Scottish Sanitary Survey Project

Sanitary Survey Report
Uyea Sound, Swarbacks Minn & Vementry: Braga Ness
SI 441, SI 487 & SI 508
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Report Distribution – Uyea Sound, Swarbacks Minn & Vementry: Braga Ness

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* Distribution of both draft and final reports to relevant agency personnel and harvesters is undertaken by FSAS.

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1. General Description

Uyea Sound is the northern half of a sound which separates the isle of Vementry from mainland Shetland. The sound joins Swarbacks Minn in the north and Cribba Sound in the south. To the east lies The Rona and beyond that, Aith Voe. Swarbacks Minn is open to the Atlantic Ocean in the west. Uyea sound itself is relatively shallow, reaching only 15m depths (Hope, 2010). The Isle of Vementry is uninhabited. The nearest village is Aith approximately 5.5 km south-east of the sound.

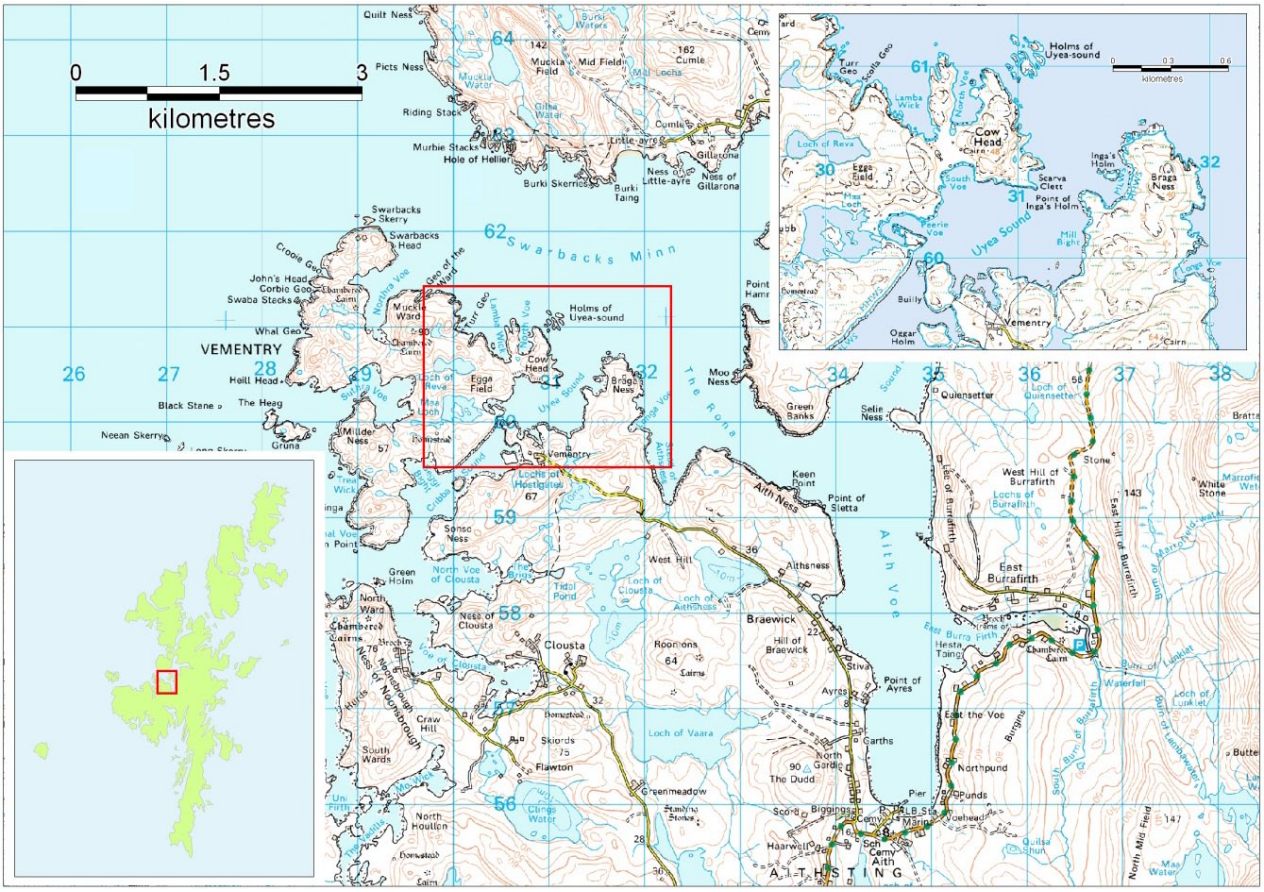

Figure 1.1 Location of Uyea Sound

2. Fishery

The sanitary survey was prompted by applications for classification of three new sites in Uyea Sound, as listed in Table 2.1. Although these sites were assigned separate production area designations, all three lie in relatively close proximity to one another within Uyea Sound. Consequently, the three sites have been considered together under a single survey. The Cow Head site was classified in 2010/2011 and production area boundaries were set as the area bounded by lines drawn between HU 3715 3150 to HU 3760 3152 and HU 3715 3260 to HU 3724 3260. The RMP was established at HU 306 601. Sampling points reported by Shetland Island Council are identified in Table 2.1. Comparison of the recorded mussel farm locations and reported sampling points showed an error in the recording of sampling locations. The sampling officer re-checked locations, recording them to 100 m accuracy. The corrected grid references are provided below.

Table 2.1 Uyea Sound Mussel Farms

Production Area	Site	SIN	Species	Sampling point	Corrected sampling point
Swarbacks Minn: Uyea Sound	Holms of Uyea Sound	SI 487 842	Common Mussels	HU 311 606	HU 3125 6064
Uyea Sound	Cow Head	SI 441 845	Common Mussels	HU 306 601	HU 3065 6019
Vementry Braga Ness	Braga Ness	SI 508 874	Common Mussels	HU 312 599	HU 3123 6000

The Holms of Uyea Sound mussel site (SI 487 842) is operated by Vementry Salmon. At the time of shoreline survey in June 2010, it consisted of one double-headed long line with 8 m deep droppers. The harvester planned to harvest the site towards the end of 2010 and indicated that he intended to slowly increase the number of lines at this site over time.

The Cow Head site (SI 441 845) is operated by Vementry Salmon and consisted of five double-headed long lines at the time of survey. The three lines closest to the shore had 8 m deep droppers, and the other two had no droppers at the time. The harvester planned to harvest stock towards the end of 2010, and also to slowly increase the number of lines at this site in the future.

The Braga Ness site (SI 508 874) is operated by Suthra Voe Shellfish and consisted of four mussel rafts with 10 m droppers.

Harvesting may be undertaken year-round, in accordance with demand. Figure 2.1 shows the relative positions of the mussel line as recorded in June, the permitted seabed lease area and the locations of the sampling points. For the purposes of illustration, the GIS file provided by Shetland Islands Council is used to represent the area approved for installation of the aquaculture sites as it coincides with the Crown Estate lease areas.

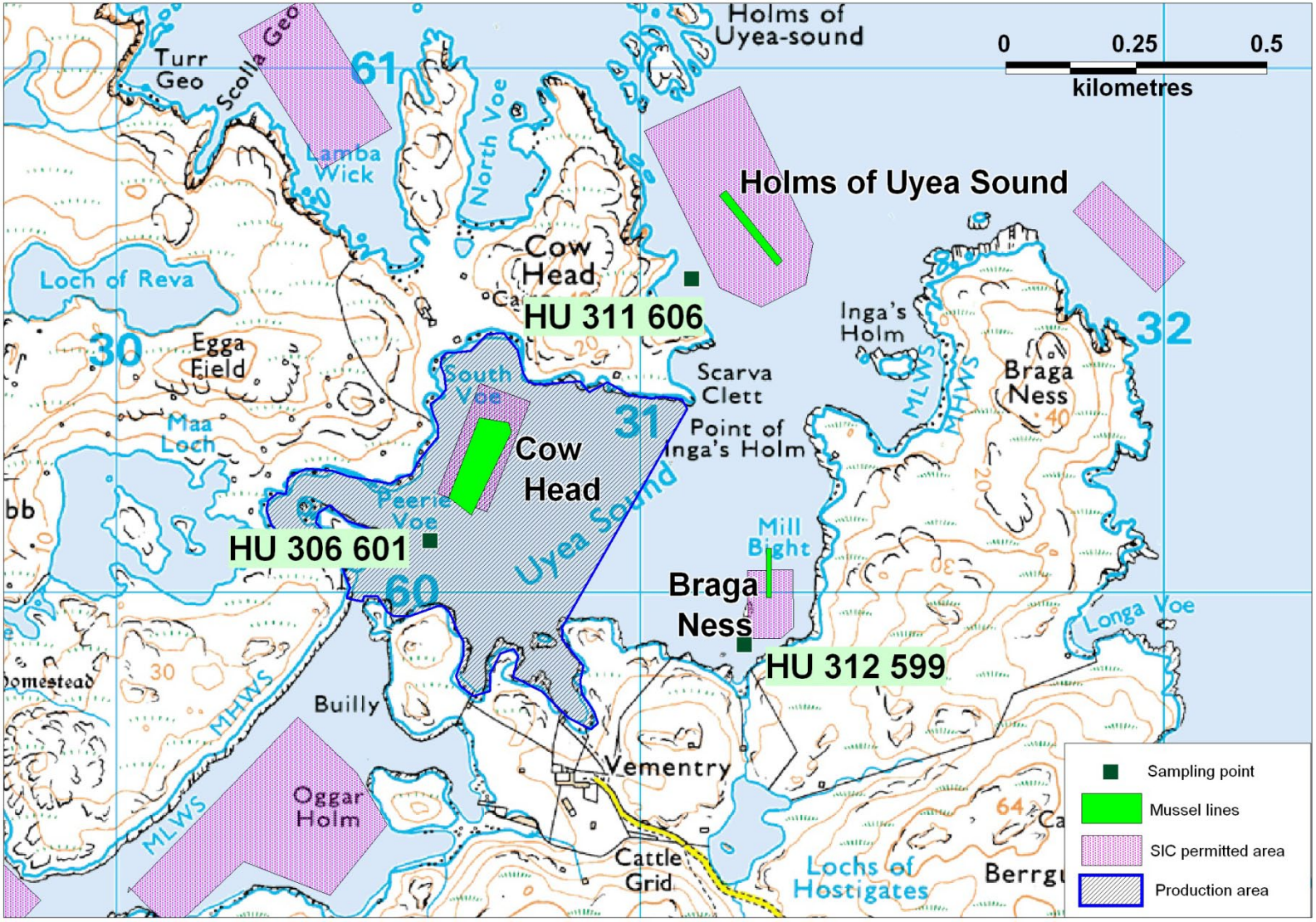

Figure 2.1 Uyea Sound Mussel Fisheries

3. Human Population

Figure 3.1 shows information obtained from the General Register Office for Scotland on the population within the census output areas in the vicinity of Uyea Sound. The last census was undertaken in 2001.

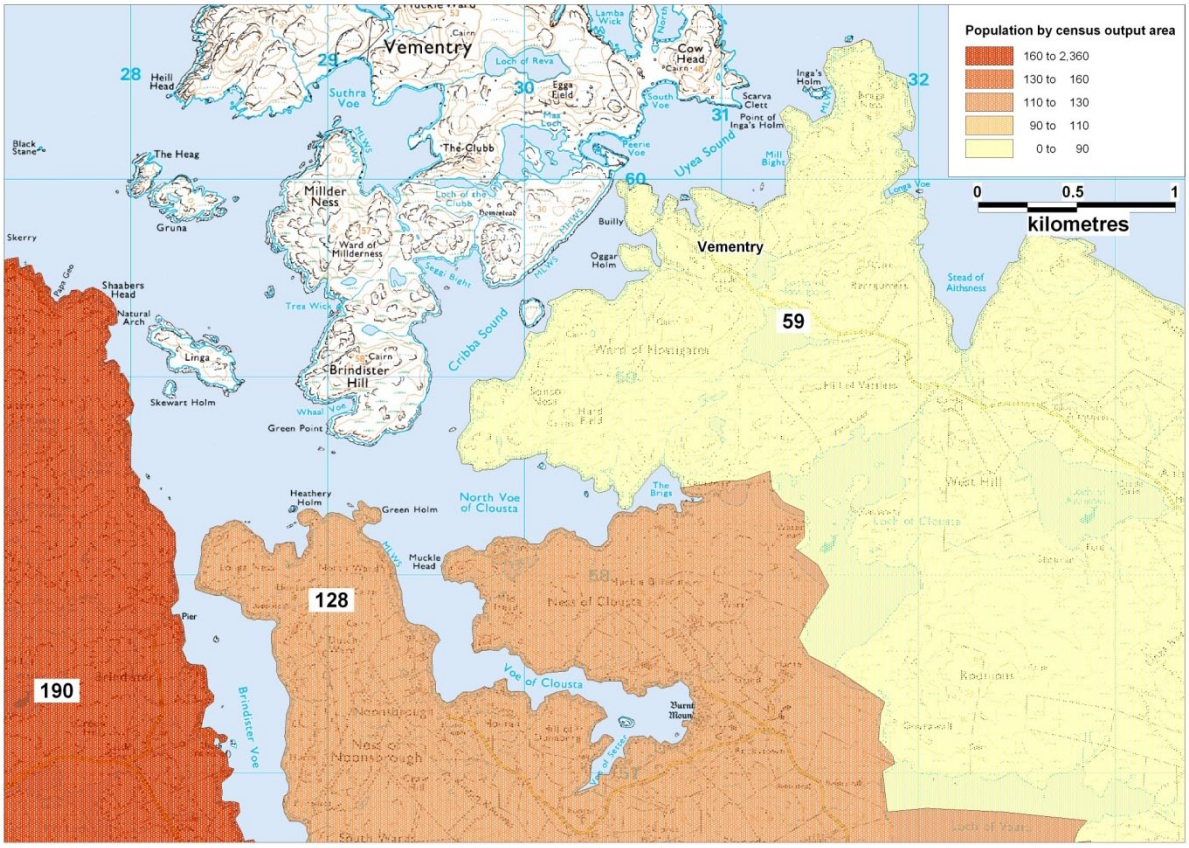

Figure 3.1 Human population adjacent to Uyea Sound

There are three population census areas within the proximity of Uyea Sound, with populations of 59, 128 and 190, although only a small fraction of the population live directly on the coastline.

There are no large settlements in the area surrounding Uyea Sound. During the shoreline survey, a small farm with outbuildings, one large house and two holiday lets were observed in Vementry to the south of Uyea Sound. No other dwellings were observed in the surrounding area. The census areas immediately surrounding Uyea Sound are relatively large and sparsely populated. The holiday lets suggest the population in the area may increase to a small extent during summer months.

Therefore, any inputs from human sewage are likely to be mainly found at Vementry, and may be slightly higher during the summer months.

4. Sewage Discharges

Information on discharges in the vicinity of Uyea Sound was solicited from Scottish Water and the Scottish Environment Protection Agency (SEPA). No community discharges were identified by Scottish Water for this area. While several discharge consents were identified by SEPA for the wider area around Uyea Sound, none were for discharges within either Uyea Sound or nearby waters and there were no consents for discharges to land within the area shown in Figure 4.1.

Two septic tanks were identified during the shoreline survey. Details of these can be found in Table 4.3 below.

Table 4.1 Discharges and septic tanks observed during shoreline surveys

No.	Date	NGR	Description
1	19/05/2010	HU 30896 59727	Septic tank and possible outfall, sewage-related debris
2	19/05/2010	HU 30855 59550	Septic tank and 2 holiday homes

The septic tank with outfall pipe was located near a shed and jetty at the head of a small inlet off the main body of Uyea Sound. The discharge is approximately 480 m southeast of the mussel lines at Cow Head and 670 m southwest of the Braga Ness mussel lines. Although no information was available regarding the size and treatment level of the discharge, the presence of sewage-related debris indicates that gross solids are being discharged. There is little in the way of development or habitation in the area, therefore even if untreated, the discharge is likely to be very small. The other septic tank is located slightly further inland and near to an inlet off Cribba Sound, to the south of Uyea Sound. It is not known whether this tank discharges to land or a nearby watercourse.

Overall, the risk of contamination to waters around the fishery from human sewage discharges is low. Any impact from the observed septic tanks is most likely to affect the mussel farms in the inner Sound.

