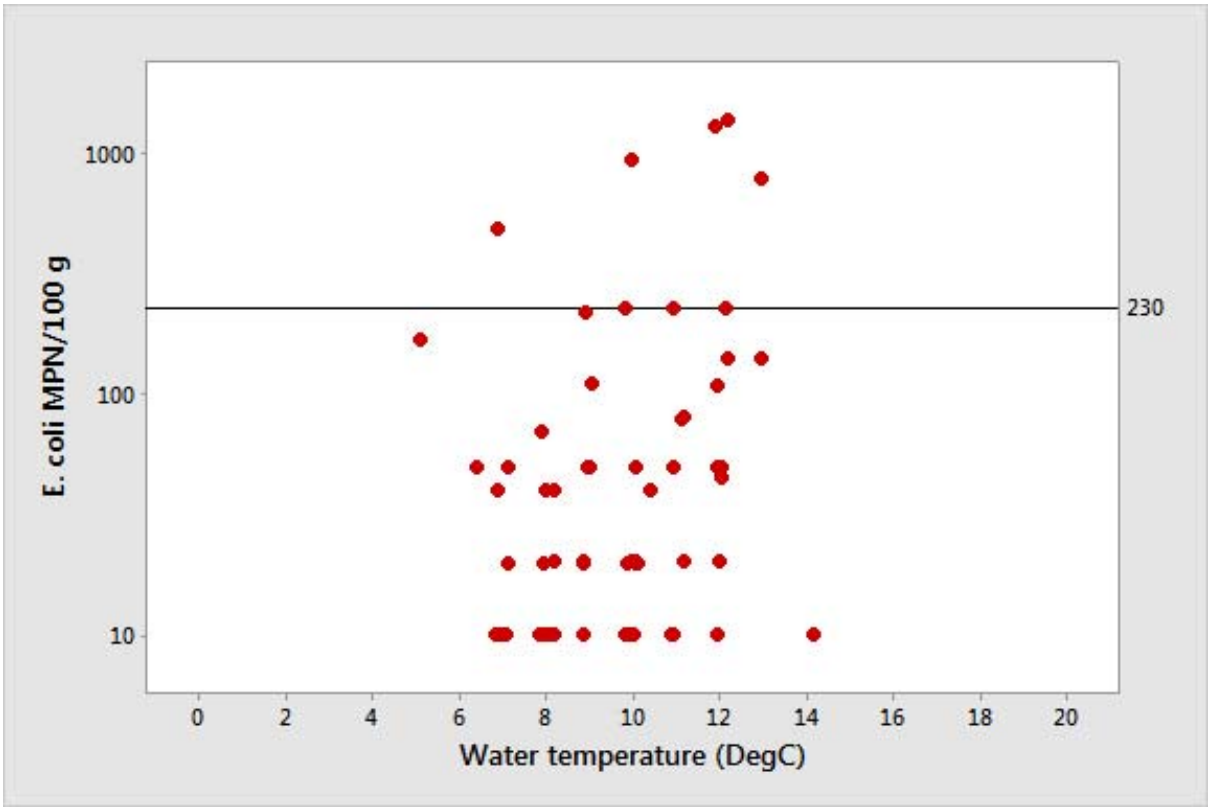


Figure 11.9 Scatterplot of *E. coli* results against water temperature at North Uyea

A highly significant correlation was found between *E. coli* results and water temperature (Spearman's rank correlation r = 0.368, p = 0.002). The majority of results >230 *E.* coli MPN/100 g were taken between 10 and 13^{o}C.

11.5.5 Analysis of results by salinity

Salinity will give a direct measure of freshwater influence and hence freshwater borne contamination at a site. A scatterplot of *E.* coli results against salinity for North Uyea is shown in Figure 11.10. Salinity was recorded for 36 out of the 70 sampling occasions. Jittering was applied to points at 0.02 (x-axis) and 0.001 (y-axis) respectively.

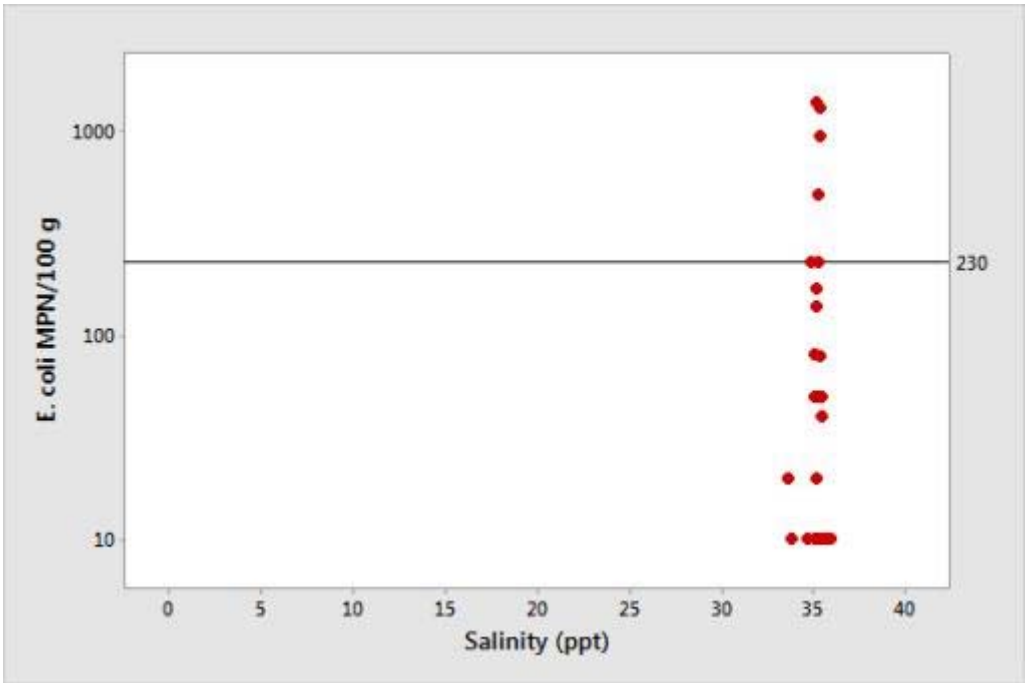


Figure 11.10 Scatterplot of *E. coli* results against salinity at North Uyea

No significant correlation was found between common mussel *E. coli* results and salinity (Spearman's rank correlation r = -0.048, p = 0.779). The range of recorded salinities was very narrow.

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

Two common mussel samples had results >1000 *E. coli* MPN/100 g and these are listed in Table 11.2.

Table 11.2 North Uyea historic *E. coli* sampling results over 1000 *E. coli* MPN/100 g

Collection Date	*E. coli* (MPN/ 100g)	Location	2 day rainfall (mm)	7 day rainfall (mm)	Water Temp (°C)	Salinity (ppt)	Tidal state (spring/neap)	Tidal State (high/low)
01/09/2009	1400	HU 603 998	14.8	48.8	12	35.19	Increasing	High
09/08/2011	1300	HU 6037 9983	13.2	53.2	12	35.31	Neap	High

The two samples were taken in September 2009 and August 2011. The reported sampling locations both lay to the southeast of the current fishery boundaries. Moderate rainfall had been reported prior to both sampling occasions although the recorded salinities reflected full strength seawater. Both samples were taken at high water.

11.7 Summary and conclusions

The majority of mussel results at North Uyea have been low, with nearly half (40%) yielding results below the limit of detection and most being <230 *E. coli* MPN/100 g.

No assessment could be undertaken with respect to spatial variation as the actual location of sampling was not clear for samples taken up to mid-2012.

A significant difference was found in results between seasons with average levels in summer and autumn being significantly higher than those in spring. The two results >1000 *E.coli* MPN/100 g were seen in August and September.

The only significant association between an environmental variable and the magnitude of the E. coli results was seen with water temperature, with higher results tending to be associated with samples taken at water temperatures between 10 and 13°C. This is obviously also associated with season.

12. Designated Waters Data

Shellfish Water Protected Areas

The Shellfish Waters Directive (2006/113/EC) was repealed on 31 December 2013 and equivalent protection for areas previously designated under that Directive is given by The Water Environment (Shellfish Water Protected Areas: Environmental Objectives etc.) (Scotland) Regulations 2013. The Uyea Sound Shellfish Water Protected Area (SWPA) has extended boundaries to include a larger area of Skuda Sound compared to the previous Uyea Sound Shellfish Growing Water (SGW), see Figure 12.1. The SWPA designation includes the production area and mussel farm. The designated SWPA for Uyea Sound is shown in Figure 12.1. Since 2007, assessment of the bacteriological status of shellfish waters has been undertaken using the shellfish hygiene *E. coli* data and this data has been reviewed in Section 11.

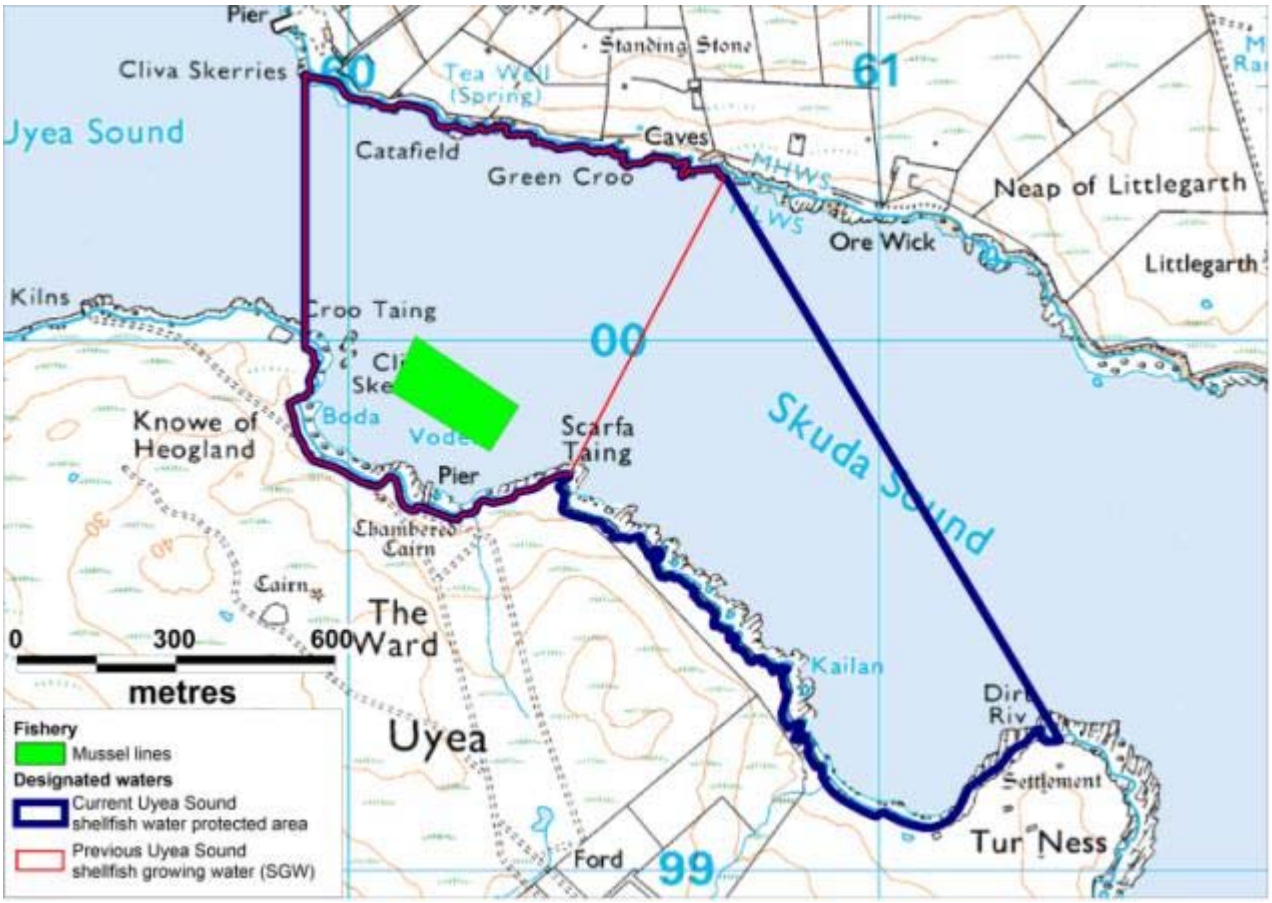


Figure 12.1 Designated shellfish water protected area – North Uyea

Bathing Waters

There are no designated bathing waters near the North Uyea production area.

13. Bathymetry and Hydrodynamics

13.1 Introduction

The study area comprises all waters west of a line drawn between HU 626 995 (Ness of Ramnageo) and HU 615 991 (Tur Ness) up to a boundary defined between HU 581 994 (Point of Burkwell) and HU 592 993 (Vee Taing) namely Skuda Sound and Uyea Sound. These are the names given to the continuous strait which separates the island of Unst and the smaller island of Uyea on the northeast coast of Shetland. Skuda Sound is orientated roughly NW-SE and merges into Uyea Sound in the west. The latter is orientated NE-SW and broadens to a bay which is to the north of the main body of the strait.

13.2 Bathymetry

An extract from Admiralty chart BA3292 (1:30,000) annotated with the limits of the study area, production area, mussel farm mooring containment area and the location of hydrographic surveys conducted in the strait is given in Figure 2.1.

