Scottish Sanitary Survey Project

Sanitary Survey Report
The Rona
SI 517 944 08
November 2010

Cefas

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Report Distribution – The Rona

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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

The Rona is a water body located between Aith Voe and Swarbacks Minn on the west coast of the main island of Shetland. The mussel site is located off the shoreline of Aith Ness, south of Papa Little island. The village of Aith lies approximately 4 km to the southeast, at the head of Aith Voe. The area is relatively open, particularly to winds and seas from the north or northwest.

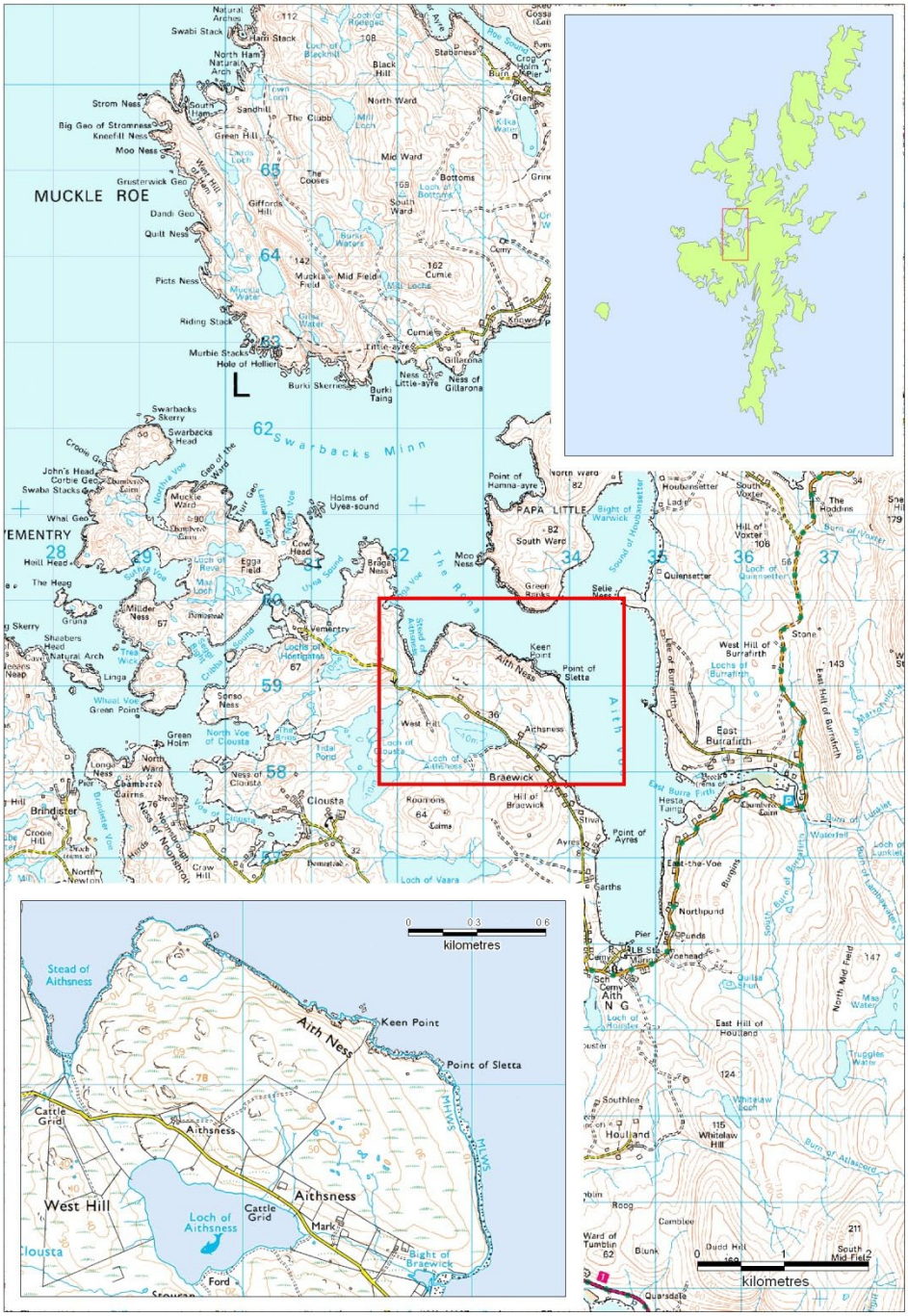

Figure 1.1 Location of The Rona – Aith Ness

2. Fishery

The sanitary survey was prompted by an application for classification of a new site in the Rona: Aith Ness, SIN SI 517 944 08 for common mussels. The site is not currently classified and does not fall within a current production area. A sampling point has been set at HU 332 595.