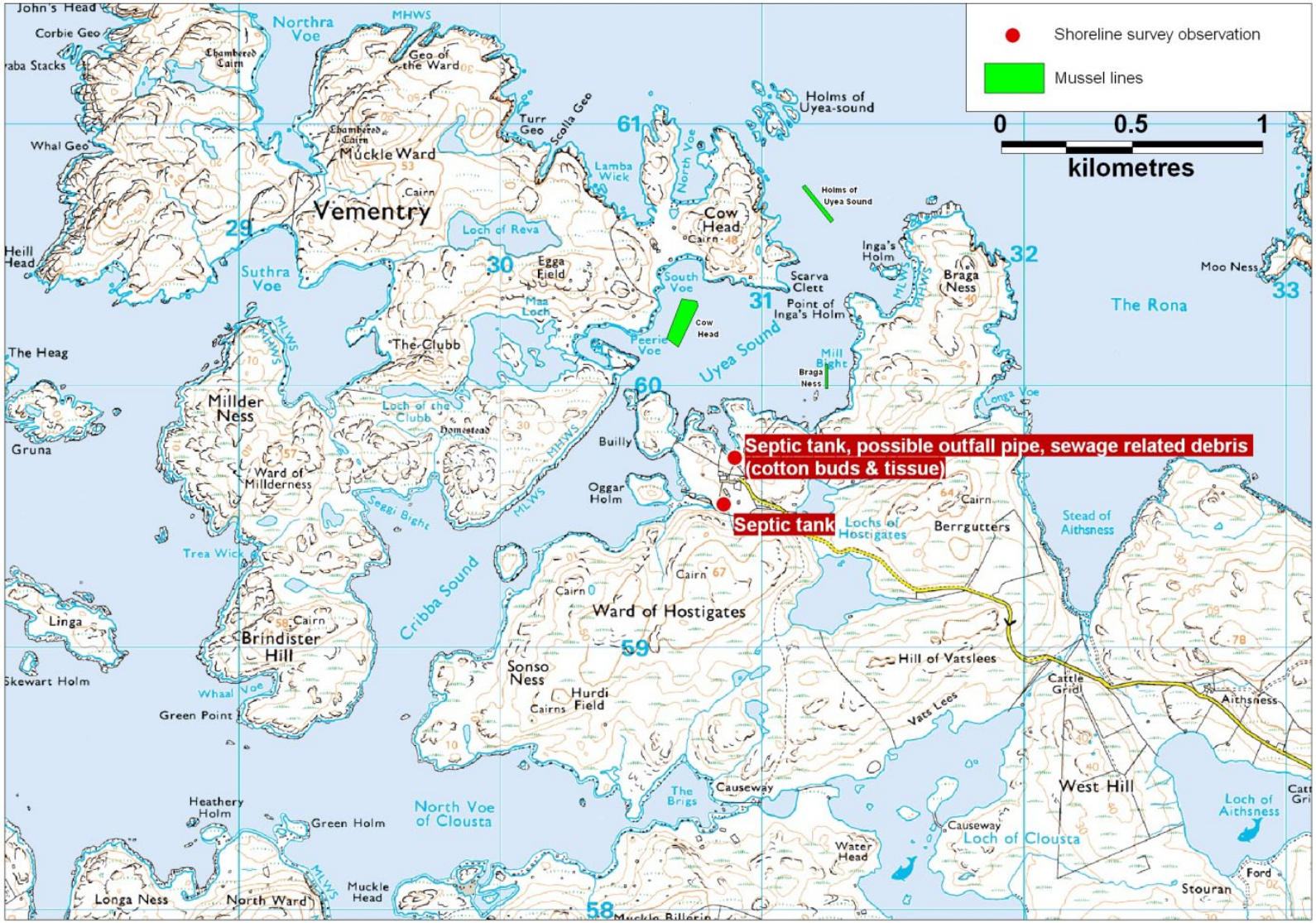

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Figure 4.1 Map of discharges for Uyea Sound

5. Geology and Soils

Geology and soil types were assessed following the method described in Appendix 3. A map of the resulting soil drainage classes is shown in Figure 5.1. Areas shaded blue indicate freely draining soils and areas shaded red indicate poorly draining soils.

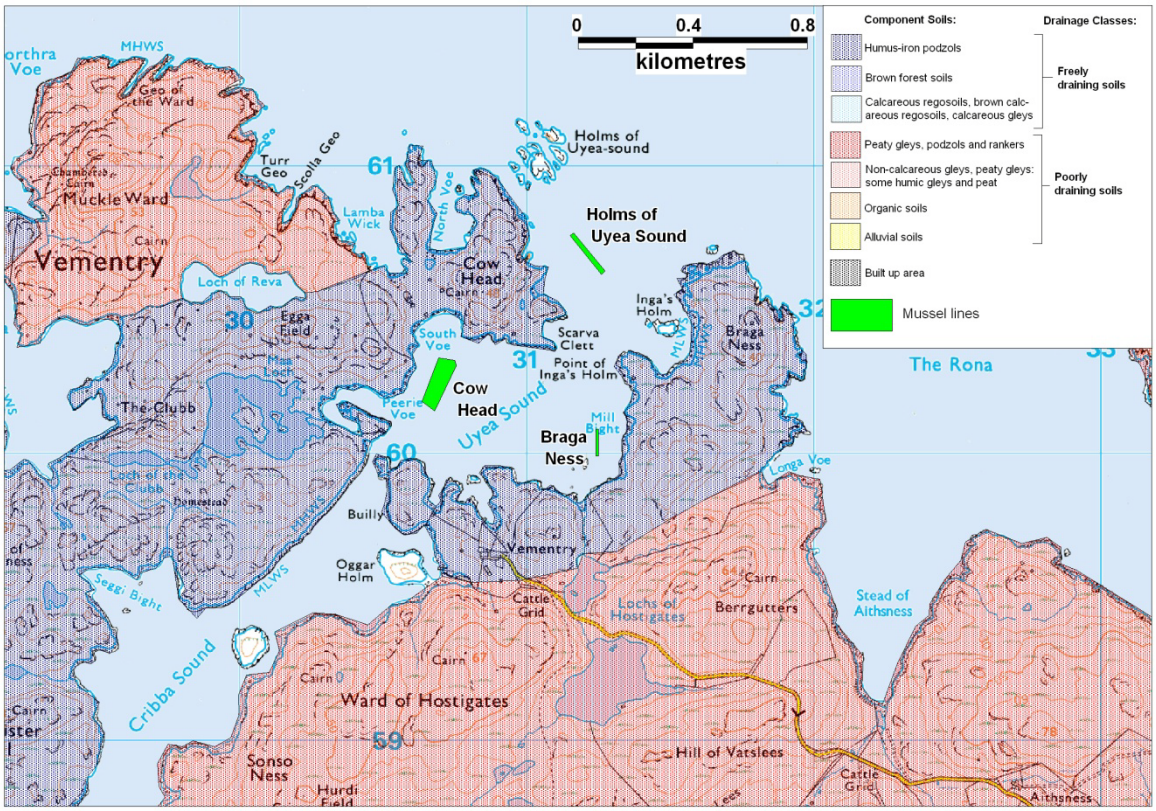

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Figure 5.1 Component soils and drainage classes for Uyea Sound

Two types of component soils are present in the area: peaty gleys, podzols and rankers and humus-iron podzols. The humus-iron podzols directly adjacent to Uyea Sound are freely draining and the peaty gleys, podzols and rankers at the north end of Vementry Island and east of Cribba Sound are poorly draining. Therefore, the potential for runoff contaminated with *E. coli* from human and/or animal waste will be higher south of Uyea Sound, along the south-east side of Cribba Sound, as well as to the Lochs of Hostigates. These two freshwater lochs discharge to Uyea Sound via a stream south of Braga Ness.

6. Land Cover

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

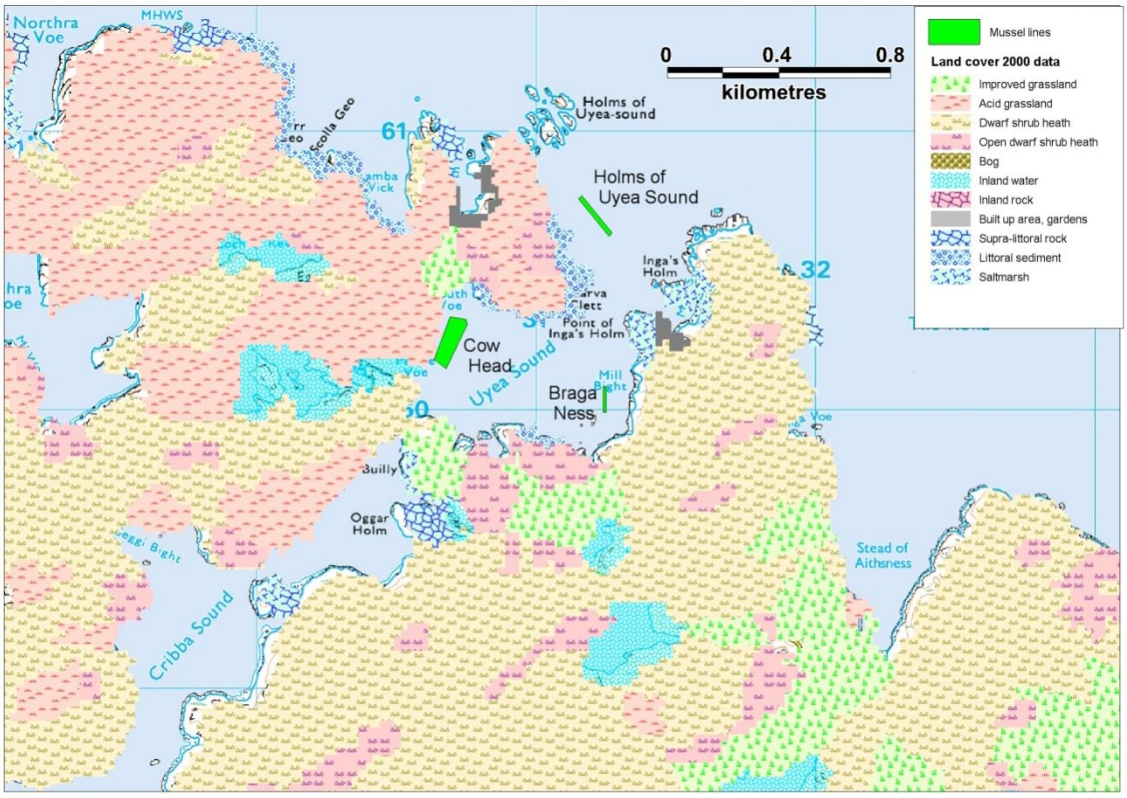

Figure 6.1 LCM2000 class land cover data for Uyea Sound

The land south of Uyea Sound is predominantly heath with an area of improved grassland close to the southern shoreline. Acid grassland dominates along the northern shore, with an area of improved grassland located north of the Cow Head mussel site.

Areas northeast of the Braga Ness site and north of the Cow Head site that have been identified as built-up are actually unpopulated. Areas identified as improved grassland are located at the head of the sound, on the shoreline immediately north of the Cow Head site and south of the shoreline south of the Braga Ness sites.

Studies undertaken by Kay et al (2008) found that faecal indicator organism export coefficients for faecal coliform bacteria were highest for urban catchment areas (approx 1.2 – 2.8x10^{9} cfu km^{-2} hr^{-1}) and lower for areas of improved grassland (approximately 8.3x10^{8} cfu km^{-2} hr^{-1}) and rough grazing (approximately 2.5x10^{8} cfu km^{-2} hr^{-1}) areas. Lowest contributions would be expected from areas of woodland (approximately 2.0x10^{7} cfu km^{-2} hr^{-1}) (Kay *et al*. 2008). The contributions from all land cover types would be expected to increase significantly after marked rainfall events, however this effect would be particularly marked from improved grassland areas (roughly 1000-fold) (Kay *et al*. 2008).

Therefore, the overall predicted contribution of contaminated runoff from these land cover types would be intermediate, and would be expected to increase significantly following rainfall events. It is likely that the areas of shoreline with improved grassland, (in particular the southern shoreline of Uyea Sound and the northern end of the Cow Head site) will be subject to higher levels of contamination.

7. Farm Animals

Agricultural census data was requested for the parish Aithsting from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD). Reported livestock populations for the parish in 2008 and 2009 are listed in Table 7.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data. Any entries which relate to less than five holdings, or where two or fewer holdings account for 85% or more of the information, are replaced with an asterisk.

Table 7.1 Livestock numbers in the Aithsting agricultural parish 2008 - 2009

	Aithsting			
	2008		2009	
	Holdings	Numbers	Holdings	Numbers
Pigs	*	*	0	0
Poultry	15	215	17	226
Cattle	12	302	13	304
Sheep	72	19,764	73	19,660
Horses and ponies	8	37	7	17

* Data withheld for reasons of confidentiality

Aithsting agricultural parish was significantly dominated by sheep, however due to the large size of the parish, and the withheld data, an accurate representation of the amount of livestock directly surrounding the shellfishery is therefore only available from the shoreline survey (see Section 15 and Appendix 7). This data relates only to the time of the site visit on 19th – 20th May 2010. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 7.1.

A total of 138 sheep and 15 horses or ponies were observed during the shoreline survey on the shore surrounding Uyea Sound. Sheep had access to the shoreline and were observed on the beach in places. Horse droppings were observed along the shoreline throughout the field where they were being grazed. The 13 Shetland ponies were being kept in a field next door to a farmhouse and barn at Vementry, which also had a field of approximately 22 sheep nearby.

The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 7.1.

The majority of livestock animals were observed along the south shore of Uyea sound, in the vicinity of the farm at Vementry. Faecal material from livestock around the sound will contribute to background levels of contamination, particularly at sites within the inner part of the sound.

Figure 7.1 Livestock observations at Uyea Sound

8. Wildlife

The Loch of Clousta Site of Special Scientific Interest (SSSI) lies approximately 1.5 km south of Uyea Sound. The Loch of Clousta is designated due to its 'tall herb ledge', which describes the vegetation growing on the holms and islands in the loch, which retain Shetlands natural vegetation as it is inaccessible for sheep grazing. Further west, the Ness of Clousta SSSI is designated for its igneous old red sandstone.

General information related to potential risks to water quality by wildlife can be found in Appendix 4. A number of wildlife species present or likely to be present at or near Uyea Sound could potentially affect water quality around the fisheries.

Seals
Shetland hosts significant populations of both European harbour, or common, seals (*Phoca vitulina vitulina*) and grey seals (*Halichoerus grypus*).

A survey conducted by the Sea Mammal Research Unit in 2001 estimated a population of 856 common seals in St Magnus Bay (SMRU, 2002), which includes the area of Uyea Sound. Shetland seal populations were reported to have declined substantially when resurveyed in 2006, though no specific numbers were available. The closest haulout site identified during this survey was on the island of Papa Little, where between 6 and 10 individuals were recorded.

Minimum grey seal pup production in Shetland was estimated at 943 in 2004. Adult numbers are estimated to be 3.5 times the pup population (Callan Duck, Sea Mammal Research Unit, personal communication). The closest identified breeding colony was at Muckle Roe, which lies to the north of Uyea Sound. Pup production here was estimated at 23 in 2004, which would imply an adult population in the area of about 80.

Therefore it is likely that both species of seals are regularly present in the area. Eighteen seals were observed during the shoreline survey, with 10 seen northeast of the Braga Ness site, near Inga's Holm and 6 seen north of Oggar Holm, to the south of Uyea Sound.

Whales/Dolphins
A variety of whales and dolphins are routinely observed near Shetland. It is possible that cetaceans will be found from time to time in the area, although the larger species will not visit this area as it is fairly shallow and enclosed. Any impact of their presence is likely to be fleeting and unpredictable.

Otters
No otters were seen during the shoreline survey at Uyea Sound, they are present in many parts of Shetland. However, the typical population densities of coastal otters are low and their impacts on the shellfishery are expected to be very minor.

Birds

A number of seabird species breed in Shetland. These were the subject of a detailed census carried out between 1998 and 2002 (Mitchell et al 2004). Total counts of all species recorded within 5 km of the mussel lines are presented in Table 8.1. Where counts are of pairs of birds, the actual number of breeding adults will be double.

Table 8.1 Seabird counts within 5km of the Uyea Sound mussel fisheries

Common name	Species	Count	Method
Black Guillemot	*Cepphus grylle*	396	Individuals on land
Atlantic puffin	*Fratercula arctica*	46	Occupied burrows
Northern Fulmar	*Fulmarus glacialis*	2417	Occupied sites
Herring Gull	*Larus argentatus*	257	Occupied nests/Occupied territory
Common Gull	*Larus canus*	101	Occupied nests/Occupied territory
Lesser Black-backed Gull	*Larus fuscus*	9	Occupied territory
Great Black-backed Gull	*Larus marinus*	87	Occupied nests/Occupied territory
Black-headed Gull	*Larus ridibundus*	41	Occupied territory
European Shag	*Phalacrocorax aristotelis*	49	Occupied nests/Occupied sites
Kittiwake	*Rissa tridactyla*	123	Occupied nests
Arctic skua	*Stercorarius parasiticus*	2	Occupied territory
Great Skua	*Stercorarius skua*	10	Occupied territory
Arctic Tern	*Sterna paradisaea*	561	Occupied nests/Occupied territory

Distributions of seabirds close to the Uyea Sound mussel sites are shown thematically mapped in Figure 8.1. Gulls, seabirds and geese were observed singly and in low numbers during the shoreline survey. No large aggregations of seabirds were seen. Where birds rest on the mussel floats, there is a potential for faecal material to be washed from the floats into the adjacent water.

Waterfowl may be present in the area at various times with some species overwintering, some stopping briefly during migration, and others breeding during the summer. Geese are likely to be present year-round, with highest numbers from October to February and lowest numbers May to July.

Summary

The impact of avian sources of faecal contamination to the fishery is likely to be highest during the summer, when a larger number of seabirds are resident in the area. Seals, geese and some gulls are all likely to be present in the area year-round. As gulls and other birds could rest on any of the mussel floats, any impact from deposition of faecal bacteria to these is presumed to be evenly distributed across the fishery. Impacts from seals are likely to be minor and unpredictable outside areas where they haul out, though there could be a decrease in water quality near to the shore south of Inga's Holm, where they were observed hauled out during the shoreline survey. Geese were observed south of the fishery, though they may be present over a wider area throughout the year. Seabird nesting sites are lie predominantly west of the fishery, with the nearest significant concentrations at the south end of Uyea Sound, south of the Cow Head site.