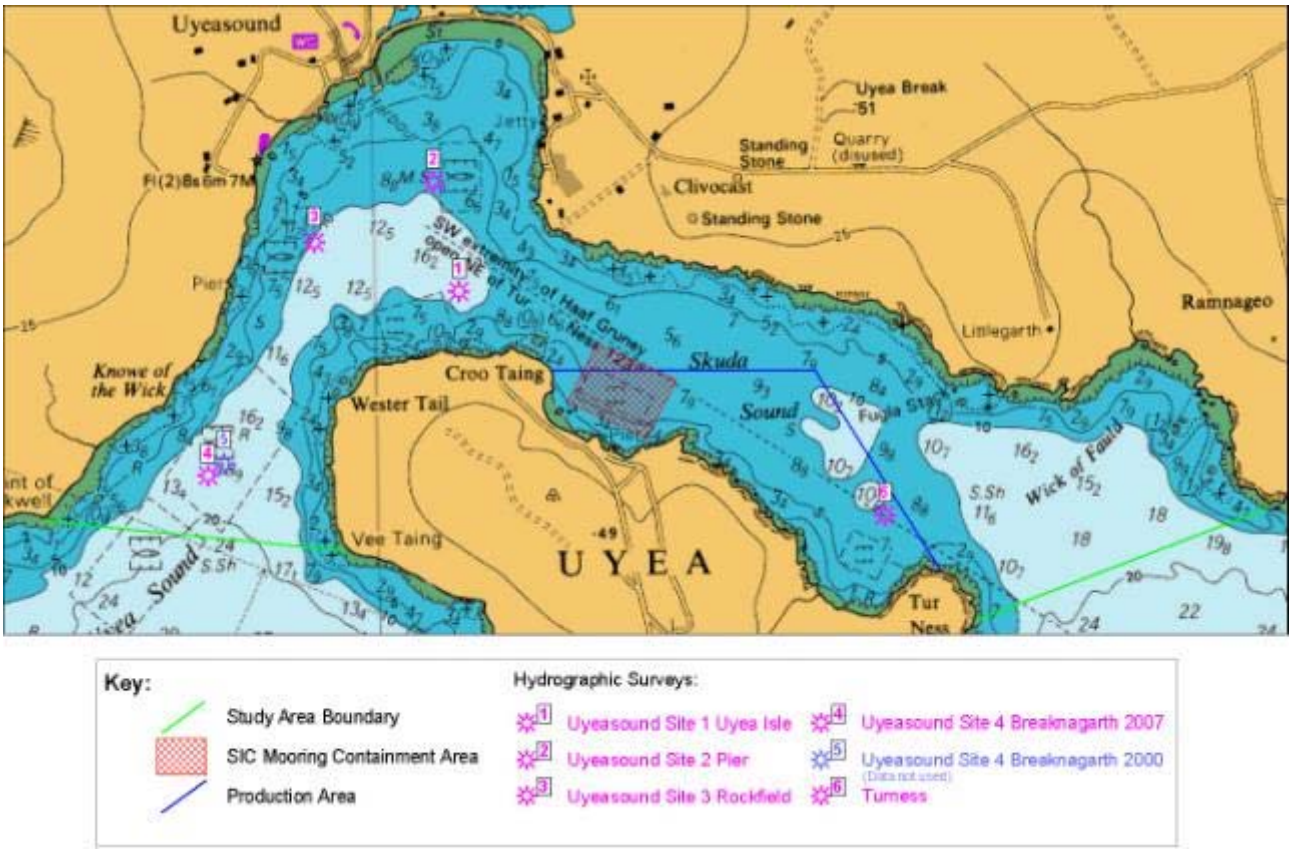
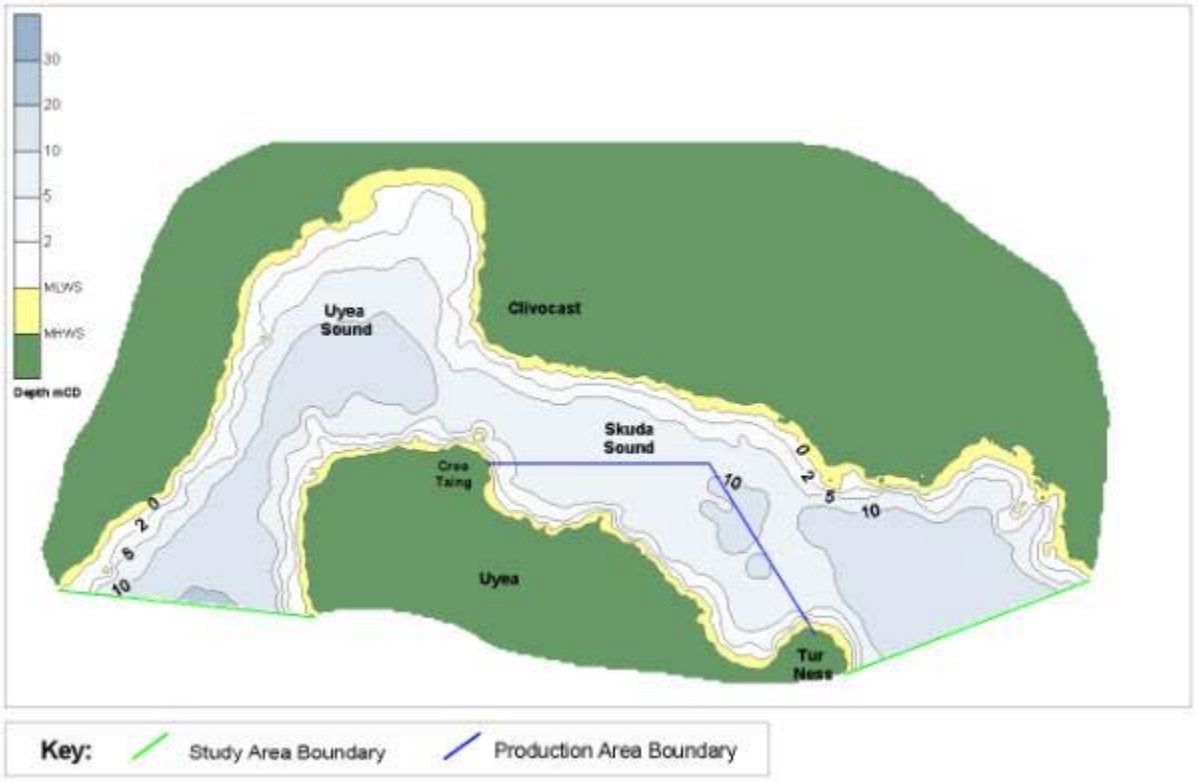


Figure 13.1 Admiralty chart extract

Vector data from an electronic version of this chart was extracted and contoured using Golden Software Surfer 8 (Figure 2.2).



Depths given as metres chart datum.

Figure 13.2 Study Area Bathymetry.

The contour plot illustrates:

- At either end of the strait the depth is largely between 10 and 20 metres.
- At most locations within the strait the depth increases gently from the shores, in particular at the large bay on northern shore where a very gentle gradient is present.
- The shallowest parts of the strait are in Skuda Sound directly adjacent to the small embayment where this fishery is located. At 5.6 metres this could be considered as a minor sill with respect to the deeper water present either side.
- A second minor sill is present at the narrowest part of Uyea Sound between Knowe of the Wick and Wester Tail on Uyea. To the north of the island the sound deepens to 16.2 metres forming a basin.
- Sill and basin features are of more interest in semi-enclosed loch systems where they may serve to restrict water exchange at depth increasing the likelihood of stratification. In this instance the shallower parts of the strait are located at the narrowest locations which will serve to concentrate any tidal streams present.

Grid volume computations in Surfer allow for the estimation of the surface area and volume. Positional information is related to the British National Grid to give Eastings as the “x” coordinate and Northings as the “y” coordinate in a three dimensional grid. The values presented in Table 2.1 represent the area and volume at chart datum by defining the surface “z” as zero. These parameters are estimated for the study area alone. The production area is defined using two open boundaries that do not form a

distinct water body, or even a part of one. Therefore in the context of the overall strait these figures are not considered relevant.

Table 13.1 Area and volume estimations using Surfer

Parameter*	Study Area
Area (km^2)	3.36
Volume (Mm^3)	26.33
Mean depth (m)	7.8
Maximum depth (m)	24

Neither Uyea Sound or Skuda Sound are included in the *Scottish Sea Lochs Catalogue* (Edwards & Sharples, 1986) or the *Catalogue of Voes, Firths and Sounds in Shetland* (Dixon, 1987).

13.2.1 Tidal Information

Information pertaining to predicted tide height is derived from the UKHO TotalTide prediction for Bluemull Sound (Culli Voe), the nearest secondary port which is located 5.7 km north-west from the study area boundary. Figures 3.1 and 3.2 show tidal curves for a fifteen day period starting on the 20 November 2014 which the date of the shoreline survey.

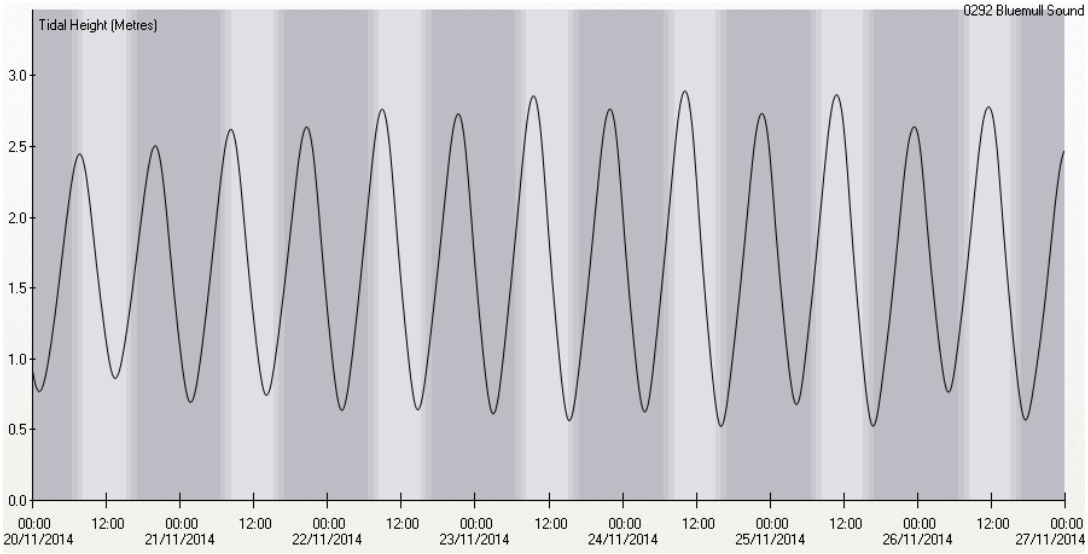


Figure 13.3 Tidal Curve Bluemull Sound 20 to 27 November 2014

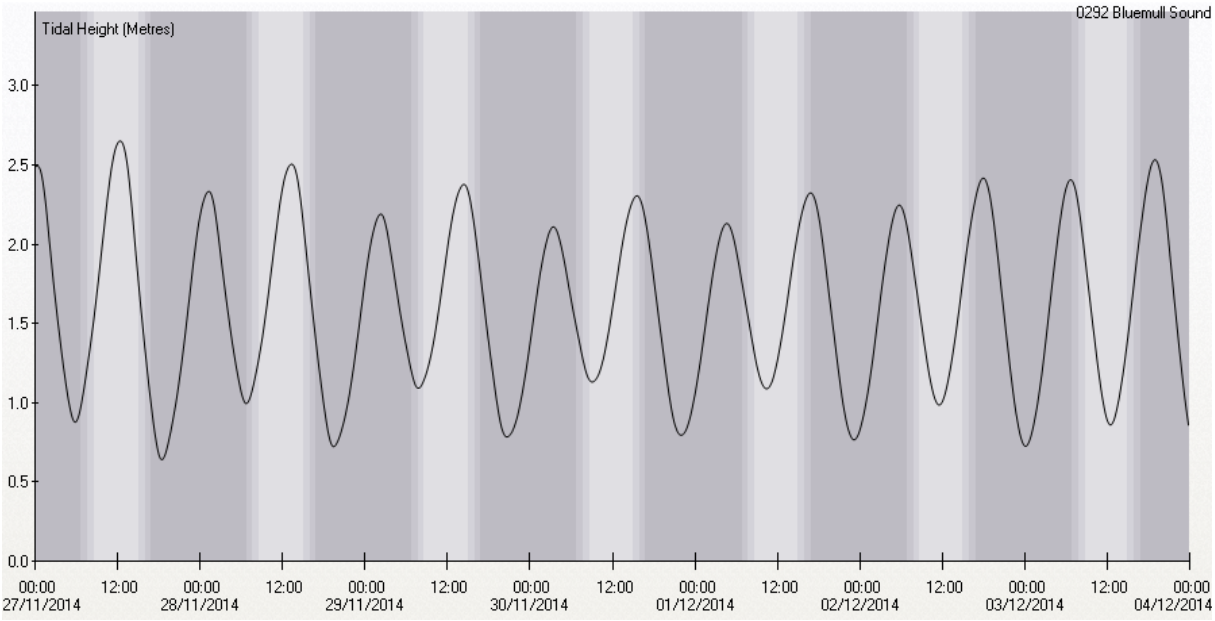


Figure 13.4 Tidal Curve Bluemull Sound 27 November to 4 December 2014

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

0292 Bluemull Sound is a Secondary Non-Harmonic port.
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

Based on the above Bluemull Sound would be classified as micro-tidal with a low tidal range of 2.1 m for springs and 0.9 m for neaps. Comparable conditions are likely to be found within the study area on account of similar topography and geographic proximity. Limited validation of this assumption is possible through pressure data collected from *in situ* measurements at the hydrographic survey locations in the area, described in Section 4.

13.2.2 Timing

Pressure data were recorded by a current meter deployed in 2007 at Uyeasound Site 4 Breaknagarth close to the western boundary of the study area. These data were compared to the Bluemull Sound TotalTide prediction for the equivalent survey period. Both high and low water at the survey location occurred later than the prediction; for high water this was consistently 45 minutes after the predicted time while for low water this was on average 70 minutes after the equivalent tidal event at

Bluemull Sound. Pressure data collected in 2004 during the Turness survey were also examined to compare conditions close to the eastern extent of the study area. A similar pattern is present with high water at between 47 minutes (springs) and 57 minutes (neaps) after the Admiralty prediction. Low water was on average 63 minutes after the predicted time.

13.2.3 Range

The range of three tides around the spring tide and three tides around the neap tide for the 2007 deployment at Uyeasound Site 4 Breaknagarth were compared to that predicted for the corresponding tides at Bluemull Sound. The observed tidal range during spring tides is lower than the prediction; 1.78 dBar against a predicted range or 2.0 m. That observed during neap tides is comparable to the predicted range; 1.13 dBar against a prediction of 1.10 m. A similar pattern is present in the Turness pressure record. Atmospheric pressure is not accounted for in the survey data.