At the time of shoreline survey, the site consisted of one double-headed long line, with 10m deep droppers. It had recently been harvested, so there was no stock present at the time. Four further long lines were installed after the shoreline survey visit, all of which have 10 m droppers and will be harvested in late 2012/early 2013. The harvester has consent to install a total of ten lines, but wasn't yet certain as to whether or when the other 5 lines would be added. 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 and the permitted seabed lease area. 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.

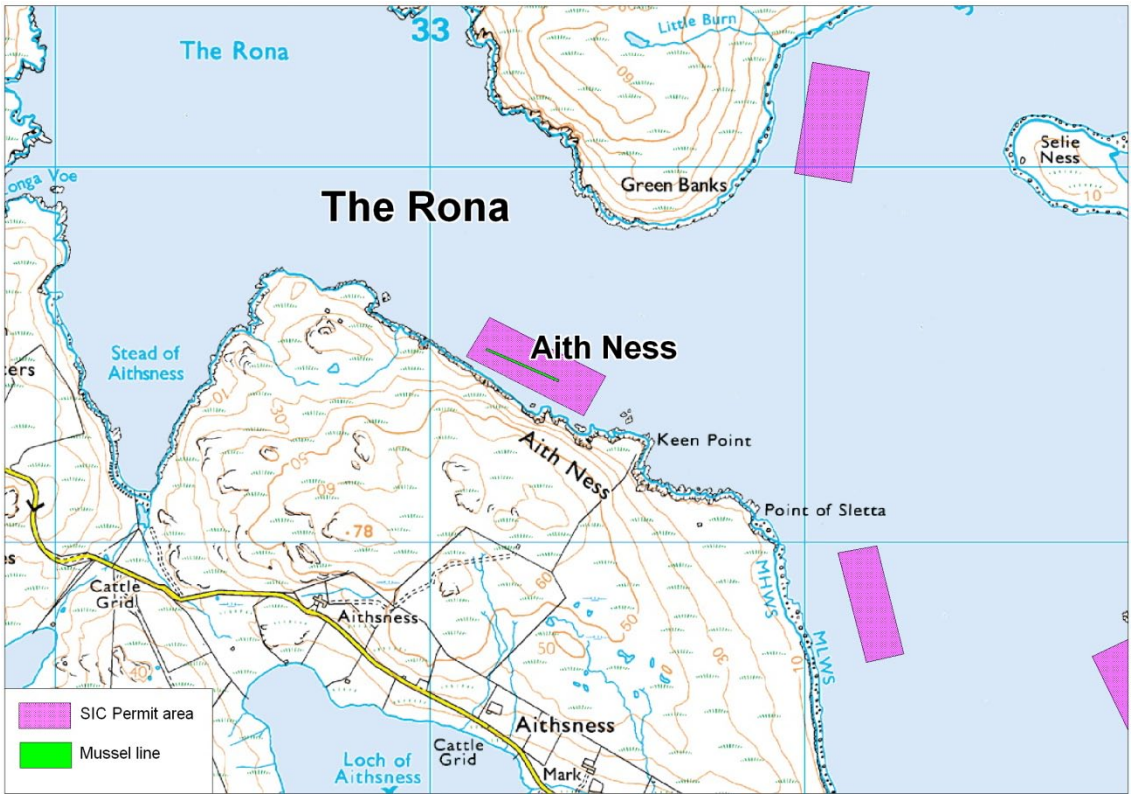

Figure 2.1 The Rona – Aith Ness Fishery

3. Human Population

Information was obtained from the General Register Office for Scotland on the population within the 2001 census output areas in the vicinity of The Rona. These data are presented in Figure 3.1.