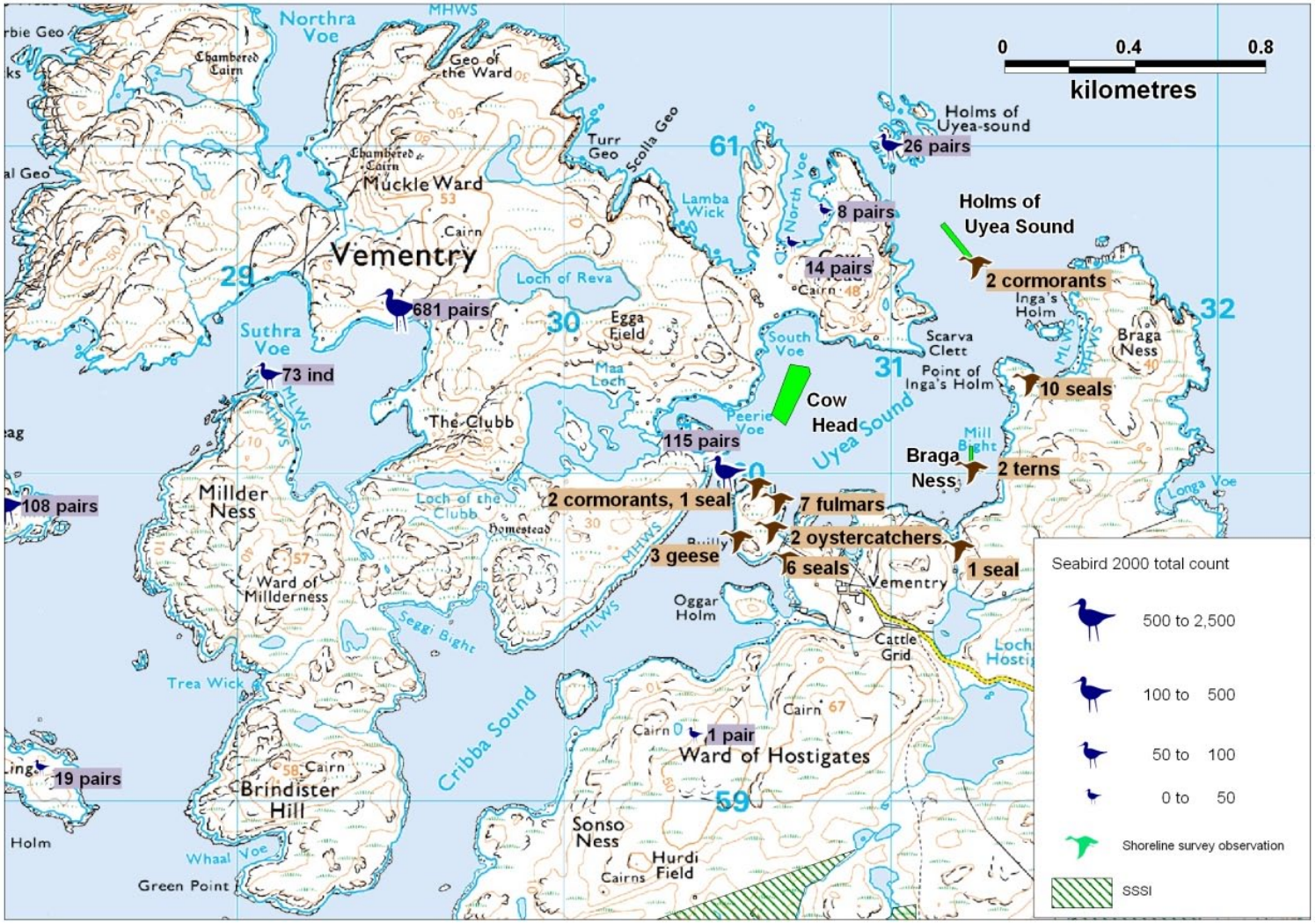

Figure 8.1 Map of seabird distributions if relevant.

9. Meteorological data

The nearest weather station is located at Lerwick, approximately 23 km to the south east of the production area, for which uninterrupted rainfall data was available for 2003-2009. Wind data was also available from this station. It is likely that overall wind and rainfall patterns are similar at Lerwick and the survey area, but differences in local topography may skew wind patterns in different ways, and conditions at any given time may differ due to the distance between them. This section aims to describe the local rain and wind patterns and how they may affect the bacterial quality of shellfish at Uyea Sound.

9.1 Rainfall

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

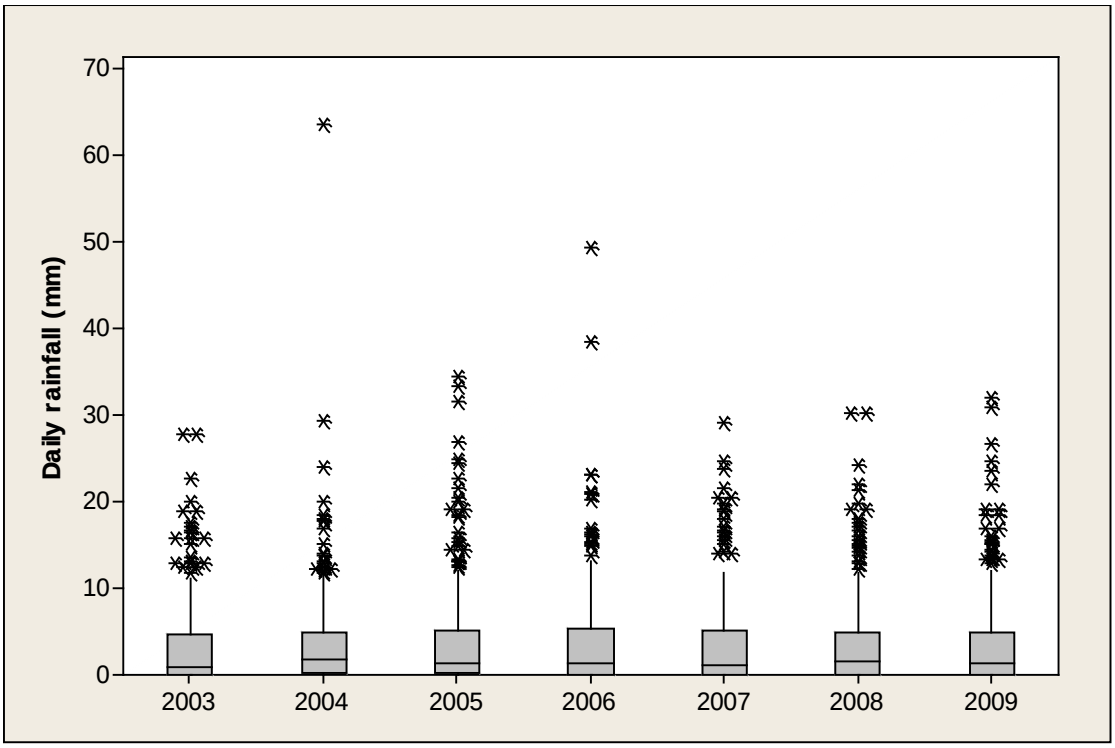

Figure 9.1 Box plot of daily rainfall values by year at Lerwick, 2003-2009

Figure 9.1 shows that rainfall patterns were generally consistent between years at this station. Peak rainfall events were highest during 2004 and 2006.

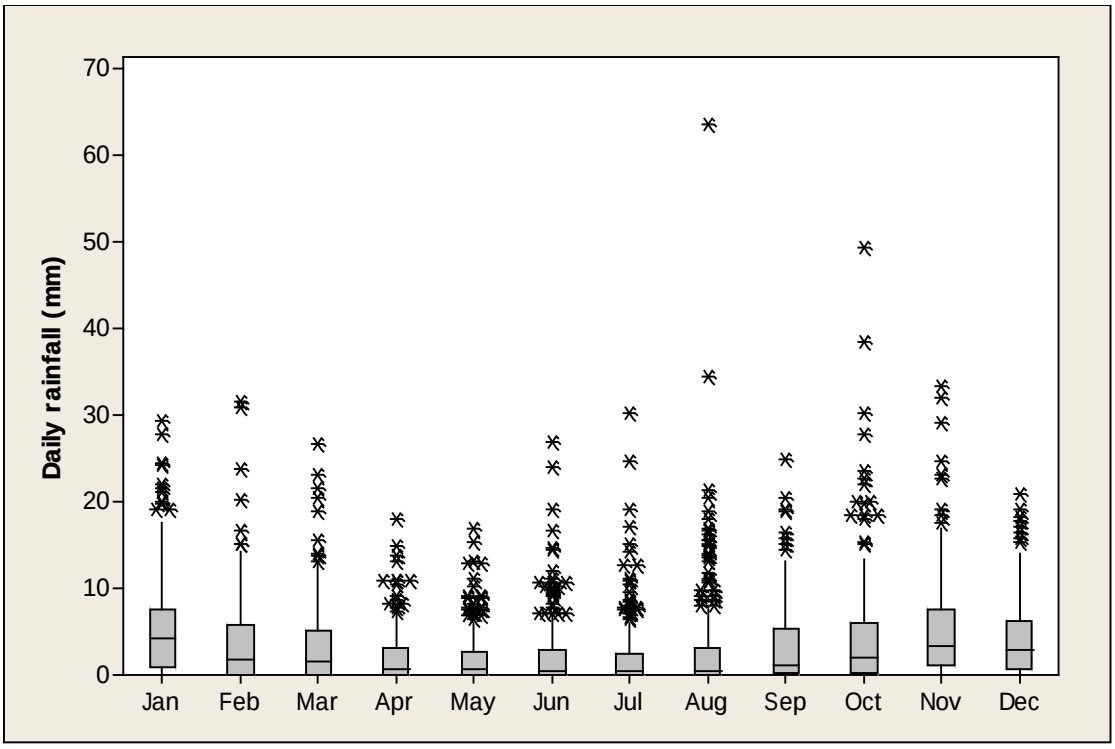

Figure 9.2 Box plot of daily rainfall values by month at Lerwick, 2003-2009

Weather was generally wetter from September through to March, with the wettest months being November and January. Days with very high rainfall (over 20 mm) have occurred in all months aside from April and May. For the period considered here, 44% of days experienced rainfall less than 1 mm, and 9% of days experienced rainfall of 10 mm or more.

It can therefore generally be expected that levels of run-off will be higher during the autumn and winter months. However, it is likely that associated faecal contamination entering the production area will be greatest when extreme rainfall events occur during summer or early autumn as faecal matter is likely to accumulate on pastures during dry periods.

9.2 Wind

Wind data collected at the Lerwick weather station is summarised by season and presented in Figures 9.3 to 9.7.

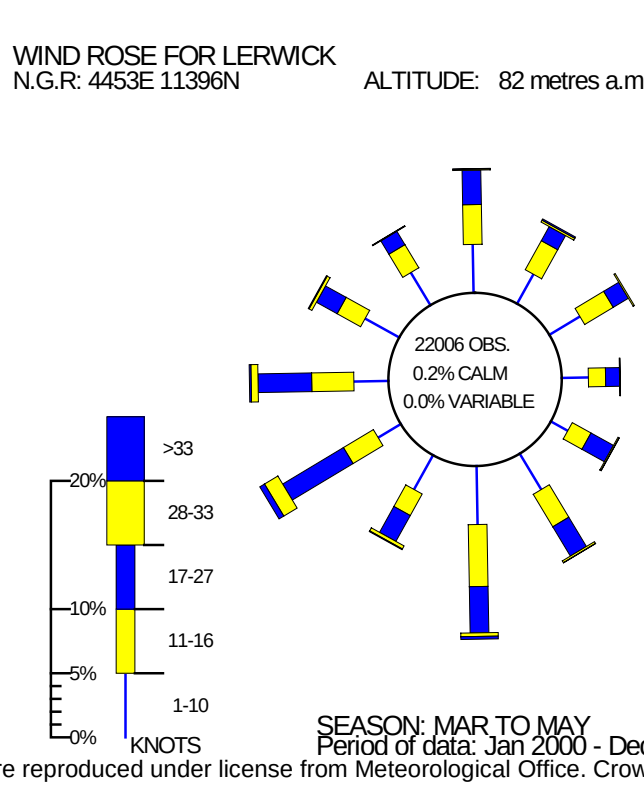

Figure 9.3 Wind rose for Lerwick (March to May)

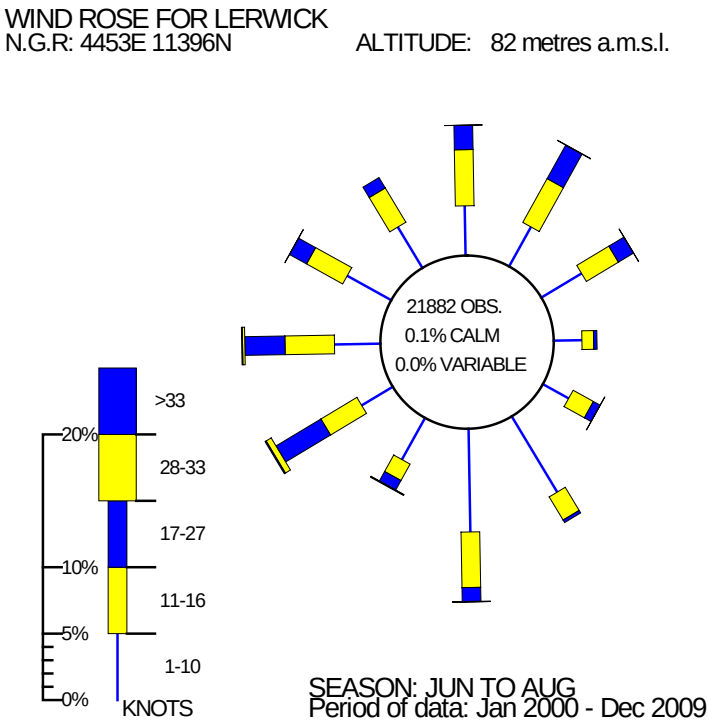

Figure 9.4 Wind rose for Lerwick (June to August)

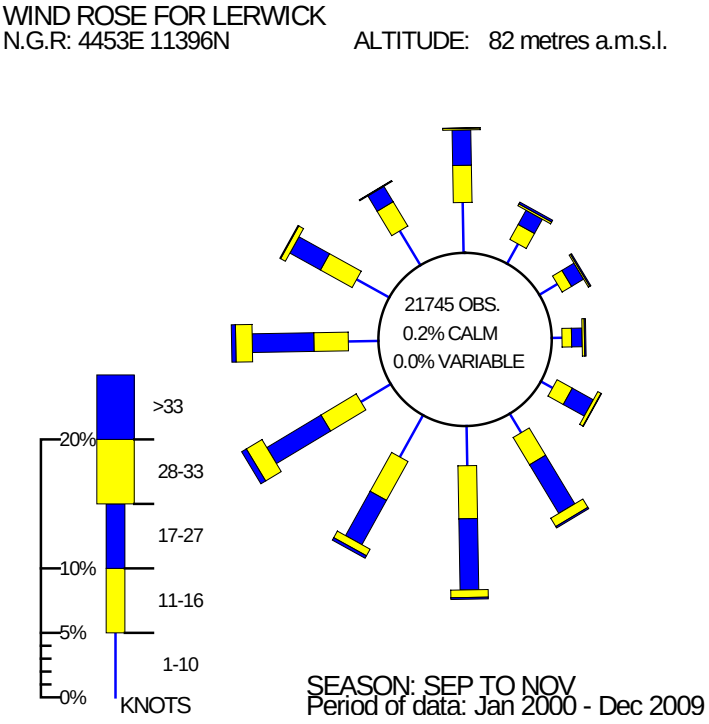

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Figure 9.5 Wind rose for Lerwick (September to November)

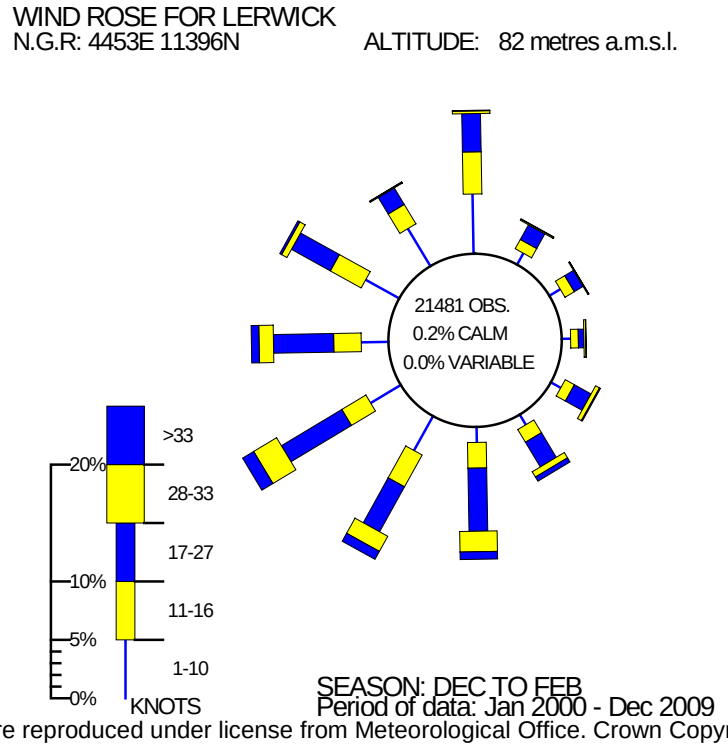

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Figure 9.6 Wind rose for Lerwick (December to February)

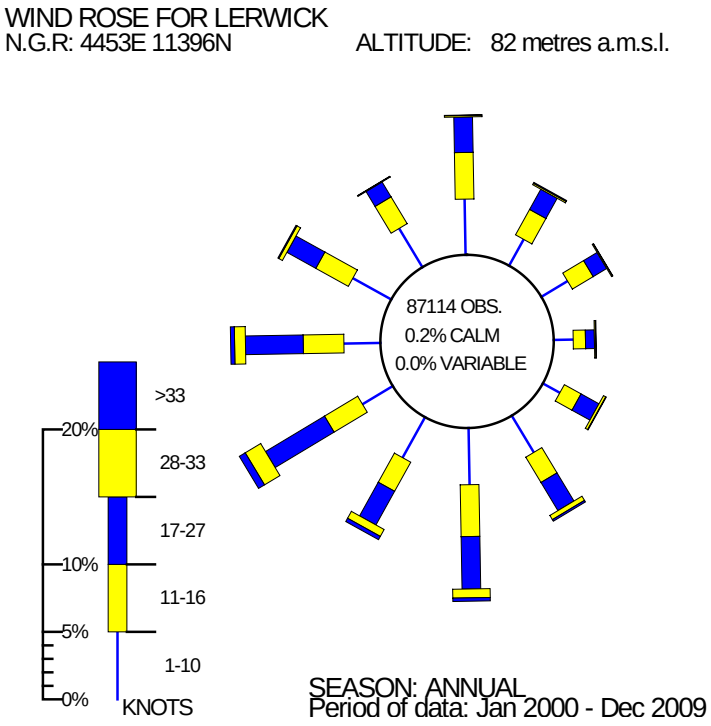

Figure 9.7 Wind rose for Lerwick (All year)

The prevailing wind direction at Lerwick is from the south and west, but wind direction often changes markedly from day to day with the passage of weather systems. There is a higher occurrence of north easterly winds during the summer. Winds are generally lightest in the summer and strongest in the winter. The Rona has a south east to north west orientation, and is also partly exposed to winds from the north east channelled down the Sound of Houbansetter, so wind patterns may be more skewed towards these directions than at Lerwick.