13.3 Tidal Volume

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

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

where V is the volume of the loch basin (m^3), A is the surface area of the loch (m^2) and R is the spring tidal range (m). The factor 0.52 is the number of days per tidal cycle, and the factor 0.7 approximates the mean tidal range from the spring tidal range, R. As the spring tidal range is used, inputs for volume and area pertain to those calculated for MLWS for the study area. Based on this method estimates of flushing time (T_f) and flushing rate (Q) for both the study and production areas are given below in Table 3.1.

Table 13.2 Estimate of flushing rate and tidal volume for the study area using the tidal prism method.

Input:		**Study Area**
Volume* (V)	Mm^3	28.04
Area* (A)	Km^2	3.45
Tidal range (R)	m	2.1
Output:		
Flushing Time (T_f)	days	2.87
Flushing Rate (Q)	Mm^3/year	3,563
Flushing Rate (Q)	Mm^3/day	9.76
Flushing Rate (Q)	Mm^3/tidal cycle	5.07

*Calculated for MLWS.

The tidal prism method indicates that 18.1 % of the low water volume of the study area is exchanged during each tidal cycle. Total exchange would take just under three days.

The second method again utilises Surfer grid computations to estimate the volume of each area at different tidal states by defining the "z" surface according to the tidal level and subtracting low water from high water (Table 3.2).

Table 13.3 Estimate of flushing rate and tidal volume of the study area using Surfer grid volume calculation.

Tide	Z (m)	Study Area Volume (Mm3)
MLWS	0.5	28.04
MHWS	2.6	35.66
Difference (spring tide)		7.62
MLWN	1.0	29.80
MHWN	1.9	33.05
Difference (Neap tide)		3.25
Average Difference		**5.43**

The estimate of the flushing rate is below the average tidal volume. Both estimations of the exchange rate given should be interpreted cautiously as both employ a gross simplification of hydrodynamic properties in a topographically complex area. The study area cannot be considered typical of a semi-enclosed water body for which the tidal prism calculation is suited. With two boundaries the degree of tidal exchange within the strait is likely to be grossly underestimated by these methods. Such interactions are beyond the scope of simple box modelling techniques.

13.4 Currents

Admiralty charts provide no tidal stream information within the study area. The Admiralty Tidal Stream Atlas for Orkney and Shetland (UKHO, 1986) does not detail tidal flow within the study area however information pertaining to the currents to be expected to the North of Fetlar and through Bluemull Sound is given. The flood tide flows from north to south from approximately 2 ¾ hours before high water at Bluemull Sound, to 3 ¼ hours after high water. After a period of slack water the ebb tide flows to the north from approximately 3 ¼ hours after high water to 2 ¾ hours before high water. Peak flow through the sound for each tide would appear to be coincidental with high and low water at Bluemull Sound.

13.4.1 Field Data

Historically there have been six field studies which give an insight into the current flow patterns in the region, all of which are located in the study area. Summary information of the deployments is given in Appendix 1 while their locations are included at Figure 2.1. Data from these hydrographic studies were provided to Cefas by SEPA which archive information concerning fish farm licencing on their Public Register. Survey data were evaluated and re-processed to the requirements outlined by SEPA in the *Regulation and Monitoring of Marine Cage Fish Farming (Scotland) Attachment VIII* (v2.7 2008) to standardise analysis. The quality of the data collected is assessed to determine if each survey suitably represents the

hydrographic conditions at each location. The surveys conducted in 2002 at Uyeasound Site 2, Pier and Uyeasound Site 3, Rockfield were conducted with an array of three instruments which have a measuring threshold of 0.014 m/s, above which the measuring rotor will begin to rotate reliably. At Site 2, 11 % of the observations were within a range of 0 to 0.014 m/s with a mean speed of 0.055 m/s, while at Site 3, 21 % of the measurements were within this range and a mean speed of 0.060 m/s was recorded. Therefore the suitably of the use of this type of instrument at these sites is considered acceptable, and further mitigated by the presence of a clear tidal signature and that near-surface waters (the movement of which is of greatest interest to this study) have the lowest proportion of currents recorded below the measuring threshold (2 % and 11 % for Site 2 and Site 3 respectively).

The surveys conducted at Uyeasound Site 1 - Uyea Isle in 2002, Uyeasound Site 4 - Breaknagarth in 2007 and Turness in 2004 all produced data that is considered acceptable to the standards defined in Attachment VIII. Of the two surveys at Site 4 the data from the deployment in 2000 is disregarded from further study in favour of the second, higher precision survey.

13.4.2 Survey Data Assessment

An assessment of the hydrographic data collected within the study area was undertaken with detailed summary statistics tabulated in Appendix 2. Figure 4.1 illustrates the frequency of currents by vector and the pertinent summary statistics for near-surface waters.

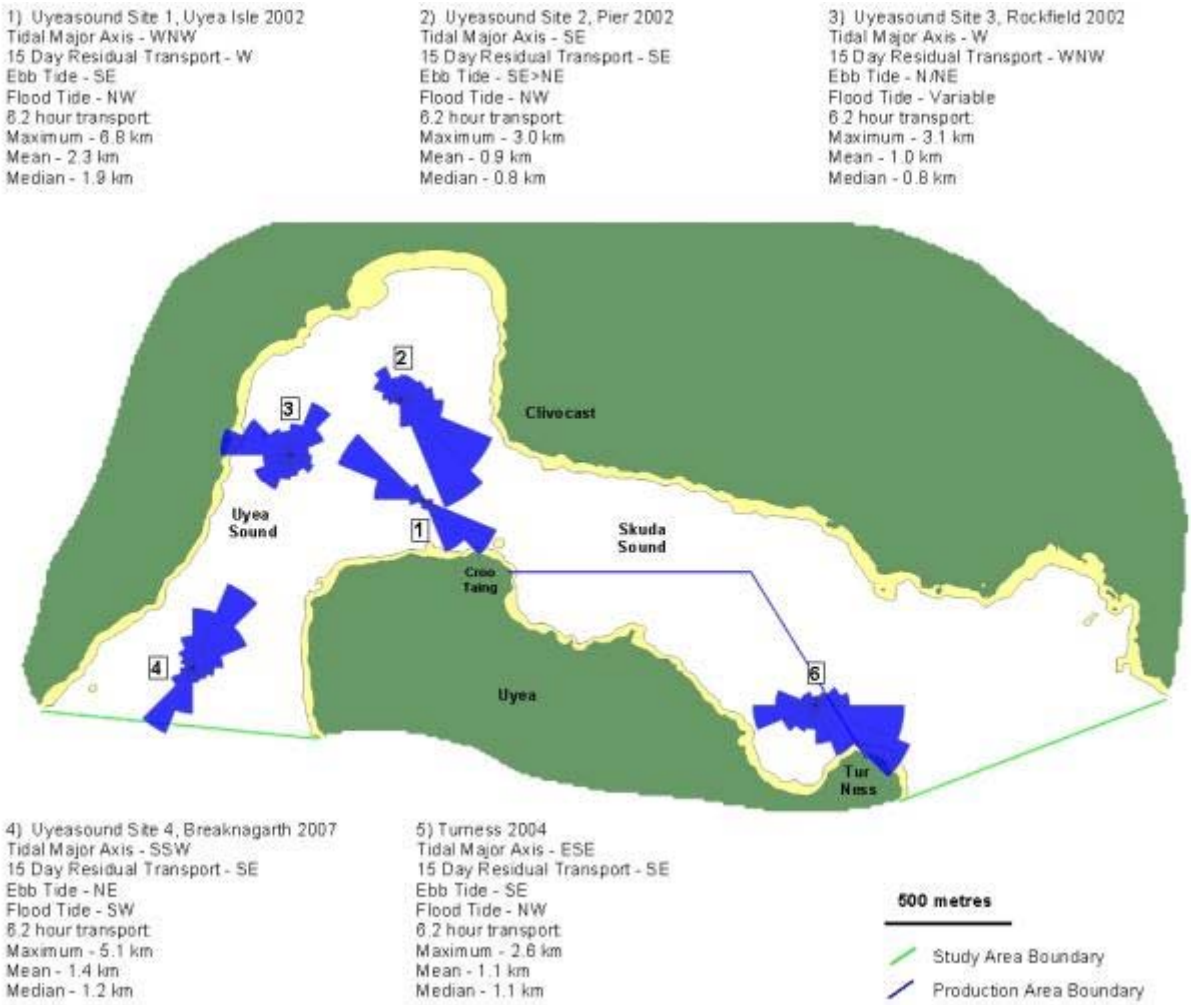


Figure 13.5 Near-surface current direction frequency (bin size 22.5°) for the five surveys undertaken within the study area including a summary of residual and tidal transport at each location.

Uyea Sound is better represented in terms of available hydrographic data with four surveys while only one exists for Skuda Sound, however overall the study area is well represented with surveys conducted close to both boundaries. Where pressure data was absent (Sites 1-3) this was substituted with the tidal height from the UKHO TotalTide prediction for Bluemull Sound including a +1 hour offset as it was determined from the available pressure data (Site 4 and Turness) that high and low water in the study area occur after the predicted time (refer to section 3.1). This allows each record in the current data to be identified as occurring on either the flood or ebb tides which in turn allows direct comparison of all five data sets despite the fact that the studies were conducted at different times.

It is apparent that the study area is strongly influenced by the tidal cycle, in particular at Site 1, Site 4 and to a lesser extent at Turness where a well-defined pattern can be identified. Tides in the study area do not follow the classic signature of a semi-enclosed water body where it would be expected that water would flow into the

system on the flood tide followed by a period of slack water and then leave the system in the reciprocal direction on the ebbing tide. Through the combined strait that is Uyea Sound and the neighbouring Skuda Sound the timing of a given tidal stream is not synchronised with high or low water. Overall, from the early to mid-part of the flood tide, through high water and until the mid-ebb tide the tidal stream is flowing west through the study area, while for the remaining time either side of low water an easterly flow is present. Locally the tidal axis conforms to the shoreline topography at any given part of the system, for example the tidal streams at Site 1 and at Turness follow the alignment of Skuda Sound while at Site 4 they are aligned along Uyea Sound. This means that when the tidal stream is recorded flowing to the north-east at Site 4 a corresponding flow to the south-east is observed at Turness.

The exception to this are the tidal streams present in the broad bay to the north of the main body of the strait. At Site 2, the flow to the north-west which is present during the flood tide does not persist over high water as was observed elsewhere in the strait. Instead a south-easterly flow is established prior to high water which continues until beyond low water. Site 3 displays the most ambiguity with regard to current direction over the tidal cycle. The ebb tide is generally to the north or north-east into the embayment, a reflection of the strong currents along the same vector present at the neighbouring Site 4 during this tidal stream. The direction of the flood tide varies as this tide progresses, gradually swinging from the initial north-east vector through south to become approximately north-west at around high water. The flow at high water is in keeping with conditions observed at Site 1 at this time. The data therefore suggest that tidal patterns within the bay are more complex than the main part of the strait and the observations indicate that there is the potential for eddies generated by the main tidal stream to form here.

With the exception of Turness where peak velocities are observed on the ebb tide prior to low water, maximum current speeds for the majority of the study area are recorded at or just prior to high water. Therefore peak velocities are associated with a general east to west movement through the strait, or in the case of Site 2 to the south-east. The latter implies that there is a dominance of surface water transport from the bay towards Skuda Sound, however the timing of the peak velocities observed is coincidental with transport in the sound towards the north-west.

The greatest overall speeds are recorded at Site 1 where the deployment location is close to the narrowest and shallowest part of the strait which would serve to constrict and amplify the tidal streams. As a result in the near-surface layer periods of greatest transport during a 6.2 hour (tidal) period are greatest here (up to 6.8 km), followed by Site 4 (up to 5.1 km). In the bay Site 2 and Site 3 have similar values at 3.0 km and 3.1 km respectively while the lowest transport in a 6.2 hour period is present at Turness (up to 2.6 km). As expected for a tidal location the spring/neap cycle is evident in the data with stronger current speeds recorded during spring tides.

The exception to this is at Site 4 where the reverse is true during the survey period, although this appears to be attributed to wind forcing.

With respect to the potential for wind driven transport Uyea Sound is exposed to the south-west with a maximum fetch of 8 to 9 km. For Skuda Sound and the upper part of Uyea Sound there is no barrier between these and the open North Sea, although the island of Haaf Gruney will provide shelter to a certain extent. However the strength of the tidal streams through the strait is very likely to prevent wind forcing from establishing currents that persist over a whole tidal cycle. The likelihood is that wind forcing may serve to augment or a given flow when the direction of tidal and wind currents are coincidental, or compound this flow when the two influences are in opposition. From the data there was some modification of the tidal stream attributed to wind forcing, the most significant of which was at Site 4 where a predominant F5/6 airflow from the south-west for the first ten days of the survey period led to lower current speeds for the tidal stream flowing against the wind direction. This airflow was coincidental with the springs phase of the tidal cycle only and is therefore is the likely explanation as to why stronger currents where recorded in near-surface waters during neap tides at this location. Elsewhere in the study area strong wind forcing effects are limited to depressing current speeds when peak flow is expected, supressing a particular flow altogether during neap tides or increasing the variability in the direction of a particular tidal stream.

13.5 Stratification

Salinity and temperature profiles were collected during the shoreline survey in November 2014 at two locations corresponding to the north-west and south eastern corners of the fishery as well as from a third location near where Skuda and Uyea Sound meet. For the measurements collected at the fishery it was not possible to collect a full profile due to depth restrictions. At all three locations the observed change over the profile was within the accuracy for the instrument used (± 0.35 ppt). The surface seawater samples collected at these locations also showed nominal levels.

A total of five watercourses were recorded draining into the study area during the shoreline survey, the largest of which flows from Easter Loch into the bay at the north of Uyea Sound. There are at least four additional watercourses that were not visited during the survey that discharge into the study area. Annual rainfall patterns have the potential to affect surface salinity. Figure 5.1 illustrates the monthly total rainfall and the 24 hour average rainfall from the Lerwick Meteorological Office from 2007 to 2012.