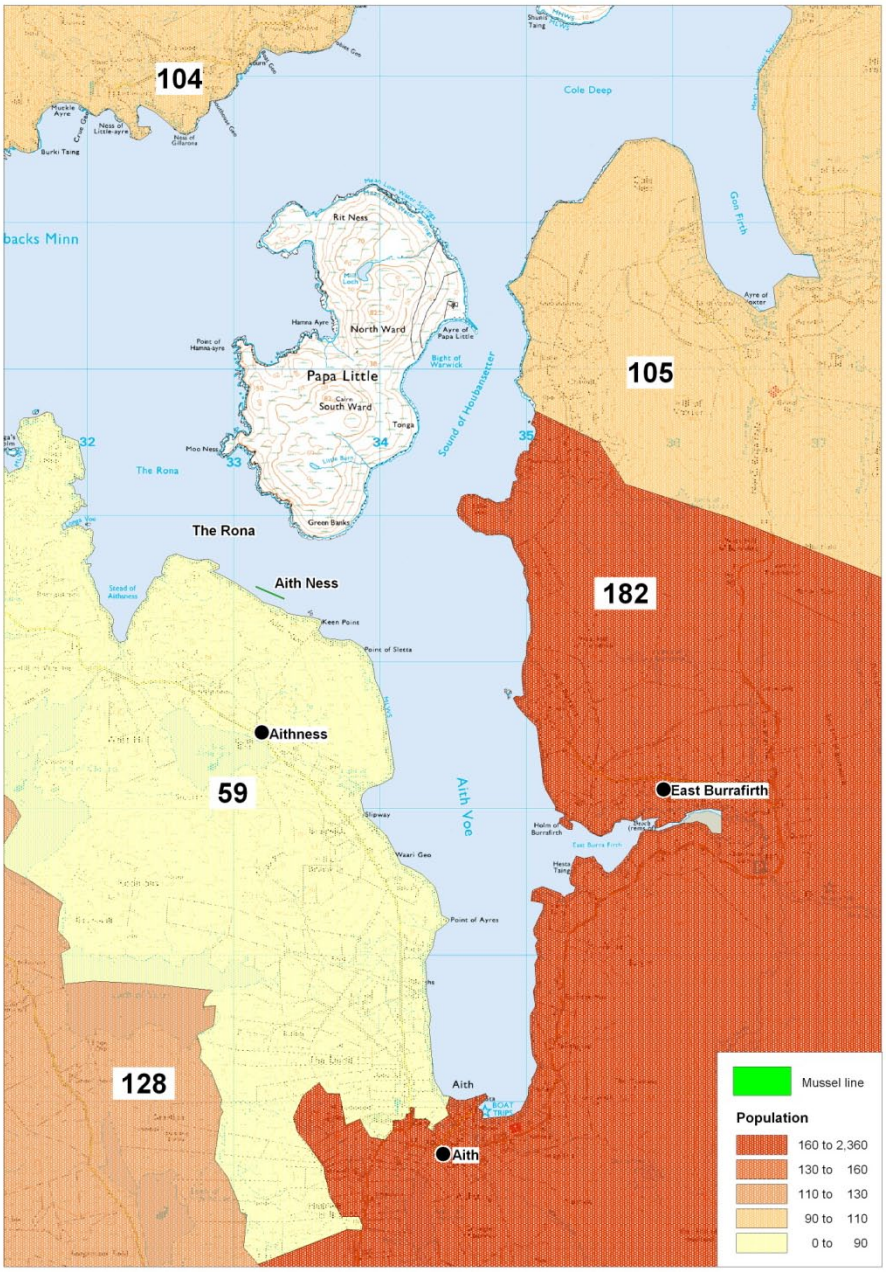

Figure 3.1 Human population adjacent to The Rona

There are five population census areas in the area of The Rona, with a total population of 578. However, the areas are large and only a portion of the total number will actually live within the area shown in Figure 3.1. Population in the area is centred around the village of Aith, approximately 4.1 km south of the fishery at the head of Aith Voe. There are small groups of private homes at Aithness and East Burrafirth, as well as further dwellings along the south

shore of East Burra Firth and both shores of Aith Voe. Some of the dwellings in the area are believed to be holiday homes, and wildlife tours operate from the marina at Aith suggesting population may increase during the summer months. Therefore, inputs from human sewage are likely to be mainly found at Aith, and may be slightly higher during the summer months.

4. Sewage Discharges

Information on discharges in the vicinity of The Rona was solicited from Scottish Water and the Scottish Environment Protection Agency (SEPA). The nearest community discharges identified by Scottish Water are in Aith, 3.7 km to the southeast of the mussel lines. These are detailed in Table 4.1.

Table 4.1 Discharges identified by Scottish Water

No.	Consent Ref No.	NGR of discharge	Discharge Name	Discharge Type	Level of Treatment	Consented Flow (DWF)	Consented Design PE
1	S16C, S59B CAR/L/1 002306	HU 3457 5601	Aith West WWPS	EO* only	None (8 hrs storage)	Not Stated	Not Stated
2	S16B, S59A CAR/L/1 002292	HU 3478 5587	Aith East WWPS	EO only	None (8 hrs storage)	Not Stated	Not Stated
3	S59X CAR/L/1 002305	HU 3495 5624	Aith	Continuous	Septic Tank	70 m^3/d	300

* EO: Emergency Overflow

No sanitary or microbiological data was available for these discharges.

Fifteen consented discharges were identified by SEPA as being in the vicinity of The Rona. Details of these discharges are presented in Table 4.2. Numbers 5-7 correspond to the discharges listed in Table 4.1.