Winds typically drive surface water at about 3% of the wind speed (Brown, 1991) so a gale force wind (34 knots or 17.2 m/s) would drive a surface water current of about 1 knot or 0.5 m/s. Therefore strong winds, particularly those from the directions to which the site is most exposed will alter the pattern of surface currents at Thee Rona. Strong winds may affect tide height depending on wind direction and local hydrodynamics. A strong wind combined with a spring tide may result in higher than usual tides, which will carry accumulated faecal matter from livestock, at and above the normal high water mark, into the production area.

10. Current and historical classification status

Uyea Sound was first classified for the harvest of common mussels as a new area in 2010, when it was given a seasonal classification as shown in Table 10.1.

Table 10.1 Classification history, Uyea Sound

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010				B	B	B	B	B	A	A	A	A
2011	A	B	B									

Vementry: Braga Ness and Swarbacks Minn have not previously been classified.

11. Historical *E. coli* data

11.1 Validation of historical data

All shellfish samples taken from the survey area from the beginning of 2002 up to the 22th November 2010 were extracted from the database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data.

There were no geographical anomalies in the reported sampling locations. All samples were received by the testing laboratory on the day of collection. Two samples had invalid test results and so could not be used in the analysis. Seventeen samples had the result reported as <20, and were assigned a nominal value of 10 for statistical assessment and graphical presentation. All *E. coli* results are reported in most probable number per 100g of shellfish flesh and intravalvular fluid.

11.2 Summary of microbiological results

Table 11.1 Summary of historical sampling and results

Sampling Summary			
Production area	Uyea Sound	Swarbacks Minn: Uyea Sound	Vementry: Braga Ness
Site	Cow Head	Holms of Uyea Sound	Braga Ness
Species	Common mussels	Common mussels	Common mussels
SIN	SI-441-845-08	SI-487-842-08	SI-507-873-08
Location	HU 306 601	HU311606	HU312599
Total no of samples	18	11	14
No. 2008	4	0	0
No. 2009	3	1	0
No. 2010	11	10	14
Results Summary			
Minimum	<20	<20	10
Maximum	230	70	1300
Median	20	10	80
Geometric mean	28	16	81
90 percentile	95	50	700
95 percentile	145	60	969
No. exceeding 230/100g	0 (0%)	0 (0%)	3 (21%)
No. exceeding 1000/100g	0 (0%)	0 (0%)	1 (7%)
No. exceeding 4600/100g	0 (0%)	0 (0%)	0 (0%)
No. exceeding 18000/100g	0 (0%)	0 (0%)	0 (0%)

Although no samples from either the Cow Head or Holms of Uyea Sound sites exceeded 230 *E. coli* MPN/100 g, one sample from Cow Head reached 230. Samples obtained from the Braga Ness site exceeded 230 *E. coli* MPN/100 g on three occasions.

11.3 Overall geographical pattern of results

Geometric mean *E. coli* results for the three sites are shown thematically mapped in Figure 11.1 below. Until the end of 2010, sampling locations for these sites were reported to 100 metre accuracy. For the purposes of representing the geometric means, the grid reference reported for the majority of samples has been used. In November and December 2010, sampling locations were restated to 10 metre accuracy. These later grid references are represented as yellow stars in Figure 11.1. There remains a discrepancy between the recorded locations of the Holms of Uyea Sound and Braga Ness mussel farms and their reported sampling locations. It was not clear at the time of writing whether these two sites had been shifted slightly to the south.

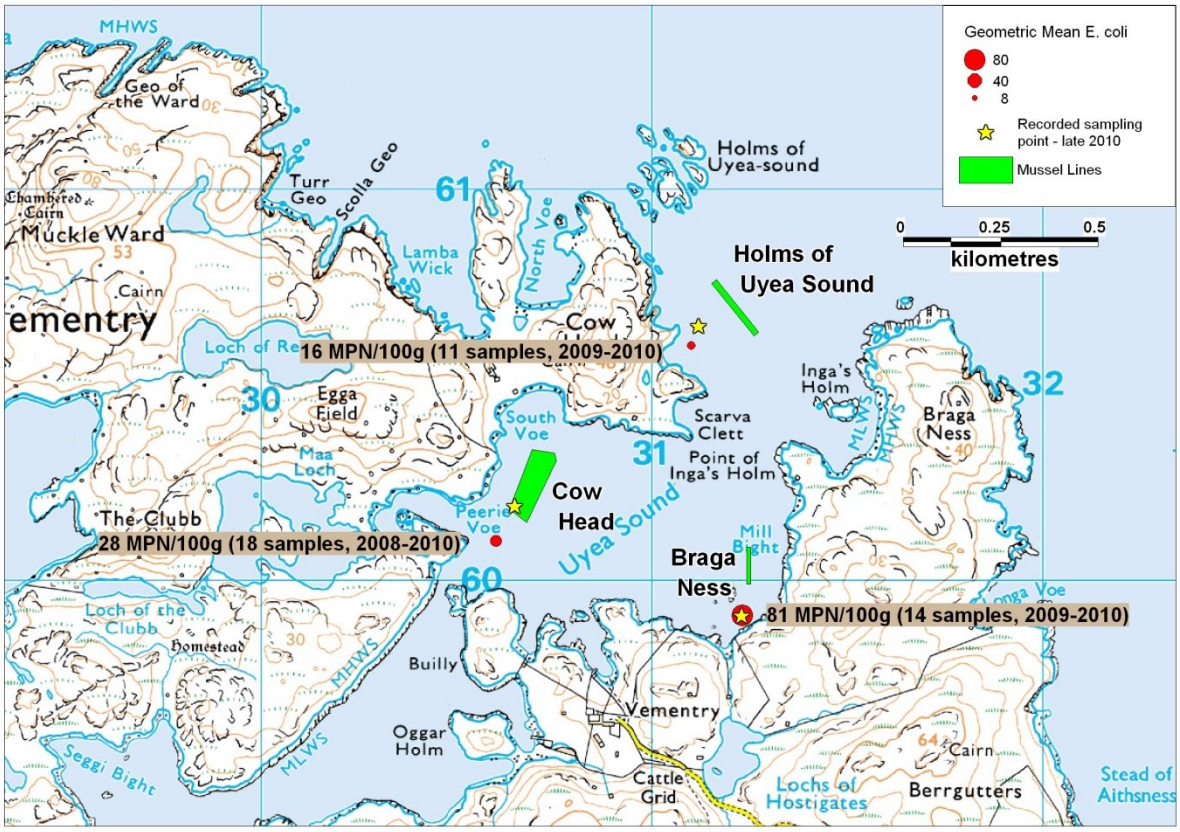

Figure 11.1 Map of geometric mean *E. coli* results for Uyea Sound

A higher geometric mean result was recorded at Braga Ness than at the other two sites. At all three sites, the majority of samples were taken in 2010 and so should roughly reflect the same period of time.

Samples were taken from both Holms of Uyea Sound and Cow Head sites on the same day and hence under the same environmental conditions on three occasions. Samples were taken from all three sites on the same day on one occasion. The results of these samplings are presented in Table 11.2.

Table 11.2 Results of paired samples from Holms of Uyea Sound and Cow Head

	E. coli result (MPN/100g)		
Sample date	Holms of Uyea Sound	Cow Head	Braga Ness
25/11/2009	<20	<20	*
13/01/2010	<20	80	*
10/02/2010	20	230	*
05/05/2010	<20	<20	*
23/06/2010	<20	<20	*
21/07/2010	50	20	230
30/08/2010	20	<20	*
20/09/2010	70	20	*
18/10/2010	<20	<20	*
15/11/2010	<20	50	*
13/12/2010	<20	130	*
Geometric mean	16	27	*

On the limited results available, it may be concluded that both sites were subject to relatively low levels of contamination at the times of sampling, although peak levels of contamination were higher at the Cow Head site. Comparison of the paired results showed no statistically significant difference between sites (paired T-test, T=-1.27, p=0.234). Samples were taken from the three sites on only one date, however on that date the result was higher at Braga Ness than at the other two sites.

Due to the limited period over which results were available, it was not possible to undertake more detailed evaluations of temporal and seasonal patterns in results, or the effect of environmental variables on levels of *E. coli* found in shellfish.

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

Only one sample gave a result of over 1000 *E. coli* MPN/100 g. This sample was taken on 19/05/2010 from Braga Ness and was found to contain 1300 *E. coli* MPN/100 g. No information was obtained regarding the environmental conditions at the time of sampling in this instance.

11.5 Sampling frequency

When a production area has held the same (non-seasonal) classification for 3 years and the geometric mean of the results falls within a certain range it is recommended that the sampling frequency be decreased from monthly to bimonthly. This is not appropriate for Uyea Sound as it has currently holds a seasonal classification and the other two production areas covered in this report are yet to be classified.

12. Designated Shellfish Growing Waters Data

The sites at Swarbacks Minn, Uyea Sound and Vementry: Braga Ness does not lie within a designated shellfish growing water. The Voe of Clousta shellfish growing water begins 250m southwest of the mussel farm at Uyea Sound. A map showing the relative positions of the Uyea Sound shellfish farms and the Voe of Clousta growing water are presented in Figure 12.1. The monitoring point for this growing water, however, lies 3 km to the southwest in a relatively protected area near a number of homes and watercourses. Therefore, it is not likely to be representative of conditions at Uyea Sound and so no results are presented here.

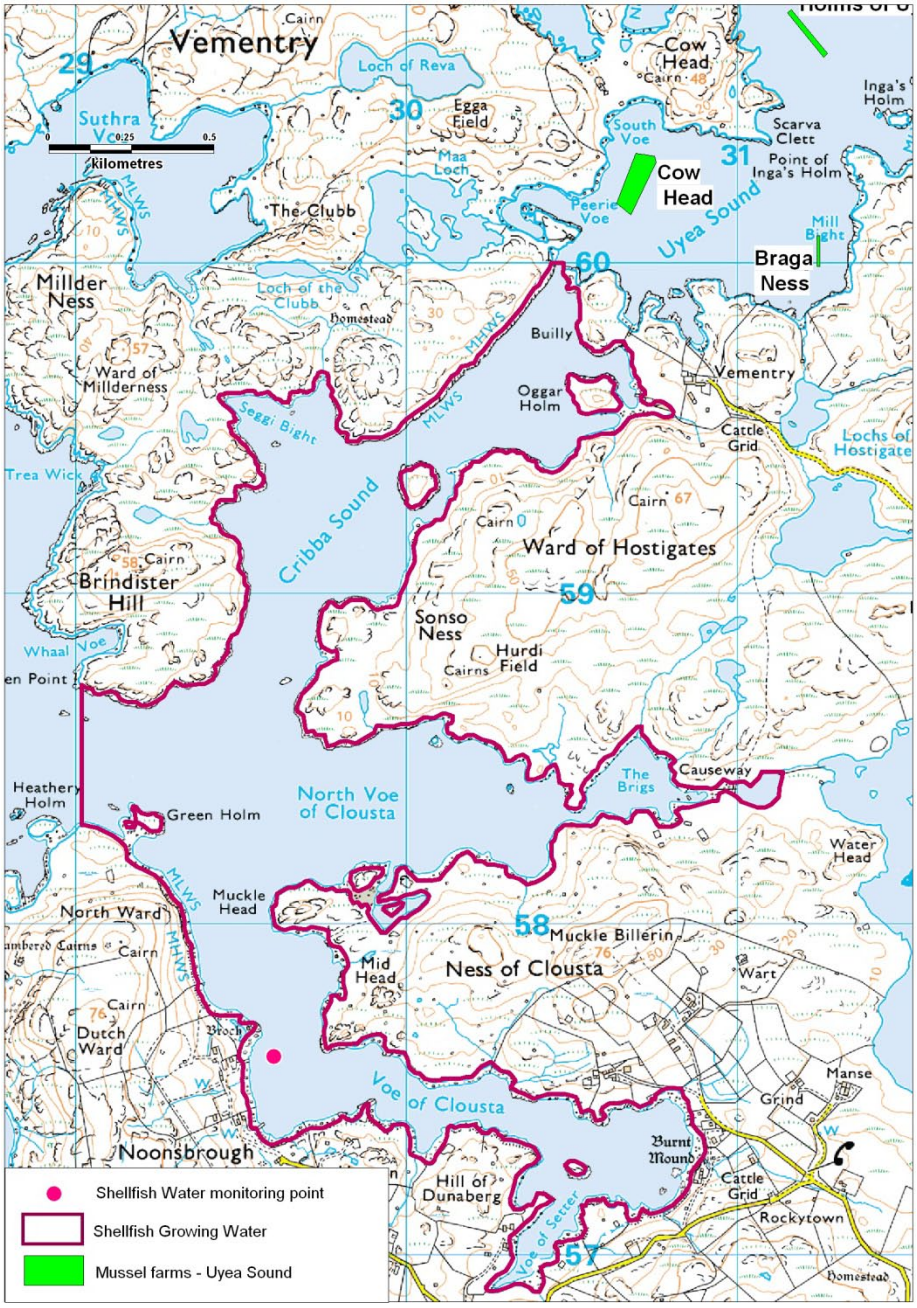

Figure 12.1 Map of designated shellfish waters near Uyea Sound

13. River Flow

There are no gauging stations on streams along the Uyea Sound coastline.

Only one stream was observed discharging into the area surveyed during the shoreline survey and this was sampled and measured. The details are given in Table 13.1. The location is shown on the map presented in Figure 13.1. Where the bacterial loading is labelled on the map, the scientific notation is written in digital format, as this is the only format recognised by the mapping software. So, where normal scientific notation for 1000 is 1×10^3, in digital format it is written as 1E+3.

The listed stream represents the only significant freshwater input into the production area. The weather was dry during the survey and had been relatively dry in the days immediately preceding the survey: there had been snow, rain and sleet showers the week before that. A number of land drains were observed during the survey but these were not flowing sufficiently to measure or sample at the time.

Table 13.1 Stream loadings for Uyea Sound

No.	Position	Description	Width (m)	Depth (m)	Flow (m/s)	Discharge (m^3/d)	*E. coli* (cfu/100 ml)	*E. coli* loading (cfu/day)
1	HU 3121 5976	Stream	0.35	0.06	0.073	132	590	7.8×10^8

The calculated loading for this stream was relatively low. The loading would be expected to increase significantly following moderate to heavy rainfall and thus the potential effects on the microbiological quality of the mussels at the Braga Ness site (in the vicinity of Mill Bight) would also increase.

A further stream is visible on the OS map along the north shore, discharging from a freshwater loch located on Vementry Island to Peerie Voe, southwest of the Cow Head site. This is likely to carry some faecal contaminants from grazing livestock and wildlife, however as this part of the shoreline was not accessed during the shoreline survey it was not measured or sampled. It is not clear whether and under what conditions this stream actively flows into the sound. At the time of shoreline survey a very slight reduction in salinity was found at the surface near the south end of the Cow Head mussel farm, indicating minor fresh water influence at this point. However, an even greater reduction was found at the northern end of the mussel farm (Appendix 8, Table 4).

The land drains would be expected to flow more heavily under rainfall conditions and could also cause localised deteriorations in water quality.