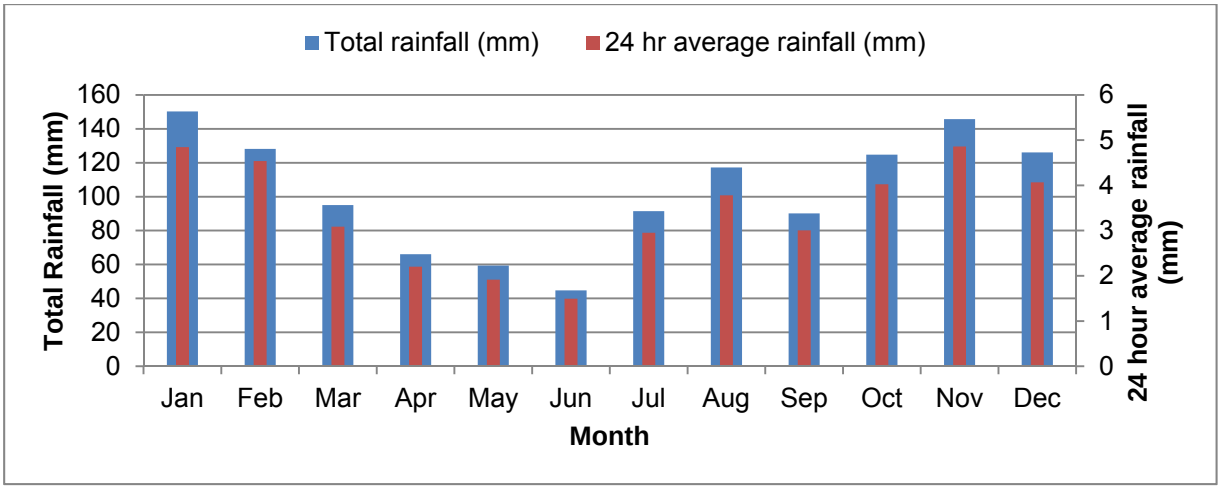


Figure 13.6 Total monthly and mean 24 hour rainfall for the period 2007 to 2012

There are no parameters pertaining to freshwater input for the study area listed in the *Scottish Sea Lochs Catalogue* or the *Catalogue of Voes, Firths and Sounds in Shetland*. These figures have been calculated using digital mapping techniques and modern rainfall totals in Table 5.1 below.

Table 13.4 Freshwater runoff parameters

Parameter	Units	SSQC 2014
Watershed	km^2	18.6
Annual Rainfall	(mm)	1,223*
Runoff	(Mm^3/yr)	18.1
Fresh/tide, per thousand	-	4.88
Salinity reduction	ppt	0.17
Runoff/width	m^2/d	59.2

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

It can be seen that the predicted salinity reduction is very low and that freshwater input has very little potential to have an influence on the production area. Considering that these figures are derived from calculations that are suited to a semi-enclosed body of water, in reality the salinity reduction is likely to be lower as a result of the tidal streams flowing through the strait which are not accounted for. This means that the estimate of freshwater to tidal water supply ratio given above is likely to be exaggerated.

The three temperature profiles showed minor variation, both over the depth of the profile and between each location; a variation of 0.2°C at the northern end of the fishery, no change at the south-east corner and a variation of 0.1°C at the mid strait location. Complete salinity and temperature profile data and water sample analysis are available in the shoreline survey report.

In summary the tidal streams observed in the area, coupled with the limited potential for freshwater influence mean that any form of stratification is unlikely in the study area.

13.6 Summary

- The tidal prediction for Bluemull Sound is not entirely applicable to the study area in terms of timing and range. Observations show that high and low water occur between 45 and 70 minutes after the predicted time throughout the study area and that the tidal range predicted for spring tides is greater than that measured.
- Figures for tidal exchange derived from the two methods indicate that between 18.1 % to 19.4 % of the low water volume of the study area could be exchanged during the tidal cycle leading to a flushing time of approximately 2.9 days. However the calculations involved simplify a complex area in terms of hydrodynamics and topography and the tidal streams observed mean the flushing time is likely to be substantially lower.
- Field observations indicate that tidal currents are the principle influence for water movement in the study area however the pattern does not conform to the classic signature with distinct flows present either side of high water. From the early to mid-part of the flood tide, through high water and until the mid-ebb tide the tidal stream is flowing west through the strait, while for the remaining time either side of low water an easterly flow is present.
- In the bay to the north of the main channel the flow observed is more complex and indicative of the formation of eddies, potentially generated by the strong tidal streams interacting with the shoreline and a more quiescent body of water.
- The strength of the tidal stream flowing through Skuda Sound at the time is likely to dominate any eddy or counter-flow where these meet so this is unlikely to influence current flow in the production area. Locally the tidal axis conforms to the shoreline topography at any given part of the system; at the production area the flow associated with high water is to the north-west towards Uyea Sound while the flow associated with low water is to the south-east towards Tur Ness.
- For the majority of the study area peak velocity is recorded at or just prior to high water and are therefore associated with a general east to west movement through the strait. The greatest speeds are recorded to the north of Uyea where the strait is narrow and of limited depth which serve to constrict the flow of tidal currents.
- The potential for wind forcing to generate surface water transport for periods that exceed an individual tidal stream is low, despite large fetches available. There is however evidence that strong winds may serve to modify a given flow.

- Close to the surface the greatest transport events during a 6.2 hour (tidal) period of up to 6.8 km are associated with elevated current speeds prior to high water to the north of Uyea. This level of transport is the result of the proximity to the narrowest and shallowest region of the strait which would serve to constrict and amplify the tidal streams and is not considered representative of the entire strait. At the mouth of Skuda Sound near Tur Ness a peak transport of 2.6 km was determined which represents the eastern extent of the present production area. Therefore the maximum transport distance for the majority of the production area would be expected to fall between these two extremes, increasing in magnitude from east to west.
- Salinity profiles collected during the November 2014 shoreline survey showed little definitive evidence of freshwater influence in the surface waters of the study area. Freshwater runoff calculations based on the watershed and bathymetric properties of the region would suggest that there is potential for a very low degree salinity reduction in the order of 0.17 ppt for the whole strait over a whole year, derived from a calculation that does not reflect the flow of tide through the strait. When the latter is considered the potential for freshwater influence would be even lower.

14. Shoreline Survey Overview

The shoreline survey was conducted on 20th November 2014. The 48 hours prior to the survey remained mainly dry, with the survey day noted as dry with sunny spells. Winds increased from an F1-2 to an F3 in an east-south-easterly direction.

The fishery is licensed for and consisted of a single mussel farm, with 8x220 m double headed long-lines and 6 m droppers. It was located adjacent to the northeast coastline of Uyea Island in Skuda Sound and was stocked at the time of the survey. Harvesting is usually conducted from August to May. Mussel samples taken from the top and bottoms of the lines at the northwestern and southeastern corners of the mussel farm all returned results of <18 *E. coli* MPN/100 g.

Uyea Island is uninhabited. Houses were concentrated to the north in Uyea Sound where the small settlements of Clivocast and Uyeasound were located. Several B&B's and self-catering holiday homes were noted in this area, with Gardiesfauld Youth Hostel and Caravan Park. Two shore-bases belonging to Cooke Aquaculture Ltd were located on the northeast side of Uyea Sound.

Sewage related infrastructure was noted on land around Uyea Sound. A community ST with an outfall pipe was noted by Uyeasound pier (northeast) and the seawater sample taken adjacent to the end of a pipe returned a result of 41 *E. coli* cfu/100 ml. Two dry pipes below a ST inspection cover and a submerged pipe were noted below two houses on the eastern side of the bay at the head of Uyea Sound. On the western side of that bay, two dry pipes to sea were noted below houses and community hall. A ST with outflow pipe to sea was noted by the public toilets close to the Westside pier (located on the northwestern side of Uyea Sound) and a seawater sample taken adjacent to this pipe returned a result of 5 *E. coli* cfu/100 ml. Four discharge pipes to sea were seen further along the western shoreline: three were noted as dry, with the fourth was submerged at the time of the survey.

Boat traffic is largely associated with aquaculture farms and leisure activities. Two piers were noted along to the east of the sound. Both were used by Cooke Aquaculture Ltd, with Uyeasound pier also used by Unst Shellfish to service mussel sites. Three workboats were berthed at Uyeasound pier, with a fourth ashore. A pontoon with a workboat, two open inflatable boats and two pleasure boats was also noted adjacent to the pier. One workboat and a small open boat were noted at Westside Pier, with a workboat harvesting a salmon farm close to Uyeasound Pier. A pier was also noted on the north side of Uyea Island.

Approximately 55 sheep with shore access were observed on Uyea Island. Fourteen sheep with no shore access were noted at the northern end of Uyea Sound. Pony faeces were recorded in a field with shore access by Uyeasound pier. Fifteen sheep with no shore access were noted on the Unst shoreline across Skuda Sound north of the mussel farm. Steep escarpments were expected to restrict shore access along

this shoreline. Agricultural buildings set inland were noted at Clivocast. Structures that could be sheep pens were recorded near the pier on Uyea Island.

Uyea Island and the land around Uyea Sound, outside the small settlements of Clivocast and Uyeasound, was predominantly rough grassland. A field cut for silage was recorded near the shoreline to the south of Clivocast.

Higher ground on Uyea Island consisted of heather, with boggy areas on lower ground and shore access in places. High embankments limited shore access along the eastern shoreline.

Five watercourses were sampled during the survey; two on the island of Uyea and three from around the head of the sound. Freshwater sample results varied between 3 and 23 *E. coli* cfu/100 ml. A slow flowing watercourse with signs of eutrophication was also noted on the west side of Uyea Island and a small watercourse close to Gardie Caravan Park contained an area of discoloured water.

Birds were the most common wildlife observed. Species included common gulls, ravens, fulmar, crows, snipe, greylag geese, ducks and swans. Twenty-three common gulls were noted on the northern side of the fishery, with faeces noted on buoys to the east. Three seals were also noted; two hauled out at the pier on Uyea Island and the other was in Skuda Sound.

Figure 14.1 Map of shoreline survey observations at North Uyea

15. Bacteriological Survey

A bacteriological survey was not undertaken at North Uyea due to the relatively simple nature of the area.

16. Overall Assessment

Human sewage impacts

The population in the area around the vicinity is low and is mainly concentrated in the small communities of Uyeasound and Clivocast. The island of Uyea is uninhabited. The majority of sewage input to the area around the bay at the head of Uyea Sound, to the northwest of the mussel farm. Discharges include a community septic tank with a consented PE of 250 and several private septic tanks. Additional sewage contamination may arise from overboard disposal from boats. This is likely to be concentrated near Uyeasound but more significant inputs in terms of the mussel lines will be possible intermittent impacts from boats using the anchorage located in the embayment near the mussel farm.

Agricultural impacts

Any contributions of faecal contamination from livestock are expected to be low but principally associated with animals located on the northeast side of Uyea, with the greatest potential impact on the mussel lines closest to the shoreline.

Wildlife impacts

Seabirds and ducks constitute the main wildlife species that will to contribute to contamination levels at the mussel farm. There is no information on which to base an assessment of spatial effects across the mussel farm. If seals haulout at the pier near the mussel farm on a regular basis, these will also constitute a source of contamination and, in this instance, any effects are likely to be greatest towards the southeastern end of the lines.

Seasonal variation

The tourist accommodation is expected to be mainly occupied from May to September inclusive and this will cause an increase in loadings from the sewage discharges. Boating activity is also expected to be greatest during this period. Inputs from livestock is likely to be greatest during spring and summer. Any contamination associated with Arctic terns is expected to occur during the breeding season from May to August.

Rainfall-associated land run-off will be highest during autumn and winter. However, high rainfall events occurring during the drier months may wash accumulated faecal material off the land. However, no association was seen between rainfall and the magnitude of *E. coli* results from mussel samples.

A significant difference was found in results between seasons with average levels in summer and autumn being significantly higher than those in spring. The two results >1000 *E.coli* MPN/100 g were seen in August and September.

Watercourses

Contamination arising from watercourses is expected to be with the greatest potential for effects being expected from the watercourses that discharge adjacent to the shellfish farm on the northern coastline of Uyea. The loadings would be expected to be higher after rainfall. However, salinity profiles collected at the mussel farm during the November 2014 shoreline survey showed little evidence of freshwater influence and runoff calculations based on the watershed and bathymetric properties of the region support the expectation of a low contribution from freshwater inputs.

Movement of contaminants

Tidal currents are the principle driver of water movement in the area although the pattern does not conform to the normal pattern of distinct flows present either side of high water. The tidal stream flows west through the strait from the early to mid-part of the flood tide, through high water and until the mid-ebb tide, while it then flows in an easterly direction either side of low water. Flows are more complex in the bay to the north of the main channel. Elsewhere in the system flows are generally oriented to the axis of the shoreline.

Peak current velocity is generally seen at, or just prior to, high water and is associated with a general east to west movement through the strait. The greatest current speeds are recorded to the north of Uyea. Strong winds may modify the expected tidal flows.

To the north of Uyea, a surface particle transport distance of up to 6.8 km is expected to be associated with peak current speeds prior to high water. At the mouth of Skuda Sound, near Tur Ness, the peak surface particle transport distance is expected to be much lower, in the region of 2.6 km was determined. Predicted particle transport distances therefore increase from east to west along Skuda Sound.

Temporal and geographical patterns of sampling results

The majority of mussel results at North Uyea have been low, with nearly half (40%) yielding results below the limit of detection and most being <230 *E. coli* MPN/100 g. No assessment could be undertaken with respect to spatial variation as the actual location of sampling was not clear for samples taken up to mid-2012.

Mussel samples taken from the top and bottoms of the lines at two locations on the mussel farm during the shoreline survey all returned results of <18 *E. coli* MPN/100 g. Subsurface seawater samples taken at the same locations yielded results of <1 and 1 *E. coli* cfu/100 ml.

Conclusions

Contamination associated with human sources is concentrated around the head of Uyea Sound. However, easterly flows are only expected through the strait at low water and contamination arising from the head of Uyea Sound would be expected to be taken along the Unst side rather than transported across to the Uyea side. However, contamination flowing south in Uyea Sound over most of the tidal cycle may be brought back round the north shore of Uyea when the current direction changes. Such contamination will have been subject to considerable dilution and is likely to be well mixed, with little differential impact across the extent of the mussel farm. More localised inputs from boating may cause intermittent contamination at the mussel farm. Contamination arising from local inputs from farm animals and birds is likely to impact intermittently at the lines with the former having a greater effect at those lines nearest to the shore. The lines at the southeastern end of the farm may be subject to contamination from seals using a haulout in the vicinity.

17. Recommendations

Production area

It is recommended that the production area be modified slightly in order that it encompasses the full extent of the lease area. It is therefore recommended that it be defined as: the area bounded by lines drawn from HP 5993 000 to HP 6000 0020 to HP 6090 0000 to HU 6136 9926 extending to MHWS. The extended area does not include any additional identified pollution sources.

RMP

It is recommended that the RMP be relocated to HU 6025 9983 in order to better reflect potential sources of contamination in the immediate vicinity of the mussel farm.

Tolerance

It is recommended that a tolerance of 40 m be applied to allow for some movement of the mussel lines.

Depth of sampling

It is recommended that the depth of sampling be 1 – 3 m.

Frequency

It is recommended that sampling be undertaken monthly.

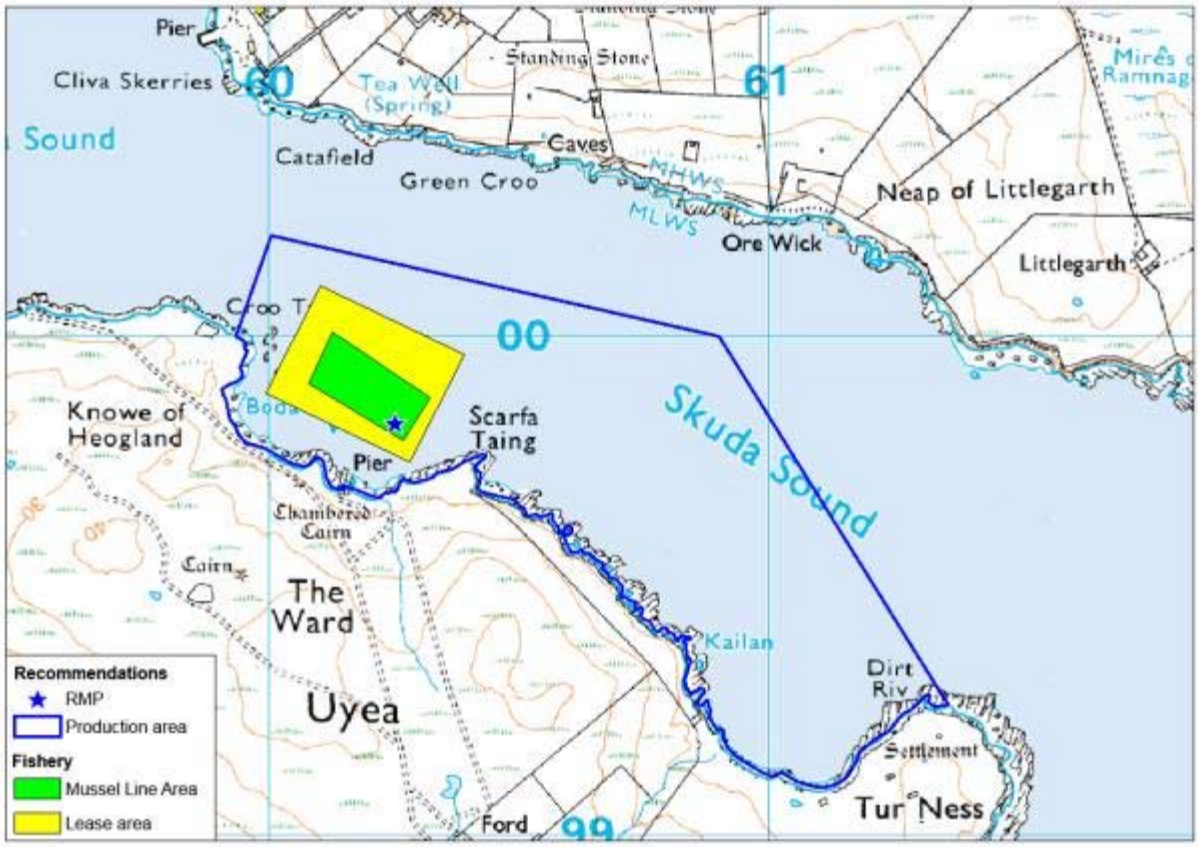


Figure 17.1 Map of recommendations at North Uyea

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1. **General Information on Wildlife Impacts**
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4. **Hydrographic Section Glossary**
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1. General Information on Wildlife Impacts

Pinnipeds

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

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

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

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

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

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

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

Cetaceans

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

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

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

Birds

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

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

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

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

Deer

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

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

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

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

Otters

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

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

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2. Tables of Typical Faecal Bacteria Concentrations

Summary of faecal coliform concentrations (cfu $100ml^{-1}$) for different treatment levels and individual types of sewage-related effluents under different flow conditions: geometric means (GMs), 95% confidence intervals (CIs), and results of t-tests 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}		
Reed bed/grass plot	71	1.3×10^{4}	5.4×10^{3}	3.4×10^{4}	2	1.5×10^{4}		
Ultraviolet disinfection	108	2.8×10^{2}	1.7×10^{2}	4.4×10^{2}	6	3.6×10^{2}		

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

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

FIO	*n*	**Base Flow**			**High Flow**		
Subcatchment land use		Geometric mean	Lower 95% CI	Upper 95% CI	Geometric mean[a]	Lower 95% CI	Upper 95% CI
Total coliforms							
All subcatchments	205	5.8×10^{3}	4.5×10^{3}	7.4×10^{3}	7.3×10^{4}**	5.9×10^{4}	9.1×10^{4}
Degree of urbanisation							
Urban	20	3.0×10^{4}	1.4×10^{4}	6.4×10^{4}	3.2×10^{5}**	1.7×10^{5}	5.9×10^{5}
Semi-urban	60	1.6×10^{4}	1.1×10^{4}	2.2×10^{4}	1.4×10^{5}**	1.0×10^{5}	2.0×10^{5}
Rural	125	2.8×10^{3}	2.1×10^{3}	3.7×10^{3}	4.2×10^{4}**	3.2×10^{4}	5.4×10^{4}
Rural subcatchments with different dominant land uses							
≥75% Imp pasture	15	6.6×10^{3}	3.7×10^{3}	1.2×10^{4}	1.3×10^{5}**	1.0×10^{5}	1.7×10^{5}
≥75% Rough Grazing	13	1.0×10^{3}	4.8×10^{2}	2.1×10^{3}	1.8×10^{4}**	1.1×10^{4}	3.1×10^{4}
≥75% Woodland	6	5.8×10^{2}	2.2×10^{2}	1.5×10^{3}	6.3×10^{3}*	4.0×10^{3}	9.9×10^{3}
Faecal coliform							
All subcatchments	205	1.8×10^{3}	1.4×10^{3}	2.3×10^{3}	2.8×10^{4}**	2.2×10^{4}	3.4×10^{4}
Degree of urbanisation							
Urban	20	9.7×10^{3}	4.6×10^{3}	2.0×10^{4}	1.0×10^{5}**	5.3×10^{4}	2.0×10^{5}
Semi-urban	60	4.4×10^{3}	3.2×10^{3}	6.1×10^{3}	4.5×10^{4}**	3.2×10^{4}	6.3×10^{4}
Rural	125	8.7×10^{2}	6.3×10^{2}	1.2×10^{3}	1.8×10^{4}**	1.3×10^{4}	2.3×10^{4}
Rural subcatchments with different dominant land uses							
≥75% Imp pasture	15	1.9×10^{3}	1.1×10^{3}	3.2×10^{3}	5.7×10^{4}**	4.1×10^{4}	7.9×10^{4}
≥75% Rough Grazing	13	3.6×10^{2}	1.6×10^{2}	7.8×10^{2}	8.6×10^{3}**	5.0×10^{3}	1.5×10^{4}
≥75% Woodland	6	3.7×10	1.2×10	1.2×10^{2}	1.5×10^{3}**	6.3×10^{2}	3.4×10^{3}
Enterococci							
All subcatchments	205	2.7×10^{2}	2.2×10^{2}	3.3×10^{2}	5.5×10^{3}**	4.4×10^{3}	6.8×10^{3}
Degree of urbanisation							
Urban	20	1.4×10^{3}	9.1×10^{2}	2.1×10^{3}	2.1×10^{4}**	1.3×10^{4}	3.3×10^{4}
Semi-urban	60	5.5×10^{2}	4.1×10^{2}	7.3×10^{2}	1.0×10^{4}**	7.6×10^{3}	1.4×10^{4}
Rural	125	1.5×10^{2}	1.1×10^{2}	1.9×10^{2}	3.3×10^{3}**	2.4×10^{3}	4.3×10^{3}
Rural subcatchments with different dominant land uses							
≥75% Imp. pasture	15	2.2×10^{2}	1.4×10^{2}	3.5×10^{2}	1.0×10^{4}**	7.9×10^{3}	1.4×10^{4}
≥75% Rough Grazing	13	4.7×10	1.7×10	1.3×10^{2}	1.2×10^{3}**	5.8×10^{2}	2.7×10^{3}
≥75% Woodland	6	1.6×10	7.4	3.5×10	1.7×10^{2}**	5.5×10	5.2×10^{2}
[a] Significant elevations in concentrations at high flow are indicated: **po0.001, *po0.05.							
[b] Degree of urbanisation categorised according to percentage built-up land: 'Urban' (X10.0%), 'Semi-urban' (2.5–9.9%) and 'Rural' (o2.5%).							

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

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

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

Source: (Gauthier & Bedard, 1986)

References

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

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

3. Statistical Data

One-way ANOVA: logec versus Season

```
Method
Null hypothesis         All means are equal
Alternative hypothesis  At least one mean is different
Significance level      α = 0.05
Equal variances were assumed for the analysis.
Factor Information
Factor  Levels  Values
season       4  1, 2, 3, 4
Analysis of Variance
Source  DF  Adj SS  Adj MS  F-Value  P-Value
season   3   2.748  0.9159     2.84    0.045
Error   66  21.292  0.3226
Total   69  24.039
Model Summary
       S    R-sq  R-sq(adj)  R-sq(pred)
0.567979  11.43%      7.40%       0.35%
Means
season   N   Mean  StDev      95% CI
1       17  1.211  0.442  (0.936, 1.486)
2       17  1.699  0.703  (1.424, 1.975)
3       18  1.683  0.626  (1.416, 1.951)
4       18  1.444  0.460  (1.176, 1.711)
Pooled StDev = 0.567979
```

Tukey Pairwise Comparisons

```
Grouping Information Using the Tukey Method and 95% Confidence
season   N   Mean  Grouping
2       17  1.699  A
3       18  1.683  A
4       18  1.444  A
1       17  1.211  A

Means that do not share a letter are significantly different.
```

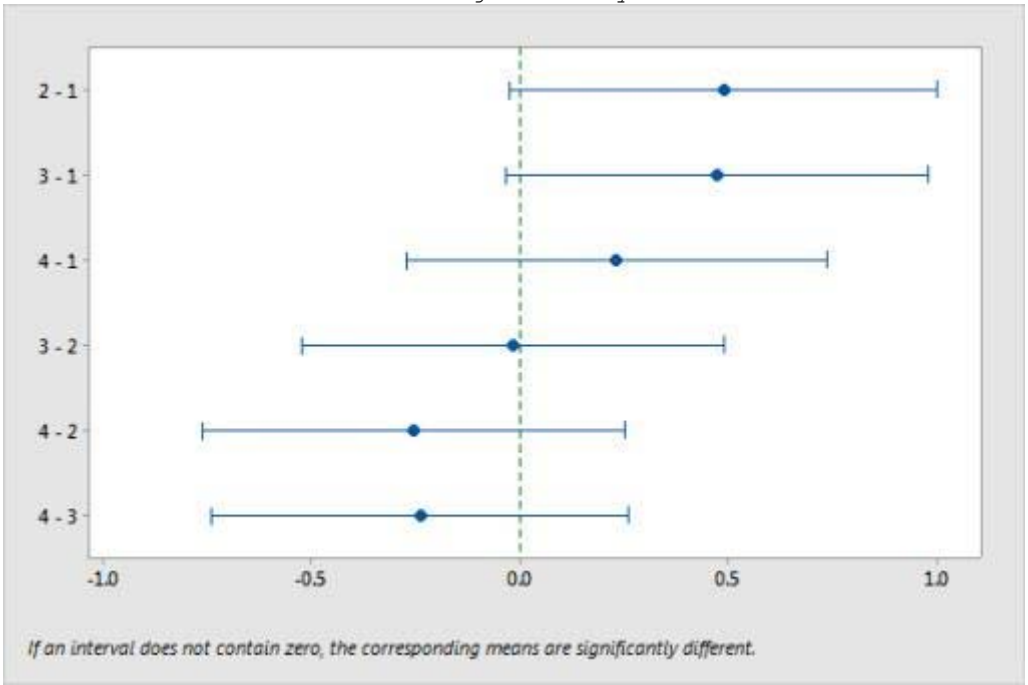

Figure 1 Tuley Pairwise Test for North Uyea sampling results against season

Fisher Pairwise Comparisons

Grouping Information Using the Fisher LSD Method and 95% Confidence

season	N	Mean	Grouping
2	17	1.699	A
3	18	1.683	A
4	18	1.444	A B
1	17	1.211	B

Means that do not share a letter are significantly different.

4. Hydrographic Assessment Glossary

The following technical terms may appear in the hydrographic assessment.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5. Shoreline Survey Report

Shoreline Survey Report

Production Area: North Uyea

Site Names: North

SIN: SI-230-453-08

Harvesters: Unst Shellfish: David Niven

Local Authority: Shetland Islands Council

Status: Existing area

Date surveyed: 20 November 2014

Surveyed by: Sean Williamson (Hall Mark Meat Hygiene Ltd.)
Helena Mackay (SSQC Ltd)
We are grateful to Unst Shellfish for providing assistance during the marine survey work.

Existing RMPs HU 6011 9997 *(E.coli)*

Area Surveyed: See Figure 1

Specific observations made on site are mapped in Figure 1 and listed in Table 1. Water and shellfish samples were collected at the locations marked on Figures 2 and 3. Bacteriology results are given in Tables 2 and 3. Salinity profiles are presented in Table 4 with profile locations marked on Figure 2. Photographs are presented in Figures 4-31.