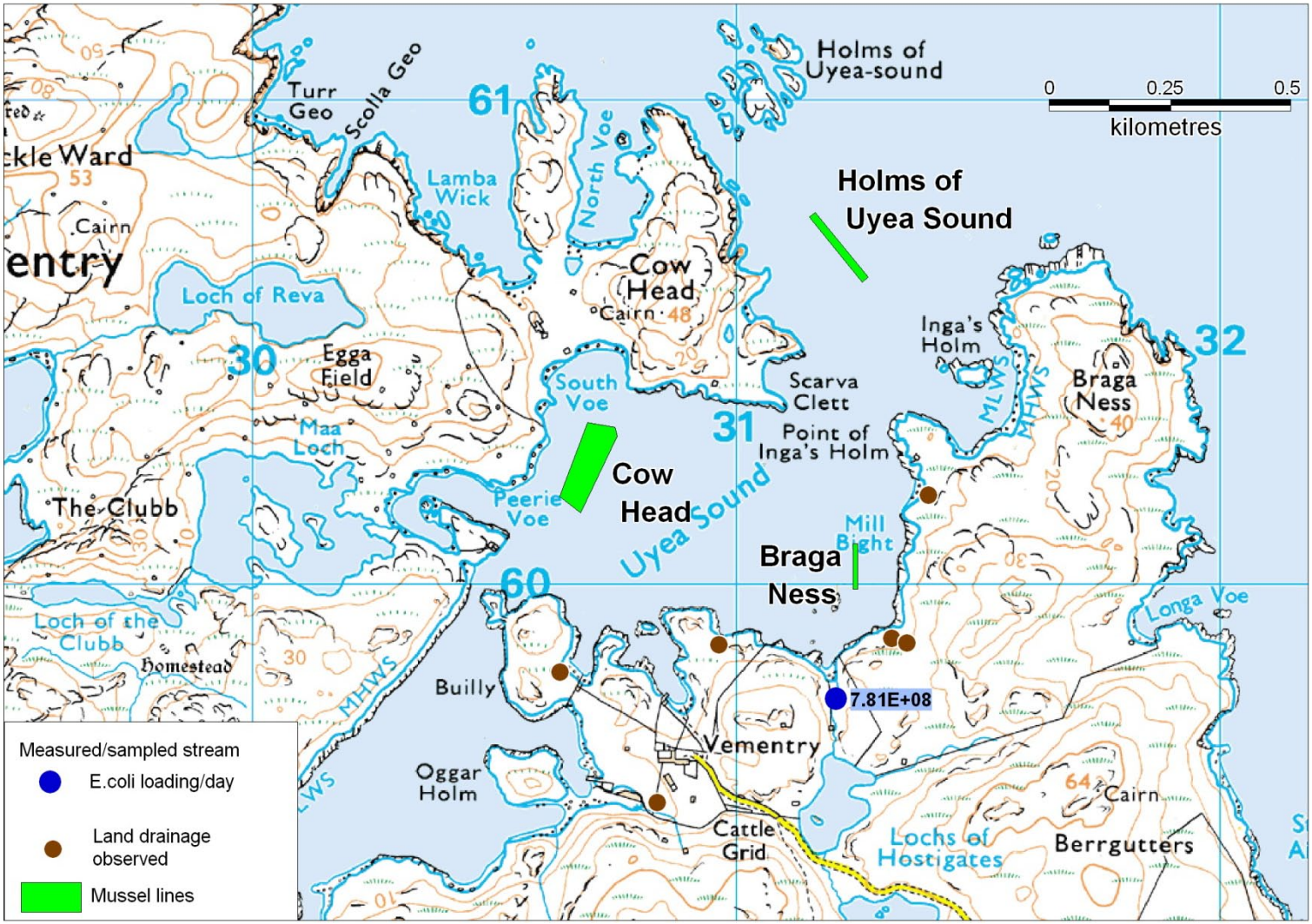

Figure 13.1 Map of stream loadings at Uyea Sound

14. Bathymetry and Hydrodynamics

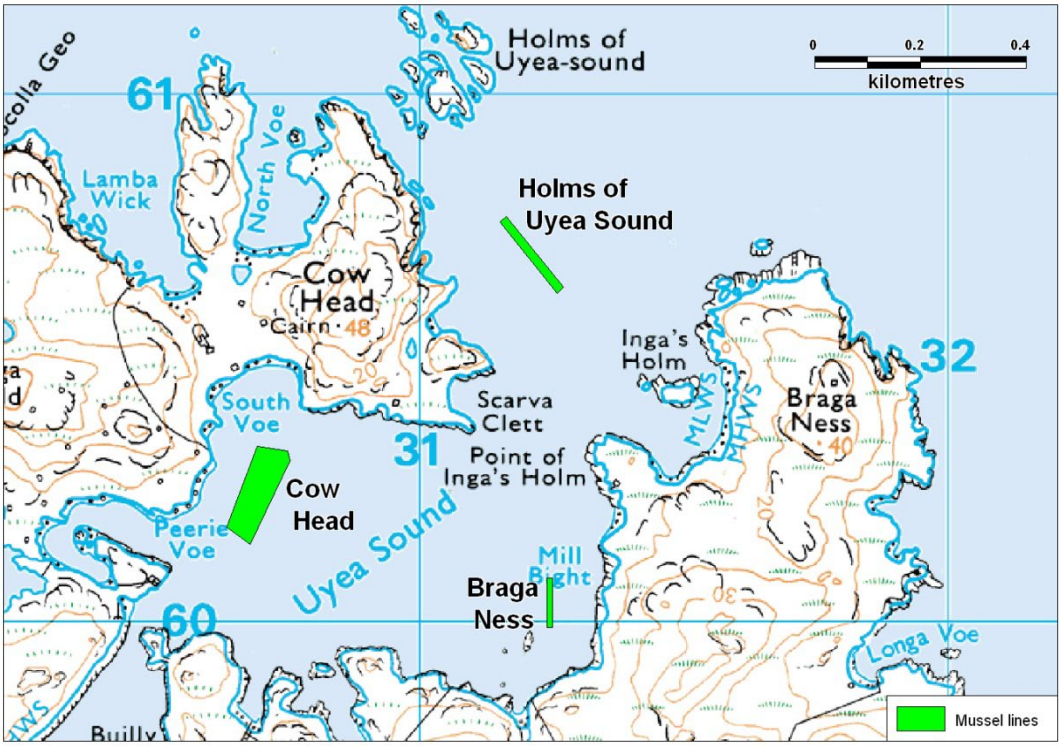

Figure 14.1 OS map of Uyea Sound

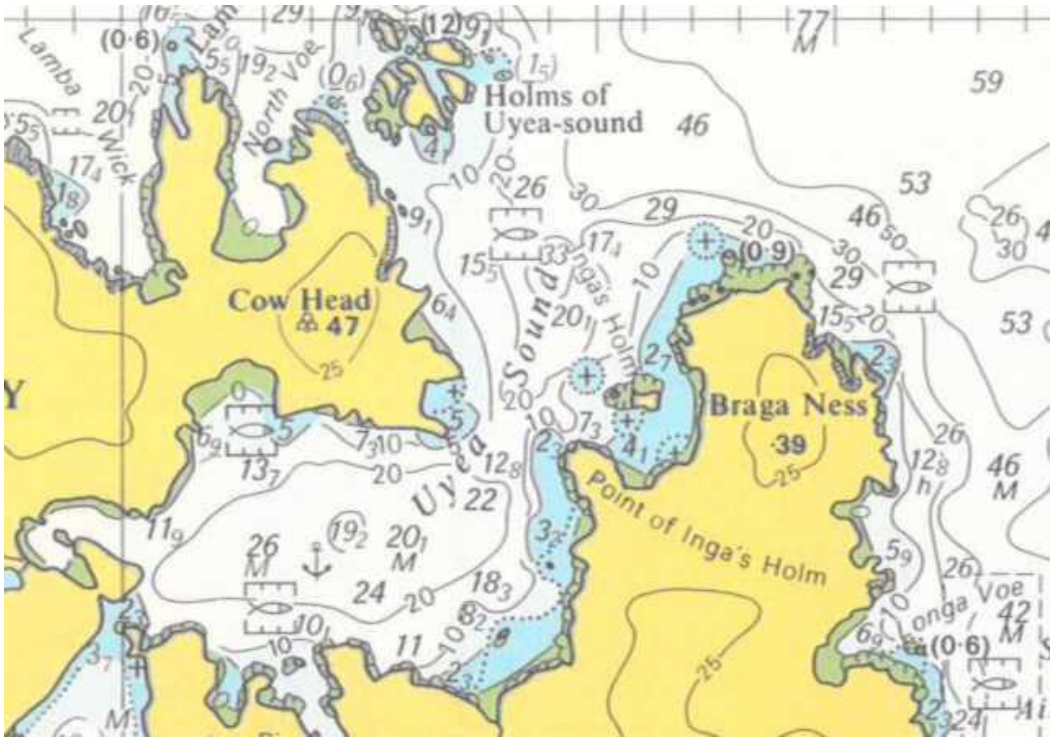

Figure 14.2 Bathymetry at Uyea Sound

Uyea Sound is located on the north-west side of Mainland, between Braga Ness and the island of Vementry. The sound lies in an approximately south-west to north-east direction with the main opening to Swarbacks Minn in the north-east and a more restricted opening to Cribba Sound in the south-west. The sound is irregularly shaped with a number of small inlets. There are a number of rocky outcrops along the shoreline and also some intertidal areas: these are more obvious on the hydrographic chart than on the OS map. There are two basins within the sound, one at the outer end which is more than 30 m in depth and one in the main area of the sound which is more than 25 m in depth. The mussel lines lie in areas which are between 10 and 20 m in depth.

14.1 Tidal Curve and Description

The two tidal curves below are for West Burra Firth, a straight line distance of approximately 6 km from Uyea Sound, and approximately 12 km by sea. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 BST on 19/05/10 and the second is for seven days beginning 00.00 BST on 26/05/10. Together they show the predicted tidal heights over high/low water for a full neap/spring tidal cycle, including the dates of the shoreline survey.

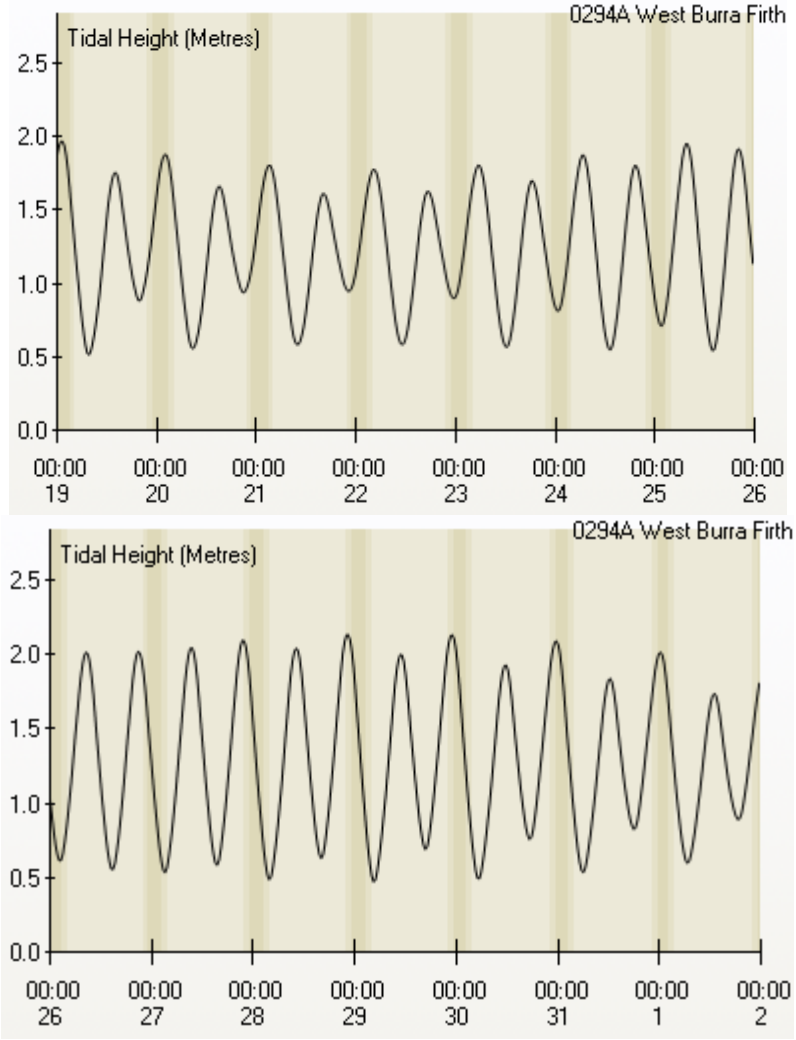

Figure 14.3 Tidal curves for West Burra Firth

The following is the summary description for West Burra Firth from TotalTide:

0294A West Burra Firth is a Secondary Non-Harmonic port. The tide type is Semi-Diurnal.

HAT	2.7 m
MHWS	2.2 m
MHWN	1.7 m
MSL	1.39 m
MLWN	1.0 m
MLWS	0.6 m
LAT	0.1 m

Predicted heights are in metres above Chart Datum. The tidal range at spring tide is 1.6 m, and at neap tide 0.7 m and so tidal ranges in the area are relatively small.

14.2 Currents

No tidal stream information was available for the vicinity of Uyea Sound.

Shetland Seafood Quality Control had undertaken two current meter studies in the vicinity to provide information in support of applications to SEPA to discharge from marine cage fish farms. These were originally undertaken for Shetland Salmon Group but the sites are now owned by Vementry Salmon. Data from the studies were provided to Cefas with the agreement of the company.

The locations at which the current meters were deployed are shown in Figure 14.4. The survey periods were as given in Table 14.1.

Table 14.1 Survey periods for the fish farm current meter studies

Location	NGR	Survey period
Cow Head Holm	HU 3127 6084	06/09/2001 - 24/09/2001
Uyeasound, Vementry	HU 3103 6016	21/08/2001 - 05/09/2001

Polar plots of the current directions and speeds at the two locations, together with the wind direction and speeds over the relevant periods, are shown in Figure 14.5.

Maximum currents in the area during the survey periods were all <20 cm/s (<0.4 knots). The highest (18.4 cm/s) was seen at near-bottom at Cow Head Holm. Mean recorded speeds were all <5 cm/s (<0.1 knots). Currents in the area are therefore generally weak. The current directions at Cow Head Holm showed a generally north/south predominance, with current speeds in the northerly direction being greater than in other directions. The near-surface recordings also showed westerly-flowing components. Recorded current directions at Uyeasound, Vementry were generally more variable although there appeared to be some trend towards the easterly direction.

At a peak current speed of 20 cm/s, the distance travelled by contaminants over a flood or ebb tide would be nearly 3 km, assuming no dilution or dispersion. At 5 cm/s, this would decrease to less than 1 km.

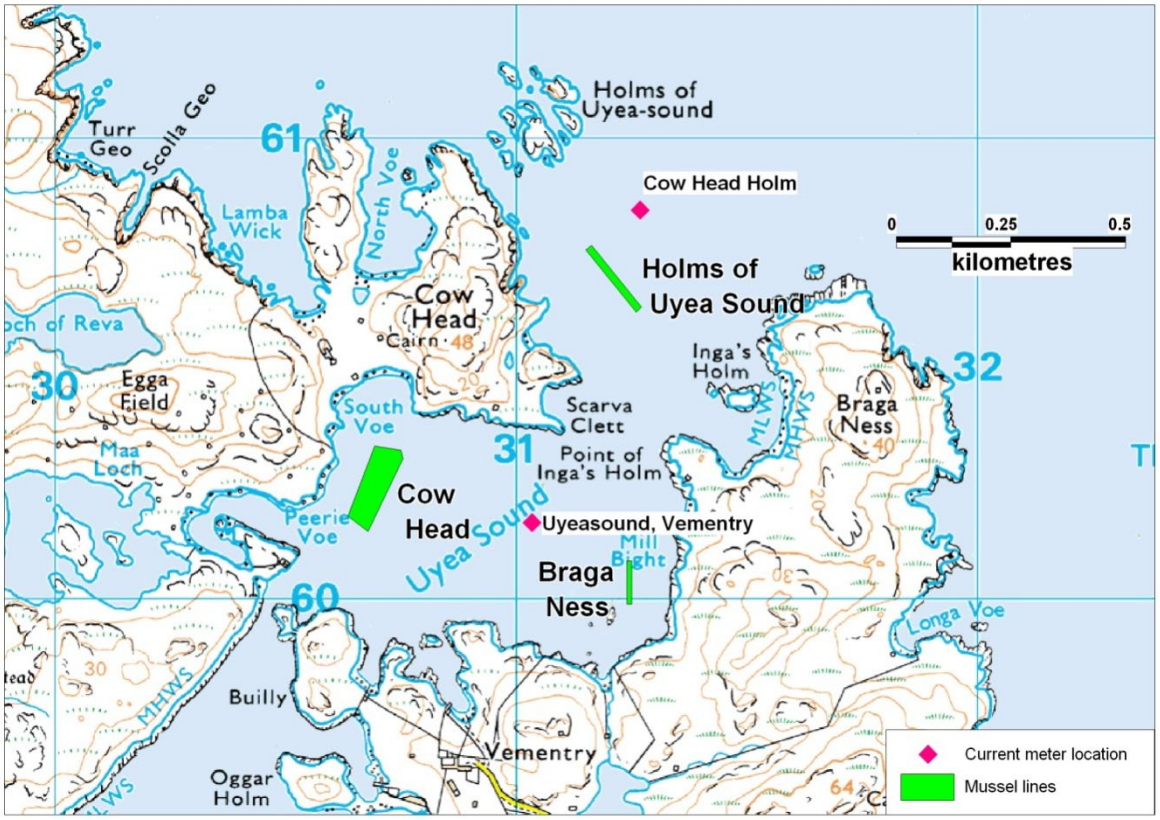

Figure 14.4 Map of current meter locations in Uyea Sound

14.3 Conclusions

The depths in Uyea Sound mean that contaminants will be subject to significant dilution within a short distance of shore. This, together with the weak currents in the area, implies that only localised sources of faecal contamination will tend to significantly impact on the water quality at the mussel lines. Contamination from within the main body of Uyea Sound may pass over the lines at Holms of Uyea Sound on the north-flowing current.