Weather

Thursday 20 November 2014

High scattered cloud cover with some sunny spells throughout the day, remaining dry for the duration of the survey. Light F1-2 south easterly breeze increased to F3 later in the day.

Preceding the shoreline survey, Wednesday 19 November was partly cloudy and dry with light SE-SSE winds and Tuesday 18 November began with scattered clouds becoming mostly cloudy by late afternoon. F3 ESE winds became SSE later in the day and it remained mainly dry.

Fishery

The location of the mussel lines for the fishery is mapped in Figure 1. The fishery had stocked mussel lines on site.

The North fishery consisted of 8 x 220m long mussel lines situated adjacent to the North East coastline of the island of Uyea in Skuda Sound (Figures 4 and 5). All lines were double-headed longlines with 6m droppers. The site is licenced for eight 220m twin-headline longlines in total. The site is harvested from August to May inclusive. Mussel samples were collected from two locations on the fishery; one from the south east corner, as specified on the plan, and the other from the second line in at the north west corner of the fishery.

Sewage/Faecal Sources

Uyea Island

There were no occupied dwelling houses on Uyea Island.

Clivocast to Uyeasound Pier section of survey

One dwelling house and several agricultural buildings lay well above the shoreline near the start of the survey walk at Clivocast. A shorebase and pier utilised by Cooke Aquaculture Ltd was positioned close to the first settlement of houses reached. There were approximately 24 dwelling houses along the section of shoreline between the shorebase and the Uyeasound pier; all but one on the upper side of the road, with two sited some distance from the shore. A community septic tank and outfall pipe was situated below the road in this vicinity (Figures 6 and 7). No other septic tanks or outlets were recorded on this section of the walk.

Uyeasound Pier to Gardie section of survey

Cooke Aquaculture Ltd's main Unst shorebase is situated above Uyeasound Pier (Figure 8). A plastic draining pipe running under the road to the sea was observed with no flow detected (Figure 9). Four dwelling houses were visible from the shoreline above the pier moving west towards Easter Loch. The observation cover of a septic tank was noted below the first house and old school buildings, the only properties sited below the road. Two outlet pipes, with ends visible above water level were noted on the beach below (Figure 10). Neither of these pipes were in use. A further redundant outlet pipe on the beach was recorded below 1 house (Figure 11). A possible sewage pipe draining to the sea was noted just to the west of the final two houses on the approach to Easter Loch, the end of the pipe was not visible underwater (Figure 12).

An outlet to the sea with no visible discharge was observed below two dwelling houses situated above the road beyond the western edge of Easter Loch (Figure

13). A second pipe running onto the beach with no outflow was recorded below the community hall and 2 houses further back above the road.

Public toilets were situated beyond the Westside Pier (Figure 14). An associated septic tank and outflow to sea were identified (Figures 15 and 16). A further 4 outlet pipes onto the beach below dwelling houses were observed between Gardiesfauld Hostel and Caravan Park and the westernmost section of the shoreline walk; no outflow was observed from 3 of the pipes (Figures 17 and 18). The end of the fourth pipe was not visible underwater (Figure 19).

Sample analysis

Five freshwater samples were obtained from watercourses around North Uyea; two were collected on the island of Uyea), and three were collected from around the head of Uyea Sound at a tributary of Easter Loch, a tributary of Scata Water and the Burn of Gardie. Five sampling points were outlined in the survey plan and all of these were collected. All the watercourses sampled were found to have *E.coli* levels between 3-23 cfu/100 ml.

Seawater samples were obtained from two locations on the North fishery; one sample was collected from the second line in at the northwest corner and another from the south east corner. *E.coli* levels were between <1 to 1 cfu/100ml. Away from the fishery four seawater samples were collected, two of which were on the sample plan. For the planned sampling points, from a designated position within Uyea Sound and from beside Uyeasound Pier; *E.coli* levels were 1 and 18 cfu/100ml respectively. Additional samples were collected during the shoreline walk from the end of an outlet pipe below the public toilets near Gardie (*E.coli* levels at 5 cfu/100ml) and from the end of an outlet pipe below Uyeasound STW (*E.coli* levels at 41 cfu/100ml).

Mussel samples were obtained from the same locations at the fishery as the seawater samples. Two samples were collected at each location, one from the top of a mussel dropper and one from the bottom of the dropper. The sample from the second line in at the NW corner of the fishery returned results of <18 *E.coli* MPN/100g for both top and bottom samples. The sample from the SE corner also returned results of <18 *E.coli* MPN/100g for both top and bottom samples.

Salinity profiles were obtained from the same locations at the fishery as the seawater samples. A third profile was collected from a designated position within Uyea Sound. In all cases observed variation in salinity measurements with depth did not exceed the accuracy value of the probe used (± 0.35 ppt). Surface salinity ranged from 35.08 ppt at a designated position within Uyea Sound, between the north coast of Uyea Isle and Cliva Skerries, to 35.32 ppt at the SE corner of the fishery. The

water was too shallow to collect salinity measurements at a 10 metre depth at the fishery.

Temperature profiles were also obtained from these locations. The profile at the NW corner of the fishery showed a slight decrease in temperature from 5m to the surface whilst the profile at the SE corner did not fluctuate. The profile collected from the designated point within Uyea Sound showed a slight decrease in temperature from 10 metres to the surface. Surface temperatures ranged from 10.1°C to 10.2°C.

Salinities of the seawater samples analysed at the laboratory showed salinities ranging from 21.63 PSU present at the sampling point below Uyeasound STW on the eastern shoreline to 34.95 PSU present at the SE corner of the North fishery.

Seasonal population

Gardiesfauld Youth Hostel and Caravan Park (sleeps 20+, plus 5 caravan bays with water connections) overlooks Uyea Sound. In the surrounding area there are several B&B and self-catering holiday properties including Hamrigarth (sleeps 6), Murrister (sleeps 5), Mailersta (sleeps 4) and Da Fustra (sleeps 3).

Boats/Shipping

Boat traffic within the Uyea Sound area is largely associated with the fishery, salmon farming and leisure activities. Cooke Aquaculture Ltd operates a shorebase servicing salmon sites from Uyeasound Pier with a secondary base to the east located at the smaller eastside pier (Figures 20 and 21). Unst Shellfish also service mussel sites from Uyeasound Pier. Three workboats were berthed at Uyeasound pier and a workboat, 2 open inflatables and 2 pleasure boats were recorded at an adjacent pontoon on the day of the survey (Figures 22 and 23). A further workboat was out of the water at the head of the pier. There were no vessels noted at the smaller eastside pier. One workboat and a small open boat were recorded at the Westside Pier. Several blocks of salmon cages were observed in Uyea and Skuda Sounds, and a workboat was recorded harvesting from a salmon site close to Uyeasound Pier.

Farming and Livestock

The majority of the land observed during the survey around the production area was rough grazing.

On the island of Uyea approximately 55 sheep were observed, all with access to the shoreline. Two seals were hauled out on the island's pier and a further was noted in the water nearby.

Fifteen sheep with no access to the shore were noted on the eastern coastline of Uyeasound. Fourteen sheep were recorded in a fenced field to the west of Easter Loch at the head of the voe with no access to the shoreline.

Pony prints and faeces were noted in an enclosed field on the eastern coastline where no animals were present. A water pipe for livestock, possibly originating from a field spring, was provided in this field (Figure 24). Steep escarpments beyond the fence may restrict any livestock access to the shoreline in this area. Pony faeces were also noted in a grazing field with access to the beach to the north of Uyeasound pier.

Agricultural buildings were noted only once during the shoreline survey, situated on the eastern coast at Clivocast. These were well above the shoreline. Possible sheep pens were recorded near the head of the pier on Uyea Island.

Land Use and Land Cover

Uyea Isle

Rough grassland dominates the coastline of Uyea Island. The shoreline is characterised by bedrock and rocky outcrops interspersed with stony beaches. A number of high embankments limit access to the shore in places, though lowland areas typically characterise the areas surrounding the furthest east section of the shoreline walk. Heather is plentiful at higher elevations. Some boggy areas, dominated by moss in places, were noted at low level points close to the shoreline Uyea Island is uninhabited with the exception of livestock.

Uyeasound Coastline

The area of Uyeasound covered by the shoreline walk is predominately small settlements with a developed waterfront to both sides of the head of the voe, quickly returning to rough grassland and agricultural use beyond the limits of the area surveyed. High embankments, limiting access to the shoreline, typify the eastern extent of the walk where grazing fields dominate the landscape. A field cut for silage was recorded between Catafield and Cliva Skerries. Moving eastwards, elevation decreases to a low level shoreline dominated by pebbled beaches interspersed with occasional fine sand stretches at the head of the voe. The western coastline becomes increasingly rocky mixed with pebbled beach expanses.

Watercourses

Five watercourses were sampled during the shoreline survey, all of which were outlined on the sample plan. Two of the samples were obtained from watercourses on the island of Uyea (Figures 25 and 26), and three from around the head of Uyea Sound at a tributary of Easter Loch (Figure 27), a tributary of Scata Water (Figure 28) and the Burn of Gardie (Figure 29). Flow rates were recorded at all five watercourses sampled. A stagnant/minimal flow watercourse with signs of eutrophication was recorded at the furthest west point of the shoreline walk on Uyea Island (Figure 30). A small watercourse to the west of the caravan park at Gardie also contained an area of discoloured water (Figure 31).

Wildlife/Birds

Birds were observed in all areas surveyed with the exception of the western shoreline beyond Easter Loch. Common gulls, ravens, a fulmar and a snipe were recorded on Uyea Island. On the walk section from Clivocast to the Uyeasound pier 17 greylag geese, 29 crows and 6 fulmars were noted. Nine swans and 2 ducks were counted on Easter Loch.

Twenty three common gulls were present on the northern side of the fishery and some bird faeces were noted on mussel buoys.

Three seals were noted during the survey, 2 were disturbed from the pier as the boat approached Uyea Island, and another was spotted in the water a short distance away.

General observations

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

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

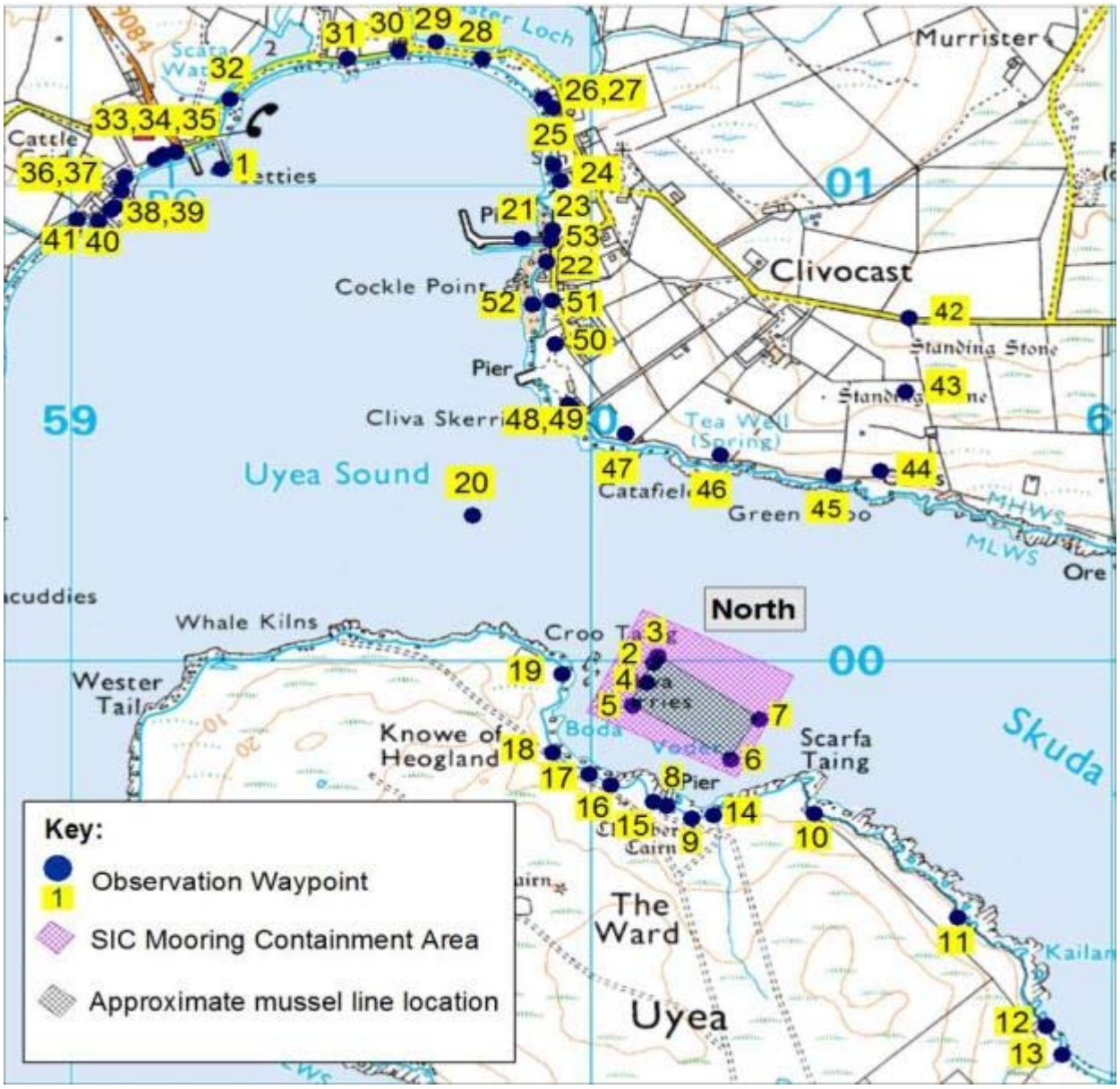

Figure 1 Map of shoreline observations Uyea Sound.

Table 1 Shoreline Observations

No	Date/Time (UT)	NGR	Easting	Northing	Associated Figure	Associated Sample	Description
1	20/11/14 08:05:21	HP 59288 01035	459288	1201035			North Uyea sanitary survey; Start of boatwork. Weather: High, scattered cloud cover, dry with light F1-F2 SE winds. Some sunny spells.
2	20/11/14 08:10:24	HU 60118 99995	460118	1199995	Figure 4	UYEA-MUSS-01 (top), UYEA-MUSS-02 (bottom) & UYEA-SW-01	Unst Shellfish's North fishery. Fishery consists of 8 x 220m lines with 6m droppers situated adjacent to the North East coastline of the island of Uyea. 2 mussel samples collected (no mussels available at the planned sample point so samples collected from second line on NW side of fishery); surface sample collected from top of a dropper, bottom sample collected from bottom of a dropper. Seawater sample collected. Salinity profile 1 collected (ppt/°C): 10m N/A, 5m 35.09/10.4, 3m 35.12/10.4, surface 35.11/10.2. Photo taken looking south across fishery to island of Uyea.
3	20/11/14 08:20:53	HP 60126 00008	460126	1200008			NW corner of North fishery. 7 common gulls on buoys.
4	20/11/14 08:21:59	HU 60104 99952	460104	1199952			RMP of North fishery.
5	20/11/14 08:23:15	HU 60078 99904	460078	1199904			SW corner of North fishery.

6	20/11/14 08:24:23	HU 60267 99790	460267	1199790	Figure 5	UYEA-MUSS-03 (top), UYEA-MUSS-04 (bottom) & UYEA-SW-02	SE corner of North fishery. 2 mussel samples collected; surface sample collected from top of a dropper, bottom sample collected from bottom of a dropper. Seawater sample collected. Salinity profile 2 collected (ppt/°C): 10m N/A, 5m 35.34/10.1, 3m 35.26/ 10.1, surface 35.32/10.1. Photo taken looking north across fishery.
7	20/11/14 08:33:56	HU 60322 99876	460322	1199876			NE corner of North fishery. 16 common gulls on buoys. Some bird faeces on buoys at the fishery.
8	20/11/14 08:37:52	HU 60143 99695	460143	1199695			Start of shoreline walk on island of Uyea. Sunny spells. 2 seals hauled out on pier disturbed (2 photos taken). Photo taken from pier looking back across fishery. Possible sheep enclosure above pier.
9	20/11/14 08:41:20	HU 60191 99667	460191	1199667			Rough grazing and heather land cover. Fenced field above shoreline but access to stony beach possible via gate. Sheep faeces present above shoreline. Some boggy areas. 1 seal in voe. 3 sheep and 1 common gull noted.

10	20/11/14 08:46:16	HU 60428 99678	460428	1199678			Shoreline becomes more rocky. 2 sheep noted on beach. 1 common gull, 1 fulmar, 1 snipe. Embankments becoming increasingly higher. Abundant heather.
11	20/11/14 08:54:13	HU 60702 99459	460702	1199459			Small field drain, not enough flow to measure. Rocky coastline.
12	20/11/14 08:59:38	HU 60873 99230	460873	1199230			Rough grazing field with access to beach. 30 sheep noted on hill above. Salmon farm site adjacent to coastline (photo taken of cages).
13	20/11/14 09:03:10	HU 60903 99169	460903	1199169	Figure 25	UYEA-FW-01	Planned freshwater sample collected from small unnamed watercourse running onto pebbled beach at further east point of Uyea island walk (No 5 in Table 3 of plan). Flow measurements recorded; Dimensions 10cm wide, 10cm deep. Flow 0.193cm/s and SD 0.007cm/s. 20 sheep noted beyond. 2 ravens. Photos taken of watercourse and beach beyond. Low level coastline.
14	20/11/14 09:23:21	HU 60234 99675	460234	1199675	Figure 26	UYEA-FW-02	Planned freshwater sample collected from small unnamed watercourse running onto shoreline (No 4 in Table 3 of plan). Flow measurements recorded; Dimensions 12cm wide, 4cm deep. Flow 0.209cm/s and SD 0.004.
15	20/11/14 09:31:43	HU 60118 99702	460118	1199702			Part of shoreline walk to west of pier. Rough grazing and heather landcover. Small stony beach followed by rocky outcrop.
16	20/11/14 09:33:15	HU 60036 99737	460036	1199737			Culvert under road cut into hill above shoreline. No flow noted.

17	20/11/14 09:34:08	HU 59995 99761	459995	1199761			Steep escarpments above stony beach, limited access to shoreline at this point. Sheep faeces near cliff edge. Some small boggy areas, often dominated by moss.
18	20/11/14 09:35:20	HU 59925 99806	459925	1199806			Small field drain, not enough flow to measure.
19	20/11/14 09:38:13	HU 59943 99971	459943	1199971	Figure 30		Stagnant watercourse with some signs of eutrophication at furthest west point of shoreline walk on island. End of island walk section.
20	20/11/14 09:51:35	HP 59771 00305	459771	1200305		UYEA-SW-03	Planned seawater sample collected from Uyea Sound. Salinity profile 3 collected (ppt/°C): 10m 35.29/10.3, 5m 35.29/10.3, 3m 35.28/10.3, surface 35.08/10.2.
21	20/11/14 10:22:36	HP 59867 00888	459867	1200888	Figure 8, Figure 22 & Figure 23		Start of shoreline walk section on mainland Unst to the west of Uyeasound Pier. 3 workboats berthed at pier, also a Voe boat, 2 open inflatables and 2 pleasure boats berthed at an adjacent pontoon. A further workboat out of the water at the head of the pier. Settlement of houses and associated buildings above the pier. Cooke Aquaculture Ltd's shorebase is situated at the head of the pier. Photos taken.
22	20/11/14 10:27:45	HP 59913 00839	459913	1200839		UYEA-SW-04	Planned sea water sample collected from side of pier at the first point of access from which it was deemed safe to do so.
23	20/11/14 10:31:46	HP 59925 00906	459925	1200906	Figure 9		Plastic drainage pipe under road draining to sea, no flow detected.

24	20/11/14 10:34:58	HP 59940 01010	459940	1201010	Figure 10		Septic tank pipe observation cover recorded below old school buildings, currently being converted to a dwelling house. 2 outlet pipes onto beach with ends visible, no flow recorded from either pipe. 2 photos taken.
25	20/11/14 10:38:11	HP 59927 01042	459927	1201042	Figure 11		Grazing field with access to beach, pony faeces present. 1 dwelling house on upper side of road, outlet pipe on beach below did not appear to be in use, on examination found to be completely dry. Photo taken.
26	20/11/14 10:41:47	HP 59925 01163	459925	1201163			Field drain with no flow. Some field Iris growing beside drain. Pebbled beach below. 2 dwelling houses above road.
27	20/11/14 10:43:21	HP 59906 01184	459906	1201184	Figure 12		Possible sewage pipe draining to sea, end of pipe not visible. Pebbled/sandy beach. Photo taken. Empty Polar Cirkel salmon cages moored just off beach.
28	20/11/14 10:47:45	HP 59790 01268	459790	1201268			Road in close proximity to beach with large body of water (Easter Loch) beyond on upper side of road. 9 swans and 2 ducks recorded on loch. 2 photos taken.
29	20/11/14 10:50:39	HP 59700 01302	459700	1201302	Figure 27	UYEA-FW-03	Planned freshwater sample collected, flow through culvert under road from Easter Loch, exiting through pipe into sea (No 3 in Table 3 of plan). Flow measurements recorded; Dimensions: 80cm wide, 14cm deep. Flow 0.487 cm/s and SD 0.035 cm/s. 2 photos taken, 1 at sample point where flow enters culvert, 1 of outlet to sea. 14 sheep noted in fenced field west of loch on the upper side of road.

30	20/11/14 10:56:16	HP 59630 01284	459630	1201284	Figure 13		Roads runs alongside beach. 2 dwelling houses on upper side of road. Piped outlet to sea, no discharge. Pebbled/Sandy beach.
31	20/11/14 10:59:17	HP 59530 01267	459530	1201267			Community Hall and 2 dwelling houses above road. Pipe running to sea on lower side of road with no visible discharge.
32	20/11/14 11:04:29	HP 59306 01182	459306	1201182	Figure 28	UYEA-FW-04	Planned freshwater sample collected (No 2 in Table 3 of plan), flow from Scata Water through culvert under road onto pebbled beach. Flow measurements taken; Dimensions 280cm wide, 4cm deep. Flow 0.328cm/s and SD 0.021cm/s.
33	20/11/14 11:11:37	HP 59202 01069	459202	1201069			Jetties on the west coast of Uyeasound (3 photos taken). 1 workboat and 1 small open boat tied up at pier. 2 dwelling houses above road.
34	20/11/14 11:44:49	HP 59176 01065	459176	1201065	Figure 14, Figure 15 & Figure 16	UYEA-SW-05	Public toilets on upper side of road. Associated septic tank and outlet pipe to sea identified. Additional sea water sample taken near outlet pipe.
35	20/11/14 11:46:02	HP 59162 01055	459162	1201055			Small caravan park next to public toilets above shoreline. Youth Hostel on hill above.
36	20/11/14 11:48:41	HP 59103 01017	459103	1201017	Figure 31		Small watercourse running onto beach, minimal flow. Discolouration of water (2 photos).
37	20/11/14 11:50:35	HP 59097 00989	459097	1200989			1 dwelling house above beach. Piped outlet on beach, end of pipe visible, no outflow.
38	20/11/14 11:53:30	HP 59084 00954	459084	1200954	Figure 17		Concrete pipe on beach below 1 dwelling house and 1 derelict house. No discharge from pipe.

39	20/11/14 11:55:53	HP 59076 00947	459076	1200947	Figure 18		Ceramic pipe onto pebbled beach, no outflow noted.
40	20/11/14 11:56:43	HP 59053 00925	459053	1200925	Figure 19		Pipe across beach into sea, end not visible underwater, below 1 dwelling house above beach. 2 photos taken.
41	20/11/14 11:59:11	HP 59011 00929	459011	1200929	Figure 29	UYEA-FW-05	Burn of Gardie, small watercourse running onto beach (2 photos). Planned freshwater sample collected (No 1 in Table 3 of plan). Flow measurements recorded; Dimensions 65cm wide, 5 cm deep. Flow 0.522cm/s and SD 0.012cm/s. 2 dwelling houses situated a good distance from the shoreline. 1 photo taken looking towards Uyea isle. End of walk section from Uyeasound Pier to Burn of Gardie.
42	20/11/14 12:41:11	HP 60609 00721	460609	1200721			Start of walk section from Clivocast to Uyeasound Pier. Fenced grazing field with sheep faeces present. 17 greylag geese in flight.
43	20/11/14 12:45:07	HP 60603 00565	460603	1200565			Fenced grazing field. Goose and pony faeces present. 7 crows in flight.
44	20/11/14 12:48:33	HP 60555 00399	460555	1200399	Figure 24		Water provision for livestock, possibly originating from field spring. Excess water flows towards embankments and possibly to sea. Photo taken. Pony hooves noted. 1 fulmar.
45	20/11/14 12:53:44	HP 60464 00388	460464	1200388			Fenced field above high cliffs. No access to shoreline. 15 crows, 5 fulmars.

46	20/11/14 12:58:58	HP 60248 00432	460248	1200432			Fenced field cut for silage. Rocky beach below, no access to shoreline due to high embankment. 1 house and several agricultural buildings on hill above a good distance from the shoreline.
47	20/11/14 13:08:18	HP 60065 00476	460065	1200476			Fenced grazing field with 15 sheep, no access to shore. 7 crows in flight.
48	20/11/14 13:11:09	HP 59961 00530	459961	1200530	Figure 20 & Figure 21		Cooke Aquaculture Ltd shorebase and pier with associated buildings and equipment (secondary shorebase; main shorebase at Uyeasound Pier). No workboats noted at this pier. 3 photos taken.
49	20/11/14 13:11:22	HP 59956 00538	459956	1200538			Small settlement of approximately 20 houses on upper side of road.
50	20/11/14 13:16:29	HP 59930 00666	459930	1200666			Small field drain running onto beach, not enough flow to measure.
51	20/11/14 13:19:21	HP 59923 00758	459923	1200758	Figure 6		Community Discharge - Uyeasound STW. Photos taken.
52	20/11/14 13:21:53	HP 59886 00749	459886	1200749	Figure 7	UYEA-SW-06	Additional seawater sample collected from near where community discharge outlet pipe enters sea. Photos taken.
53	20/11/14 13:28:21	HP 59921 00884	459921	1200884			End of walk section Clivocast to Uyeasound Pier.

Sampling

Water and shellfish samples were collected at the locations indicated in Figures 2 and 3. All of the five freshwater samples detailed in the survey plan were obtained. Two additional seawater samples were obtained; one from the end of an outlet pipe below the public toilets near Gardie and another from the end of an outlet pipe below Uyeasound STW community discharge. All samples were transported initially by a cool backpack and then in a cool box to SSQC Ltd. for analysis within 24 hours of sample collection.