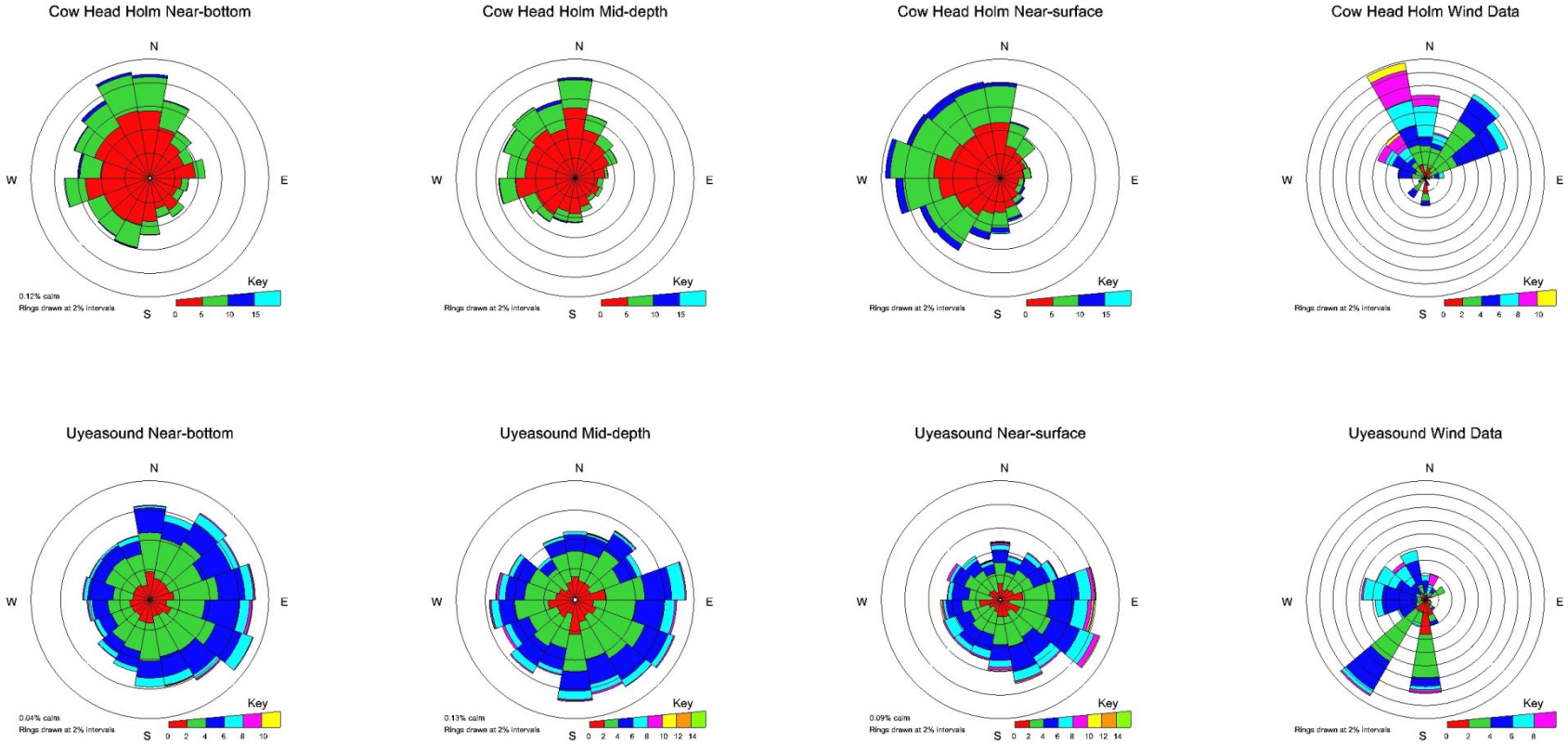

Figure 14.5 Current and wind plots for the Cow Head Holm and Uyeasound, Vementry fish farm surveys

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

15. Shoreline Survey Overview

The physical survey of the shoreline at Uyea Sound was conducted on the 19th and 20th May 2010 under relatively dry and calm weather conditions. Snow, rain and sleet had fallen in the week previous to the survey.

The Swarbacks Minn: Uyea Sound: Holms of Uyea Sound fishery consisted of one double-headed long line with 8 m droppers. The Uyea Sound: Cow Head fishery consisted of five double-headed long lines. The three long lines closest to shore had 8 m droppers on them. The two long lines furthest from the shore had no droppers or stock on them at the time of the shoreline survey. The harvester planned to next harvest the stock at these sites toward the end of 2010. In the future the harvester indicated that he planned to slowly increase the number of long lines at both sites. The Vementry Braga Ness: Braga Ness fishery consisted of four mussel rafts with 10 m droppers.

There were no large settlements in the area surrounding Uyea Sound. There was a small farm with outbuildings, one large house and two holiday lets in Vementry, located to the south of Uyea Sound. No other dwellings were observed in the surrounding area. A septic tank, possible outfall pipe and sewage related debris (cotton buds and toilet roll) were observed in a small bay north of Vementry. Another septic tank was observed close to the holidays lets, located to the west of Vementry. A single mussel boat was observed in Uyea Sound at the time of the survey.

Sheep and lambs were observed grazing along much of the shoreline. The animals had access to the shoreline and were observed on the beach in places. The majority of livestock were found along the south shore and near the farm. Horse droppings were observed along the shoreline north of the farm, where a horse was kept. From the boat, sheep were observed grazing on the Cow Head headland. Gulls, oystercatchers, terns, fulmars, cormorants and geese were observed during the survey, but no major aggregations of birds were recorded. Seals were observed along much of the shoreline, with a group of ten at the north end of Uyea Sound near Inga's Holm.

Seawater samples taken during the shoreline survey contained <1 *E. coli* cfu/100ml in all cases. Salinity profiles taken at the mussel sites all indicated that there was no freshwater influence or stratification at the time, with all measurements indicative of full strength seawater.

A single fresh water input was recorded flowing into Uyea Sound at the time of the shoreline survey. A fresh water sample collected from this stream returned a moderately high result of 590 *E. coli* cfu/100 ml. In addition, a number of dry land drains or small stream beds were observed, primarily along the south shore of the sound.

Mussel samples were taken from all three sites. At the Holms of Uyea Sound site, mussel samples were taken from the south end of the mussel line. At Braga Ness, they were taken from both ends of the mussel rafts at two different depths and at Cow Head, they were taken from both ends of the mussel lines. In all cases, samples were collected from two different depths. The mussel sample results are summarised in Table 15.1.

Site	Location	Depth 1	*E. coli* (MPN/100 g)	Depth 2	*E. coli* (MPN/100 g)
Holms of Uyea Sound	HU 3125 6064	<1 m	50	4 m	20
Braga Ness	HU 3124 6005	<1 m	<20	3 m	20
Braga Ness	HU 3125 6000	<1 m	<20	4 m	<20
Cow Head	HU 3071 6031	<1 m	70	4 m	<20
Cow Head	HU 3065 6019	<1 m	20	4 m	<20

The sample results indicate low or very low levels of faecal contamination. There appeared to be a tendency toward higher results near the surface.

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

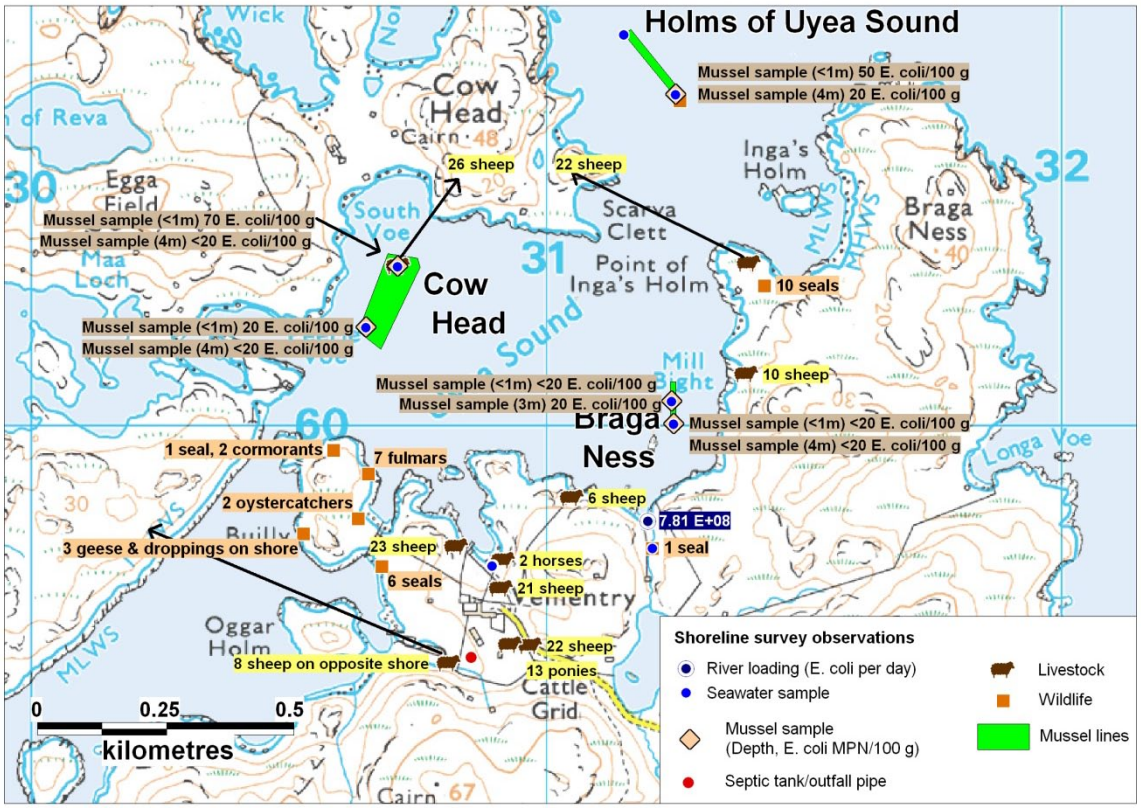

Figure 15.1 Summary of shoreline survey findings for Uyea Sound

16. Overall Assessment

Human sewage impacts

Sources of human sewage to the area are limited, with only two private septic tanks identified near Vementry on the south shore of the sound. This is the only area of habitation along the sound. Only the northernmost of these septic tanks had an observed discharge, and sewage-related debris along the shoreline near the discharge pipe suggested that it was active at least some of the time. A seawater sample taken nearby, however, contained <1 *E. coli* cfu/100 ML, suggesting that either the discharge was not operating at the time or that it had little impact at the point sampled. It is likely that this discharge will have primarily a localised impact due to potential for dilution within the sound and that it is unlikely to cause a marked deterioration in water quality at the fisheries. The second septic tank was located near a stream discharging to the north end of Cribba Sound, south of Vementry, and was associated with two holiday homes. If this tank discharges to the stream, or any associated soakaway system fails, then there would be a localised and seasonal impact to the stream and its receiving water in Cribba Sound.

Agricultural impacts

Livestock are kept in the area and sheep were observed grazing on both the north and south shores of the sound. The majority of these were located on the south shore, near the farm at Vementry where there were also ponies and horses. Livestock were able to access the shore, and sheep were observed on the shoreline north of the Cow Head mussel farm. Faecal contamination from grazing livestock is likely to impact the near-shore areas around much of of the sound but particularly along the south shore, and transport of this contamination is likely to be mostly via rainfall runoff. It is likely that faecal contamination to the area will predominantly come from livestock animals due to their numbers and proximity to the shore.

Wildlife impacts

A small number of seabirds were observed in the vicinity during the shoreline survey. A relatively large number of seals were observed in the area, with 10 hauled out on the east shore in the outer part of the sound. There may be higher levels of faecal bacteria near to where the animals spend time hauled out, however this it has not been possible to substantiate this. As the sound is relatively deep, there is ample opportunity for dilution of any faecal waste. Although there is a possibility of impact on the fishery should one or more animals defacate directly adjacent to the lines, there is no evidence to suggest that this would be more likely to occur at any one part of the fishery.

Breeding seabirds are seasonally present at nesting sites on Vementry Island, west of the fishery. The largest concentration directly adjacent to the sound is a colony of over 200 fulmars to the southwest of the Cow Head site. Faecal material may be washed from nesting areas into the sound by rainfall, and this is most likely to occur during and just after the summer breeding season.

Seasonal variation

There was insufficient *E. coli* monitoring history on which to base an assessment of seasonal variation in results at any of the shellfish farms. Two of the dwellings at Vementry are holiday homes and more likely to be occupied during the summer holiday months, so any septic discharges related to these would also be more likely to operate at that time. There is likely to be an increase in livestock population from late spring to autumn, when lambs are present. Rainfall patterns show generally wetter weather from September to March, with April and May being the driest months. Therefore, streams and land drains are likely to flow more often during the wet season. However, rainfall of greater than 20 mm per day can occur outside the wet season and therefore rainfall-dependent contamination may affect the fishery at any time of year.

Rivers and streams

Only one stream was observed, measured and sampled during the shoreline survey. However, a number of presumed land drains were observed that were wet but not flowing during the shoreline survey. These could be expected to carry rainfall runoff from the surrounding land during wetter weather. The stream and many of the land drains were observed along the east shore of the sound, nearest the Braga Ness site. A salinity profile undertaken at the southern end of the Braga Ness site showed a 4 ppt reduction between 3 metres depth and the surface, which indicates freshwater influence at that location.

A further stream appears on the OS map on Vementry Island, near the head of Peerie Voe west of the Cow Head site. As this part of the shoreline was not visited during the shoreline survey, it is not clear under what conditions this stream flows into the voe. A salinity profile taken at the southern end of the mussel farm showed no freshwater influence, however one taken at the north end of the farm showed a 0.6 ppt reduction in surface salinity, indicating some fresh water influence at that location.

A reduction in surface salinity was also recorded at the Holms of Uyea Sound site. The reduction was higher at the northwestern end of the lines than at the southeastern end, suggesting that the source may lie nearer that end of the mussel farm. However, there is little land area and no large watercourses adjacent to the area so the source is not clear. Seawater samples taken at the time of shoreline survey indicated little *E. coli* contamination at any of the locations sampled.

Movement of contaminants

Data from current meter studies identified slow current speeds within both the inner and outer sound. Currents in the outer sound, nearer the Holms of Uyea Sound site, flowed predominantly to the northwest while currents in the inner sound were more variable with easterly flows slightly more prevalent, particularly near the surface. The waters of the sound are sufficiently deep to

allow for significant dilution of any contaminants entering the water body. Faecal contaminants carried via the stream south of Braga Ness are anticipated to predominantly impact at the Braga Ness site. Due to the weak easterly currents and prevailing southwesterly wind direction, it is not expected that contaminants from this source would impact the Cow Head site under prevailing conditions.

Any sewage discharge and runoff associated with the farm at Vementry is likely to be retained and diluted largely within the embayment to which it discharges and the eastern side of the inner sound.

Any contaminants arising within the inner sound may be carried across the Holms of Uyea Sound site on the outgoing tide.

Temporal and geographical patterns of sampling results

There was insufficient monitoring history on which to base a temporal assessment of historical sampling results.

Sample results were available from all three sites at Uyea Sound, covering roughly the same period of time. No statistically significant difference was found between paired results for the Holms of Uyea Sound and Cow Head sites. Braga Ness was sampled on the same date as the other two sites on only one occasion and results were one order of magnitude higher at Braga Ness (230 *E. coli* MPN/100 g) than at Holms of Uyea Sound or Cow Head (50 and 20 *E. coli* MPN/100 g, respectively). The geometric mean *E. coli* result was higher for Braga Ness, and results greater than 230 *E. coli*/100 g occurred at this site but not at the others. The highest result overall occurred at Braga Ness.

As the three sites within Uyea Sound are new, they do not yet have sufficient monitoring history to conduct a stability assessment.

Conclusions

Uyea Sound has little in the way of human sewage contamination, with only one identified discharge. A farm located on the southeast shore is likely to be a source of diffuse pollution from livestock, which may be carried to the sound via direct runoff from land adjacent to the shore and potentiall via the stream north of the farm. Livestock are also likely to be a source of contamination arising from rainfall runoff around much of the sound. Given the relatively low current speeds and deep waters present within the sound, contaminants are likely to be subject to substantial dilution and are unlikely to travel more than 1 km from their source within a tidal cycle. Results from *E. coli* monitoring were higher at the Braga Ness site, which lies closest to the identified sources of faecal contamination.

17. Recommendations

Production area

Given the small area of the sound and relative lack of large contaminating sources, it is recommended that the three areas be combined into a single production area. Areas near the mouths of streams and the inlet nearest the farm should be excluded from the production area as contamination levels may be higher in these areas than at the mussel farms. The production area should also encompass the full extents of the seabed leases granted for the three mussel farms as the harvesters have expressed an intention to expand their mussel farms within these areas.

It is recommended that the production area boundaries be established as the area bounded by lines drawn between HU 3050 6020 to HU 3052 6010 to HU 3085 5993 and between HU 3094 5994 to HU 3125 5989 and between HU 3177 6066 to HU 3123 6100 to HU 3095 6087 extending to MHWS.