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

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

Table 2 Water sample *E.coli* results

No.	Sample Ref.	Date/Time (UT)	Position	Type*	*E.coli* (cfu/100ml)	Salinity**
1	UYEA-SW-01	20/11/14 08:10:24	HU 60118 99995	SW	<1	34.43
2	UYEA-SW-02	20/11/14 08:24:23	HU 60267 99790	SW	1	34.95
3	UYEA-FW-01	20/11/14 09:03:10	HU 60903 99169	FW	7	-
4	UYEA-FW-02	20/11/14 09:23:21	HU 60234 99675	FW	3	-
5	UYEA-SW-03	20/11/14 09:51:35	HP 59771 00305	SW	1	34.74
6	UYEA-SW-04	20/11/14 10:27:45	HP 59913 00839	SW	18	34.57
7	UYEA-FW-03	20/11/14 10:50:39	HP 59700 01302	FW	13	-
8	UYEA-FW-04	20/11/14 11:04:29	HP 59306 01182	FW	23	-
9	UYEA-SW-05	20/11/14 11:44:49	HP 59176 01065	SW	5	30.16
10	UYEA-FW-05	20/11/14 11:59:11	HP 59011 00929	FW	16	-
11	UYEA-SW-06	20/11/14 13:21:53	HP 59886 00749	SW	41	21.63

*FW = freshwater, SW = seawater **Practical Salinity Scale 1978 (PSS-78)

Table 3 Shellfish sample *E.coli* results

No.	Sample Ref.	Date/Time (UT)	Position	Type	Depth	*E.coli* (MPN/100g)
1	UYEA-MUSS-01	20/11/14 08:10:24	HU 60118 99995	Common Mussels	Top	<18
2	UYEA-MUSS-02	20/11/14 08:10:24	HU 60118 99995	Common Mussels	Bottom	<18
3	UYEA-MUSS-03	20/11/14 08:24:23	HU 60267 99790	Common Mussels	Top	<18
4	UYEA-MUSS-04	20/11/14 08:24:23	HU 60267 99790	Common Mussels	Bottom	<18

Table 4 Salinity profiles

Profile	Date/Time (UT)	Position	Depth (m)	Salinity (ppt) (± 0.35 ppt)	Temperature (°C)
1	20/11/14 08:10:24	HU 60118 99995	Surface	35.11	10.2
			3	35.12	10.4
			5	35.09	10.4
			10	N/A	N/A
2	20/11/14 08:24:23	HU 60267 99790	Surface	35.32	10.1
			3	35.26	10.1
			5	35.34	10.1
			10	N/A	N/A
3	20/11/14 09:51:35	HP 59771 00305	Surface	35.08	10.2
			3	35.28	10.3
			5	35.29	10.3
			10	35.29	10.3

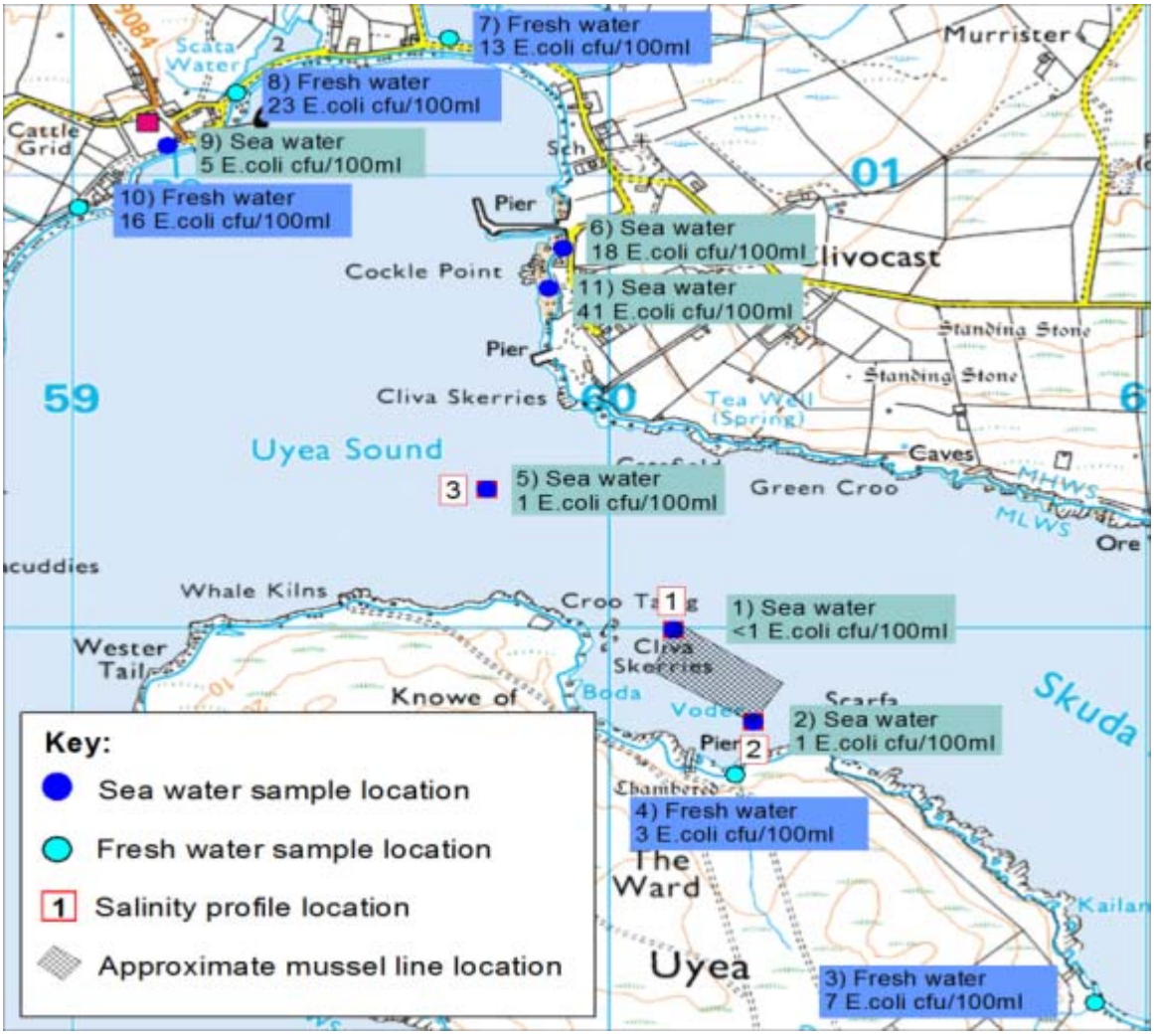

Figure 2 Map of water sample results and salinity profile locations at Uyea Sound.

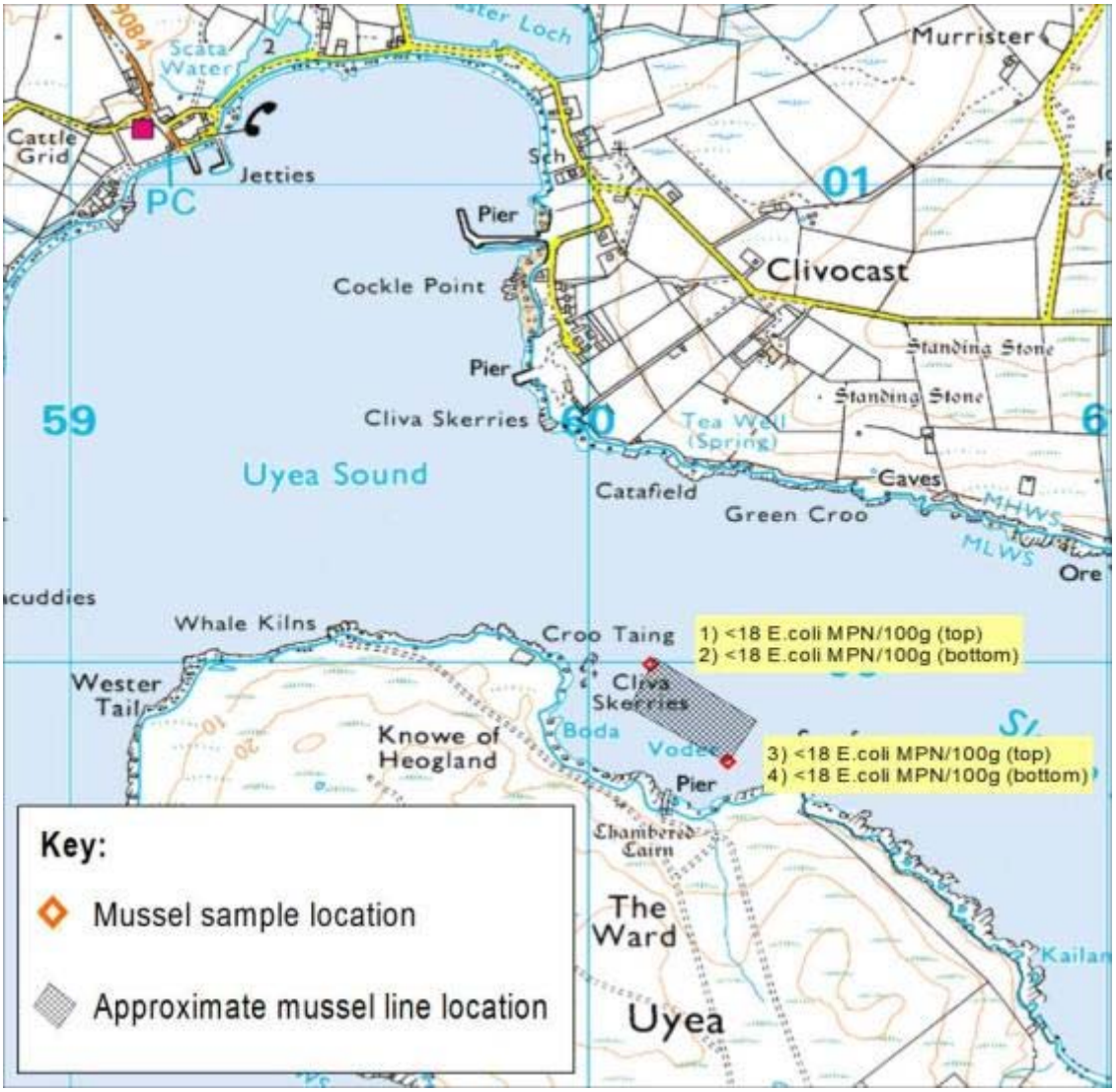

Figure 3 Map of shellfish sample results at Uyea Sound.

Photographs

Figure 4 – Mussel lines at the North fishery looking south.

Figure 5 – Mussel lines at the North fishery looking north.

Figure 6 – Uyeasound STW Community discharge.

Figure 7 – Outfall pipe for Uyeasound STW Community discharge.

Figure 8 – Cooke Aquaculture Ltd's shorebase at top of Uyeasound Pier.

Figure 9 – Plastic pipe (no outflow) near Uyeasound Pier.

Figure 10 – Two outlet pipes below old school buildings (no discharge).

Figure 11 – Outlet pipe below 1 dwelling house on eastern coastline (no discharge).

Figure 12 – Possible sewage pipe to the east of Easter Loch.

Figure 13 – Outlet to sea (no visible discharge) west of Easter Loch.

Figure 14 – Public toilets beyond the Westside pier.

Figure 15 – Septic tank associated with public toilets.

Figure 16 – Outflow from septic tank below public toilets.

Figure 17 – Plastic pipe with no outflow on western shoreline.

Figure 18 – Pipe across beach on western shoreline.

Figure 19 – Pipe running into sea near westernmost point of shoreline walk.

Figure 20 – Second Cooke Aquaculture Ltd shorebase.

Figure 21 – Eastside Pier below second Cooke Aquaculture Ltd shorebase.

Figure 22 – Workboats at Uyeasound Pier.

Figure 23 – Pontoon and boats adjacent to Uyeasound Pier.

Figure 24 – Livestock water provision on eastern coast.

Figure 25 – Freshwater sample collected on island of Uyea (No 5)

Figure 26 – Freshwater sample collected on island of Uyea (No 4).

Figure 27 – Freshwater sample collected from Easter Loch.

Figure 28 – Freshwater sample collected from Scata Water.

Figure 29 – Burn of Gardie.

Figure 30 – Stagnant watercourse on island of Uyea.

Figure 31 – Discolouration in watercourse on western coastline.

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6. SEPA Discharge Consents

Licence No.	NGR	Discharge Type	Discharges to	Op	PE
CAR/L/1001845	HP 56888 01570	Fish Farm Freshwater Cage			
CAR/L/1001847	HP 59456 01630	Fish Farm Freshwater Tank or Hatchery			
CAR/L/1001927	HU 59650 98750	Fish Farm Marine Cage			
CAR/L/1001950	HP 60158 01006	Fish Farm Freshwater Tank or Hatchery			
CAR/L/1002345	HP 56300 01100	Fish Farm Freshwater Cage			
CAR/L/1003867	HU 61100 99457	Fish Farm Marine Cage			
CAR/L/1003868	HU 56397 99934	Fish Farm Marine Cage			
CAR/L/1003886	HU 57071 99462	Fish Farm Marine Cage			
CAR/L/1004026	HP 59872 00853	Sewage (Public) Primary	Uyea Sound	=	250
CAR/L/1004070	HU 58700 99800	Fish Farm Marine Cage			
CAR/L/1004215	HP 59700 00200	Fish Farm Marine Cage			
CAR/L/1004216	HP 58978 00398	Fish Farm Marine Cage			
CAR/L/1005091	HU 59600 98900	Fish Farm Marine Cage			
CAR/L/1008750	HP 56400 00000	Fish Farm Marine Cage			
CAR/L/1008751	HU 58400 99340	Fish Farm Marine Cage			
CAR/L/1008781	HU 58080 98710	Fish Farm Marine Cage			
CAR/L/1011474	HP 59505 01794	Abstraction Return			
CAR/L/1011474	HP 59505 01794	Impoundment Fish Production			
CAR/L/1011474	HP 59504 01795	Abstraction Fish Production			
CAR/L/1011481	HP 60100 00900	Abstraction Fish Production			
CAR/L/1011481	HP 60152 01010	Abstraction Return			
CAR/L/1015761	HP 59700 00800	Fish Farm Marine Cage			
CAR/L/1022801	HP 56557 00524	Sewage (Public) Primary	Wick of Belmont	<	15
CAR/R/1007732	HP 59560 03780	Sheep Dip onto Land			
CAR/R/1016089	HP 58908 01753	Sewage (Private) Primary	Land	=	6
CAR/R/1047362	HP 62950 00679	Sewage (Private) Primary	Soakaway	<=	5
CAR/R/1047371	HP 62980 00710	Sewage (Private) Primary	Soakaway	<=	5
CAR/R/1047372	HP 58840 01100	Sewage (Private) Primary	Soakaway	<=	5
CAR/R/1047435	HP 60227 01850	Sewage (Private) Primary	Soakaway	<=	5
CAR/R/1057768	HP 58750 00990	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1057783	HP 62980 01300	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1057845	HP 58770 00630	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1057847	HP 58660 00770	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1057899	HP 60513 01767	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1059213	HP 59150 01230	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1067217	HP 59810 01856	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1067232	HP 58614 01843	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1067314	HP 60270 00630	Sewage (Private) Primary	Land	=	6
CAR/R/1069757	HP 63047 01049	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1078688	HP 59160 01210	Sewage (Private) Primary	Soakaway	=	15
CAR/R/1082617	HP 59480 01380	Sewage (Private) Primary	Soakaway	=	5
CAR/R/1105195	HP 60310 00860	Sewage (Private) Primary	Land	=	6

LS=Land/Soakaway, SW= Seawater Body, FW= Freshwater Body, PE= Population Equivalent, - = Not applicable