RMP

The most clearly identifiable sources of both human and livestock faecal contamination lie to the south of the Braga Ness mussel farm. Therefore, the RMP should be established to lie at the southernmost end of Braga Ness in order to be most protective of public health. The recommended RMP location is therefore HU 3125 5999. Should the Braga Ness mussel farm be extended southwards, the RMP location should be reviewed and amended southward as necessary.

Frequency

Because the area has only one year monitoring history, it is recommended that monthly sampling be maintained until such time as it is appropriate to undertake a stablility assessment for the area.

Depth of sampling

There was some evidence of stratification at the southern end of Braga Ness, and the nearest contaminating source is the stream to the south of the mussel farm. As contamination from this source is likely to be entrained within the freshwater plume until it disperses, and this plume was found at the surface during the shoreline survey, it is recommended that samples be taken from a depth of 1 m.

Tolerance

In order to allow for some movement of the mussel lines with tide and wind, a sampling tolerance of 40 m is recommended. If it is not possible to obtain stock from within this tolerance due to rotational harvest of the stock, bagged

mussels may be hung from a float at the RMP so long as the stock to be sampled is placed in situ at least 2 weeks prior to sampling.

Figure 17.1 shows the recommended extents of the production area, the recommended RMP location and the locations of the mussel farms.

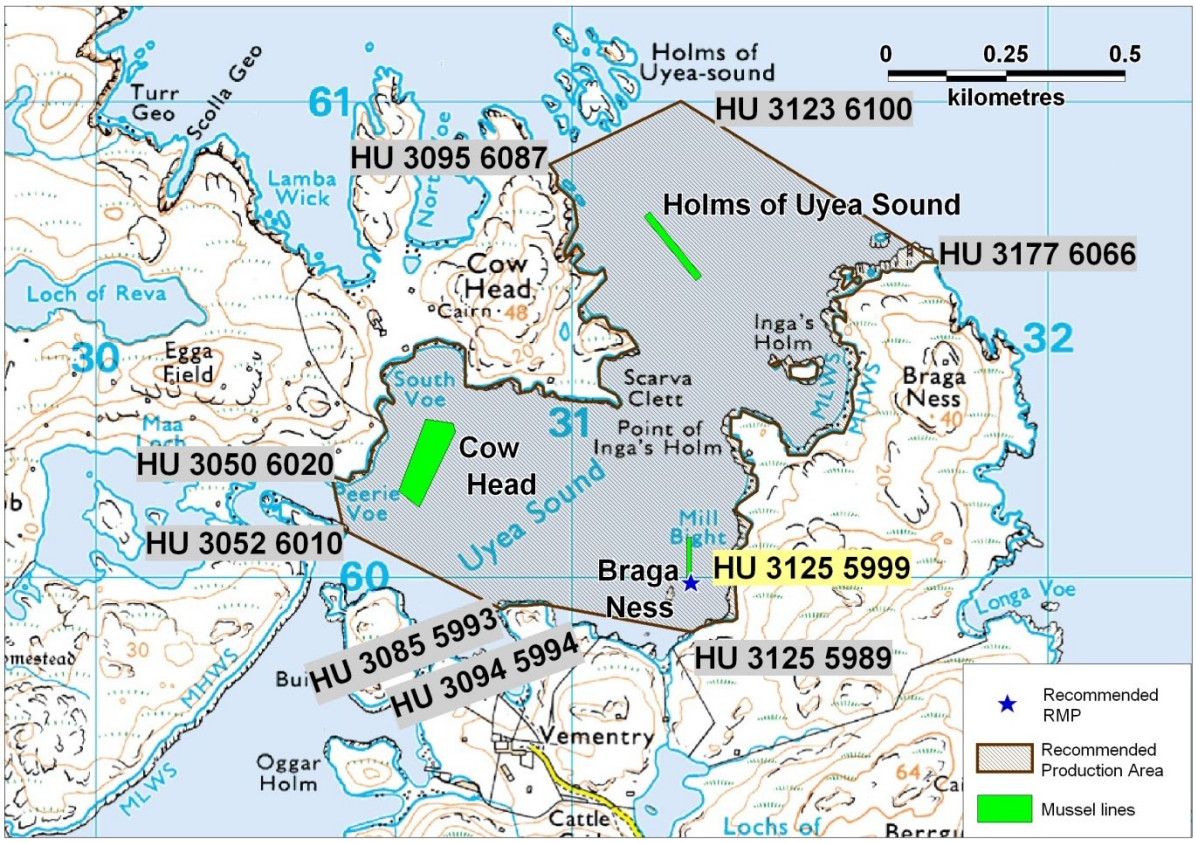

Figure 17.1 Map of recommendations at Uyea Sound

18. References

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2. **Table of Proposed Boundaries and RMPs**
3. **Geology and Soils Information**
4. **General Information on Wildlife Impacts**
5. **Tables of Typical Faecal Bacteria Concentrations**
6. **Statistical Data**
7. **Hydrographic Methods**
8. **Shoreline Survey Report**

Sampling Plan for Uyea Sound

PRODUCTION AREA	Uyea Sound
SITE NAME	Braga Ness
SIN	SI 508 874
SPECIES	Common mussel
TYPE OF FISHERY	Aquaculture
NGR OF RMP	HU 3125 5999
EAST	431250
NORTH	1159990
TOLERANCE (M)	40
DEPTH (M)	1
METHOD OF SAMPLING	Hand
FREQUENCY OF SAMPLING	Monthly
LOCAL AUTHORITY	Shetland Island Council
AUTHORISED SAMPLER(S)	Sean Williamson George Williamson Kathryn Winter Marion Slater
LOCAL AUTHORITY LIAISON OFFICER	Dawn Manson

Table of Proposed Boundaries and RMPs

PRODUCTION AREA	**Uyea Sound**
SPECIES	**Common Mussel**
SIN	**SI 508 874**
EXISTING BOUNDARY	**Area bounded by lines drawn between HU 3715 3150 to HU 3760 3152 and HU 3715 3260 to HU 3724 3260**
EXISTING RMP	**HU 306 601**
RECOMMENDED BOUNDARY	**Area bounded by lines drawn between HU 3050 6020 to HU 3052 6010 to HU 3085 5993 and between HU 3094 5994 to HU 3125 5989 and between HU 3177 6066 to HU 3123 6100 to HU 3095 6087 extending to MHWS**
RECOMMENDED RMP	**HU 3125 5999**
COMMENTS	**Area extended to include all three mussel farms in Uyea Sound, with single RMP at Braga Ness**

Geology and Soils Assessment

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

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

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

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

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

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

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

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

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

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

Glossary of Soil Terminology

Calcareous: Containing free calcium carbonate.

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

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

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

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

General Information on Wildlife Impacts

Pinnipeds

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

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

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

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

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

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

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

Cetaceans

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

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

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

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

Birds

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

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

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

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

Deer

No deer are present on Shetland

Other

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

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

References:

Alderisio, K.A. and N. DeLuca (1999). Seasonal enumeration of fecal coliform bacteria from the feces of Ring-billed gulls (*Larus delawarensis*) and Canada geese (*Branta canadensis*). *Applied and Environmental Microbiology*, 65:5628-5630.

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

Lisle, J.T., Smith, J.J., Edwards, D.D., andd McFeters, G.A. (2004). Occurrence of microbial indicators and *Clostridium perfringens* in wastewater, water column samples, sediments, drinking water and Weddell Seal feces collected at McMurdo Station, Antarctica. *Applied and Environmental Microbiology*, 70:7269-7276.

Scottish Natural Heritage. http://www.snh.org.uk/publications/on-line/wildlife/otters/biology.asp. Accessed October 2007.

Tables of Typical Faecal Bacteria Concentrations

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

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

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

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

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

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

Statistical Data

All statistical analyses undertaken using Minitab ® V15.1 statistical software.
Paired T-Test and CI: C1, C2

Paired T for C1 - C2

	N	Mean	StDev	SE Mean
C1	11	1.195	0.311	0.094
C2	11	1.425	0.509	0.153
Difference	11	-0.230	0.603	0.182

95% CI for mean difference: (-0.635, 0.175)
T-Test of mean difference = 0 (vs not = 0): T-Value = -1.27 P-Value = 0.234

Hydrographic Methods

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

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

Background processes

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

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

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

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

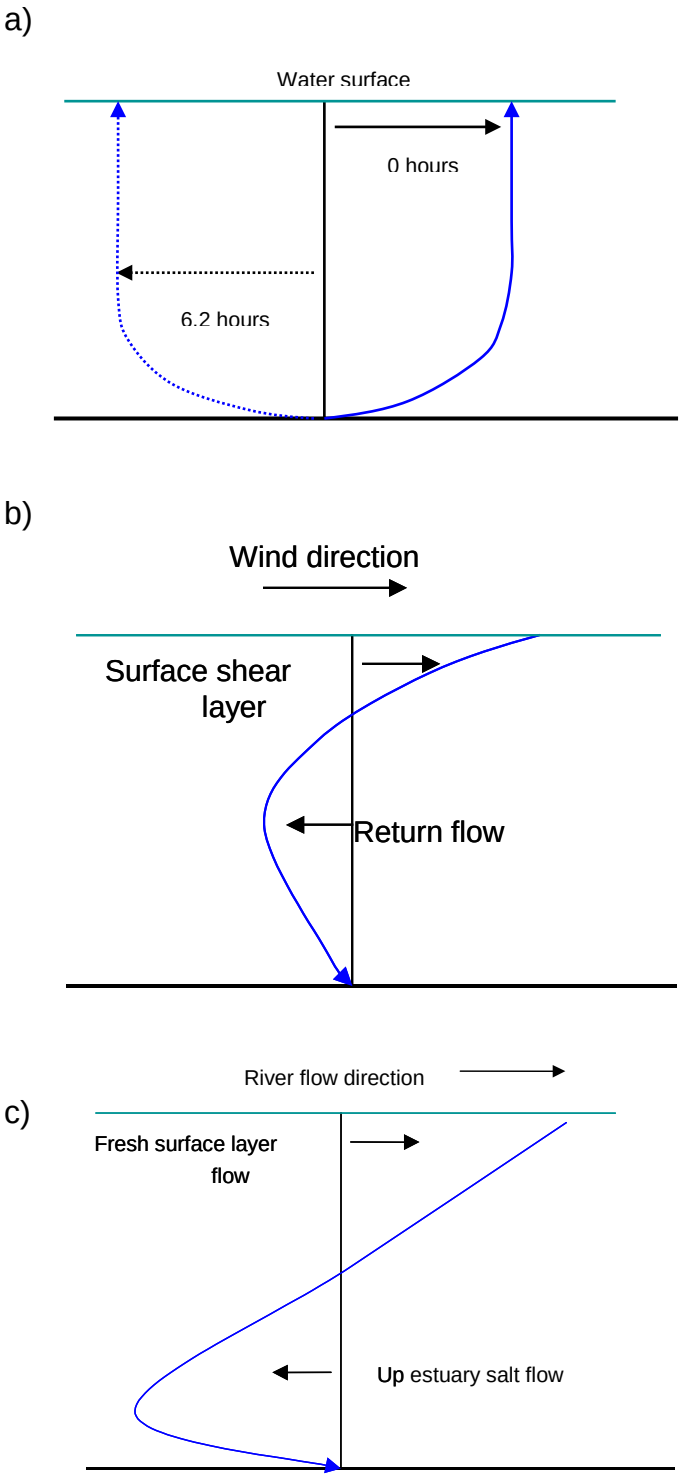

Figure 1. Typical vertical profiles for water currents. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction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

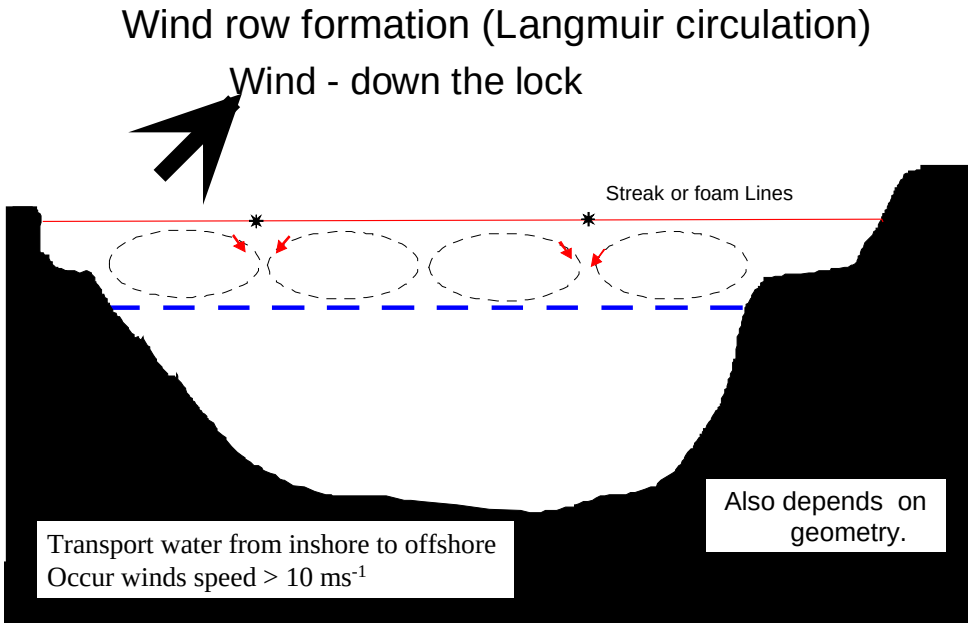

Figure 2. Schematic of wind driven 'wind row' currents. The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

Non-modelling Assessment

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

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

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

The catalogue of Scottish Sea Loch produced by the SMBA is used to quantify sills, volume fluxes and likely flow velocities. Because the flow is so constrained by the rapidly varying bathymetry, care has to be used in the extrapolation of direct measurements of current flow. Mean flow velocities can be estimated at the sills by using estimates of the sill area and the volume change through a tidal cycle. This in turn can be used to estimate the

maximum distance travelled in a tidal cycle in the sill area. Away from the sill area, tidal velocities are general low and transport events are dominated by wind or density effects. Sea Lochs generally have a surface layer of fresher water; the extent of this depends on freshwater input, sill depth and quantity of mixing.

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

References

European Commission 1996. Report on the equivalence of EU and US legislation for the Sanitary Production of Live Bivalve Molluscs for Human Consumption. EU Scientific Veterinary Committee Working Group on Faecal Coliforms in Shellfish, August 1996.

Glossary

The following technical terms may appear in the hydrographic assessment.

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

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

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

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

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

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

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

Spring/Neap Tides. The strongest tides in a month are called spring tides and the weakest are called neap tides. Spring tides occur every 14 days with neaps tides occurring 7 days after springs. Both tidal range and tidal currents are strongest at Spring tides.

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

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

Return flow. Often a surface flow at the surface is accompanied by a compensating flow in the opposite direction at the bed (see figure 1).

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

Shoreline Survey Report

Production Area:

Production Area	Site	SIN	Species
Swarbacks Minn: Uyea Sound	Holms of Uyea Sound	SI 487 842 08	Mussels
Uyea Sound	Cow Head	SI 441 845 08	Mussels
Vementry Braga Ness	Braga Ness	SI 507 874 08	Mussels

Harvesters: *Swarbacks Minn: Uyea Sound: Holms of Uyea Sound & Uyea Sound: Cow Head*
Hamish Hunter (Vementry Aquaculture)
Vementry Braga Ness: Braga Ness
Jim Georgeson (Suthravoe Shellfish)
Status: New application
Date Surveyed: 19/5/10 and 20/5/10
Surveyed by: Sean Williamson, Jessica Larkham, Frances Hockley
Sampling Point: Cow Head, nominal RMP (HU 306 601) Sampling point (HU 3065 6019)
Vementry Braga Ness (HU 312 599)
Area Surveyed: See Figure 1.

Weather Observations

19/5/10 Calm, occasionally overcast and dry
20/5/10 Calm, slightly overcast and dry
The weather had been relatively dry in the days preceding the survey. Snow, rain and sleet showers, the week before.

Specific observations made on site are mapped in Figure 1 and listed in Table 1. Water and shellfish samples were collected at sites marked on Figures 2 and 3. Bacteriology results are given in Tables 2 and 3. Salinity profiles are presented in Table 4. Photographs are presented in Figures 4-23.

Fishery

Swarbacks Minn: Uyea Sound: Holms of Uyea Sound (SI 487 842 08). This site consisted of one double long line, with 8 m droppers. The harvester plans to next harvest the stock towards the end of 2010. In the future the harvester has plans to slowly increase the number of long lines at the site.

Uyea Sound: Cow Head (SI 441 845 08). This site consisted of five double long lines. The three long lines closest to shore had 8 m droppers on. The two long lines furthest from the shore had no droppers or stock on them at the time of the shoreline survey. The harvester plans to next harvest the stock towards the end of 2010. In the future the harvester has plans to slowly increase the number of long lines at the site.

Vementry Braga Ness: Braga Ness (SI 507 874 08). This site consists of four mussel rafts with 10 m droppers. There was sufficient stock to sample at the time of the shoreline survey.

Sewage/Faecal Sources

Human – There are no large settlements in the area surrounding Uyea Sound. There was a small farm with outbuildings, one large house and two holiday lets in Vementry, located to the south of Uyea Sound. No other dwellings were observed in the surrounding area. A septic tank, possible outfall pipe and sewage related debris (cotton buds and toilet roll) was observed in a small bay, north of Vementry. Another septic tank was observed close to the holidays lets, which are located to the west of Vementry.

Livestock – The land surrounding the production area was a mixture of rough grassland, heath land and some areas of improved pastures. Livestock were observed grazing along most of the shoreline. Sheep and lambs had access to the shoreline and were observed on the beach in places. There was a small farm with several outbuildings located at Vementry. South of the farm was a field with 22 sheep and 12 Shetland ponies, and the field north of the farm enclosed a horse. Horse droppings were observed along the shoreline throughout this field. Located in a field in front of the farm adjacent to the shoreline were two flocks of sheep (one contained approximately 21 sheep and the other 23 sheep). Further along the coastline adjacent to the Braga Ness site, an additional 16 sheep were observed grazing in total. From the boat, approximately 25 sheep were observed grazing on the Cow Head headland.

A single stream was observed discharging into Uyea Sound. The stream was located to the east of Vementry and discharged into the south of Uyea Sound close to the Holms of Uyea Sound mussel line. A fresh water sample was taken from the stream and had moderate levels of *E. coli* (590 cfu/100 ml). There were also several land drains leading from the fields into Uyea Sound, these were recorded but not sampled or measured. It is likely that land runoff is an important pathway for moving contamination from livestock into Uyea Sound.

E. coli levels in the six sea water samples taken offshore in the vicinity of the mussel lines was low (<1 *E. coli* cfu/100ml in all cases). Levels of *E. coli* in the two additional sea water samples taken from the shore were also low (<1 *E. coli* cfu/100ml in both cases).

At the Holms of Uyea site, the two mussel samples taken from the single long line gave low results of 20 and 50 *E. coli* MPN/100 g. At the Cow Head site, the four mussel samples taken from the northern and southern ends of the long lines had low results ranging from <20 to 70 *E. coli* MPN/100 g. At the Braga Ness site the four mussel samples taken from two separate rafts had low results ranging from <20 to 20 *E. coli* MPN/100 g. Salinity measurements taken during the survey indicated that there was little freshwater influence on

the water body at the time, with salinities all around that of full strength seawater with very little or no stratification.

Seasonal Population

There were two self catering cottages located in Vementry. There are no other hotels or B&BS in the area however the whole of Shetland is a popular tourist destination. The main attractions are wildlife watching and outdoor pursuits. Therefore the population is likely to be slightly higher during the summer months.

Boats/Shipping

Boat traffic in Uyea Sound is very light and limited to small fishing boats, mussel boats and small pleasure boats and yachts. A single mussel boat was observed in Uyea Sound at the time of the shoreline survey.

Land Use

The land surrounding Uyea Sound is a mixture of rough grassland, heath land and some areas of improved pasture, which is grazed by sheep and Shetland ponies. The Braga Ness peninsula is predominately heath land.

Wildlife/Birds

Gulls, oystercatchers, terns, fulmars, cormorants and geese were observed during the survey, but no major aggregations of wildlife were recorded. Two cormorants were observed sat on the mussel line buoys at Holms of Uyea Sound, 10 terns were observed on the Cow Head mussel lines, and 2 terns on the mussel raft floatation buoys at Braga Ness. Seals were spotted all along the shoreline, with a group of ten at the north end of Uyea Sound near Inga's Holm.

General observations

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

Dimensions and flows of watercourses are estimated at the most convenient point of access and not necessarily at the point at which the watercourses enter the sound.

Figure 1. Shoreline Observations

Table 1. Shoreline observations

No.	Date	Time	Position	Photograph	Associated sample	Observation
1	19/05/2010	09:26	HU 30896 59727	Figures 4-8	USSW1	Septic tank and possible outfall pipe, sewage related debris (cotton buds and tissue). Shellfish harvester's shed with jetty and boat. Seawater sample USSW1 salinity 36ppt. House, farm and outbuildings.
2	19/05/2010	09:32	HU 30916 59737			1 horse, 1 pony, horse droppings in field
3	19/05/2010	09:40	HU 30963 59886	Figure 9		Lots of mussel shells. Evidence of rubbish pile dumped on shoreline
4	19/05/2010	09:41	HU 30965 59876			Land drain/small stream
5	19/05/2010	09:44	HU 31050 59858			6 sheep. End of horse field (horse droppings all along shoreline to this point)
6	19/05/2010	09:49	HU 31207 59762	Figures 10-11	USFW1	Stream, width 35cm, depth 6cm, flow 0.073m/sec. Temporary floating jetty on shore, 1 seal. Green algae on shoreline.
7	19/05/2010	09:53	HU 31198 59814		USSW2	Seawater sample USSW2 salinity 37ppt. A lot of mussel shells in water
8	19/05/2010	09:59	HU 31323 59889			Land drain
9	19/05/2010	10:01	HU 31354 59880			Land drain
10	19/05/2010	10:07	HU 31389 60098	Figure 12		10 sheep (2 of which on beach)
11	19/05/2010	10:10	HU 31398 60185			Land drain
12	19/05/2010	10:16	HU 31394 60313			Opposite bank has 22 sheep
13	19/05/2010	10:19	HU 31425 60271	Figure 13		10 seals near Inga's Holm
14	19/05/2010	10:22	HU 31486 60242			Dead bird
15	19/05/2010	10:31	HU 31604 60407			End of shoreline walk
16	19/05/2010	10:57	HU 30969 59571	Figure 14		22 sheep, 2 ponies
17	19/05/2010	11:44	HU 30912 59683			21 sheep
18	19/05/2010	11:46	HU 30826 59764			23 sheep
19	19/05/2010	11:54	HU 30636 59819			Land drain. 2 Oyster catchers
20	19/05/2010	11:56	HU 30656 59906			7 fulmars
21	19/05/2010	12:00	HU 30588 59952			1 cormorant, 1 seal
22	19/05/2010	12:08	HU 30530 59790			3 geese, goose droppings on shore
23	19/05/2010	12:13	HU 30682 59726			6 seals
24	19/05/2010	12:20	HU 30811 59537			7 sheep on opposite shore (to the west)
25	19/05/2010	12:22	HU 30837 59550			Land runoff, smells of horse manure
26	19/05/2010	12:23	HU 30855 59550	Figures 15-17		Septic tank, 2 holiday lets
27	19/05/2010	12:26	HU 30930 59573	Figure 18		12 ponies (total for field, 2 previously counted in observation No.,16)
28	20/05/2010	09:46	HU 31261 60630			End of Holms of Uyea Sound mussel lines. 2 cormorants on lines
29	20/05/2010	09:48	HU 31252 60642	Figure 19	USSW3, USMUSSEL1 (4m),	Salinity surface - 36.30, 3m - 36.70, 5m - 36.80, 10m - 36.93. Seawater sample salinity 38ppt. (Holms of Uyea)

No.	Date	Time	Position	Photograph	Associated sample	Observation
					USMUSSEL2 (surface <1m)	
30	20/05/2010	09:54	HU 31152 60758		USSW4	End of lines. No mussel sample taken. Salinity surface - 33.72; 3m - 36.47; 5m - 36.58, 10m - 36.78. Water temperature at 5m 9.4oC. Seawater sample salinity 38ppt. (Holms of Uyea)
31	20/05/2010	10:05	HU 30712 60308	Figure 20	USSW5, USMUSSEL 3 (4m), USMUSSEL 4 (surface <1m)	Cow Head. 25 sheep on shore (Cow Head). Approx 10 terns on site. Salinity surface - 36.53; 3m - 37.02; 5m - 37.08; 10m - 37.13. Seawater sample salinity 39ppt
32	20/05/2010	10:14	HU 30755 60306			Corner of lines, end two lines have no stock (Cow Head)
33	20/05/2010	10:15	HU 30750 60324			Outer end of lines (Cow Head)
34	20/05/2010	10:16	HU 30693 60333			Corner of lines (Cow Head)
35	20/05/2010	10:17	HU 30635 60181			Corner of lines (Cow Head)
36	20/05/2010	10:18	HU 30679 60147			Corner of lines (Cow Head)
37	20/05/2010	10:19	HU 30651 60190	Figure 21	USSW6, USMUSSEL 5 (4m), USMUSSEL 6 (surface <1m)	Salinity surface - 37.10; 3m - 37.12; 5m - 37.12; 10m - 37.16. Seawater sample salinity 38ppt (Cow Head)
38	20/05/2010	10:38	HU 31247 60077			End of Braga Ness Mussel Rafts
39	20/05/2010	10:39	HU 31246 59997			End of Braga Ness Mussel Rafts
40	20/05/2010	10:41	HU 31248 60003	Figure 22	USSW7, USMUSSEL 7 (surface <1m), USMUSSEL 8 (4m)	2 Terns on end buoy. Salinity surface - 32.75; 3m - 37.15, 5m - 37.17, 10m 37.19. Water temperature at 5m 9.2oC. Seawater sample salinity 38ppt (Braga Ness)
41	20/05/2010	10:48	HU 31244 60047	Figure 23	USSW8, USMUSSEL 9 (3m), USMUSSEL 10 (surface <1m)	Salinity surface - 37.17; 3m - 37.17; 5m - 37.17; 10m - 37.20. Water temperature 9.3oC at 5m. Seawater sample salinity 38ppt. (Braga Ness)

Sampling

Water and shellfish samples were collected at sites marked on the maps in Figures 2 and 3 respectively. Bacteriology results follow in Tables 2 and 3.

Seawater samples were tested for salinity using a hand held refractometer. These readings are recorded in Table 1 as salinity in parts per thousand (ppt). Samples of seawater were also tested for salinity by the laboratory using a salinity meter under controlled conditions. These results are shown in Table 2, given in units of grams salt per litre of water. Note that this is equivalent to ppt.

Table 2. Water sample *E. coli* results

No.	Sample Ref.	Date	Time	Position	Type	*E. coli* (cfu/100 ml)	Salinity (ppt)	Salinity (g L^{-1})
1	USSW1	19/05/2010	09:26	HU 30896 59727	Sea Water	<1	36	35.14
2	USSW2	19/05/2010	09:49	HU 31207 59762	Sea Water	<1	37	35.13
3	USFW1	19/05/2010	09:53	HU 31198 59814	Fresh Water	590		
4	USSW3	20/05/2010	09:48	HU 31252 60642	Sea Water	<1	38	35.4
5	USSW4	20/05/2010	09:54	HU 31152 60758	Sea Water	<1	38	35.41
6	USSW5	20/05/2010	10:05	HU 30712 60308	Sea Water	<1	39	35.34
7	USSW6	20/05/2010	10:19	HU 30651 60190	Sea Water	<1	38	35.37
8	USSW7	20/05/2010	10:41	HU 31248 60003	Sea Water	<1	38	35.54
9	USSW8	20/05/2010	10:48	HU 31244 60047	Sea Water	<1	38	35.57

Table 3. Shellfish sample *E. coli* results

No.	Sample Ref.	Date	Time	Position	Species	Depth	Result (*E. coli* MPN/100 g)
1	US1-Holms of Uyea	20/05/2010	09:52	HU 31252 60642	Mussels	4 m	20
2	US2-Holms of Uyea	20/05/2010	09:52	HU 31252 60642	Mussels	Surface <1 m	50
3	US3-Cow Head	20/05/2010	10:05	HU 30712 60308	Mussels	4 m	<20
4	US4-Cow Head	20/05/2010	10:05	HU 30712 60308	Mussels	Surface <1 m	70
5	US5-Cow Head	20/05/2010	10:19	HU 30651 60190	Mussels	4 m	<20
6	US6-Cow Head	20/05/2010	10:19	HU 30651 60190	Mussels	Surface <1 m	20
7	US7-Braga Ness	20/05/2010	10:41	HU 31248 60003	Mussels	Surface <1 m	<20
8	US8-Braga Ness	20/05/2010	10:41	HU 31248 60003	Mussels	4 m	<20
9	US9-Braga Ness	20/05/2010	10:48	HU 31244 60047	Mussels	3 m	20
10	US10-Braga Ness	20/05/2010	10:48	HU 31244 60047	Mussels	Surface <1 m	<20

Table 4. Salinity profiles

Profile	Date	Time	Position	Depth (m)	Salinity (ppt)
1	20/05/2010	09:48	HU 31252 60642	Surface	36.30
				3	36.70
				5	36.80
				10	36.93
2	20/05/2010	09:54	HU 31152 60758	Surface	33.72
				3	36.47
				5	36.58
				10	36.78
3	20/05/2010	10:05	HU 30712 60308	Surface	36.53
				3	37.02
				5	37.08
				10	37.13
4	20/05/2010	10:19	HU 30651 60190	Surface	37.10
				3	37.12
				5	37.12
				10	37.16
5	20/05/2010	10:41	HU 31248 60003	Surface	32.75
				3	37.15
				5	37.17
				10	37.19
6	20/05/2010	10:48	HU 31244 60047	Surface	37.17
				3	37.17
				5	37.17
				10	37.20

Figure 2. Water sample results

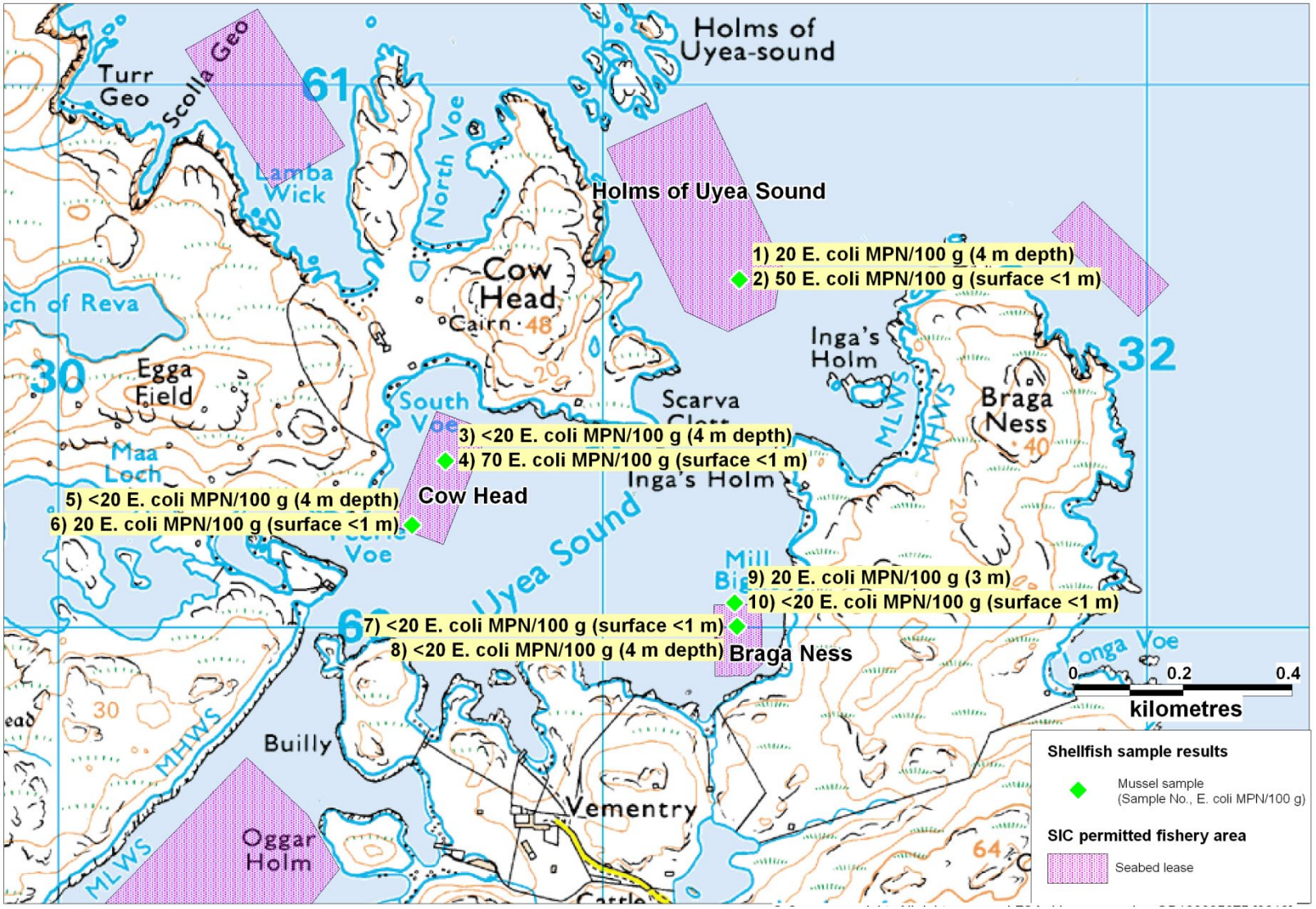

Figure 3. Shellfish sample results

Photographs

Figure 4. Septic tank and outfall pipe

Figure 5. Sanitary debris on shoreline – cotton buds and toilet roll

Figure 6. Location of sea water sample USSW1

Figure 7. Shellfish harvesters shed with jetty and boat

Figure 8. House, farm and out buildings

Figure 9. Mussel shells

Figure10. Stream, location of USFW1. Temporary floating jetty on shore.

Figure 11. Green algae on shoreline

Figure 12. Sheep and lambs on the shoreline and beach

Figure 13. 10 seals, near Inga's Holm

Figure 14. Farm out buildings, field of 22 sheep and 2 ponies

Figure 15. Septic tank

Figure 16. Holiday let

Figure 17. Holiday let

Figure 18. Field of Shetland ponies

Figure 19. Holms of Uyea mussel line

Figure 20. Cow Head mussel lines

Figure 21. Cow Head mussel lines

Figure 22. Braga Ness mussel rafts

Figure 23. Braga Ness mussel rafts