Table 4.2 Discharge consents identified by SEPA

No.	Ref No.	NGR of discharge	Discharge Type	Level of Treatment	Consented flow (DWF) m^3/d	Consented/ design PE	Discharges to
1	CAR/R/1077054	HU 33640 58270	Continuous	Septic Tank		5	Soakaway
2	CAR/R/1073539	HU 33842 57801	Continuous	Septic Tank		5	Soakaway
3	CAR/R/1042679	HU 33930 57614	Continuous	Septic Tank		5	Soakaway
4	CAR/R/1041943	HU 34306 57251	Continuous	Septic Tank		5	Soakaway
5	CAR/L/1002306 (S16C, S59B)	HU 34570 56010	Intermittent	Emergency Overflow (EO)	-	-	Aith Voe
6	CAR/L/1002292 (S16B, S59A)	HU 34780 55870	Intermittent	Emergency Overflow (EO)	-	-	Aith Voe
7	CAR/L/1002305 (S59X)	HU 35100 56200 (HU 3495 5624)	Continuous	Primary	not provided	not provided	Aith Voe
8	CAR/R/1013090	HU 35220 56830	Continuous	Septic Tank		5	Land
9	CAR/R/1039922	HU 35200 56980	Continuous	Septic Tank		5	Soakaway
10	CAR/R/1014050	HU 35620 57600	Continuous	Septic Tank		5	Aith Voe
11	CAR/R/1039784	HU 36150 57740	Continuous	Septic Tank		5	Soakaway
12	CAR/R/1020320	HU 36236 57698	Continuous	Septic Tank		5	Soakaway
13	CAR/R/1039870	HU 36020 58120	Continuous	Septic Tank		5	Soakaway
14	CAR/R/1040856	HU 35590 57890	Continuous	Septic Tank		8	East Burra Firth
15	CAR/R/1046892	HU 35344 58042	Continuous	Septic Tank		15	Soakaway

No consented flow volumes were provided for the discharges in Table 4.2.

Entries 1-3 in Table 4.1 relate to entries 5-7 in Table 4.2, and to entries 1 and 10 in Table 4.3. The main discharge from the Aith Voe septic tank was not seen during the shoreline survey and was presumed to be underwater at the time.

No sewage discharges were identified by SW or SEPA to the north or west of the fishery and no discharges or other sewage infrastructure were identified immediately adjacent to the fishery during the shoreline survey in May 2010. A survey was undertaken in 2009 at Aith Voe and East Burra Firth, including areas to the south and southeast of the area surveyed for The Rona. These observations are listed in Table 4.3 below. All of the sewage discharges identified in the tables are shown mapped in Figure 4.1 along with the location of the fishery.

Table 4.3 Discharges and septic tanks observed during shoreline surveys

No	Date	NGR	Description	SEPA consent no.
1	31/09/09	HU 3457 5592	Pumping station (Aith West)	S16C, S59B
2	31/09/09	HU 3456 5597	Pipe on shoreline running from Aith West pumping station. Ceramic in poor repair with major crack, no apparent flow. Seawater sample 6 by pipe (90 *E. coli* cfu/100ml)	S16C, S59B
3	31/09/09	HU 3430 5674	Discharge pipe flowing, sudsy. Flow could not be determined. Water sample 8 from discharge (1900 *E. coli* cfu/100ml)	
4	31/09/09	HU 3433 5706	Septic discharge pipe, completely dry, no green algae or other signs of septic input	
5	31/09/09	HU 3437 5725	Septic tank with no apparent discharge pipe. Foul water puddled around base with wet, overgrown ditch leading to shoreline. Odour and flies, but no apparent flow over shoreline.	CAR/R/1041943
6	01/09/09	HU 3379 5790	Septic tank, concrete, presumably to soakaway	
7	01/09/09	HU 3386 5779	Septic tank downhill from road, presumably to soakaway	CAR/R/1073539
8	01/09/09	HU 3393 5767	Septic tank below house, concrete, presumably to soakaway	
9	01/09/09	HU 3396 5762	Inspection hatch with nearby septic tank downhill, presumably to soakaway	CAR/R/1042679
10	01/09/09	HU 3479 5582	Aith East pumping station	S16B, S59A
11	01/09/09	HU 3479 5584	Outfall pipe from Aith East pumping station, no odour apparent, seawater sample number 16 by end (4 *E. coli* cfu/100ml)	S16B, S59A
12	01/09/09	HU 3486 5586	Discharge pipe, flowing across sand. Water sample 17 from discharge (26000 *E. coli* cfu/100ml)	
13	01/09/09	HU 3501 5579	Septic tank downhill from road, presumably to soakaway	
14	01/09/09	HU 3533 5803	Septic tank, 1 house, presumably to soakaway	CAR/R/1046892
15	01/09/09	HU 3630 5817	Septic tank, 1 house, presumably to soakaway	

The nearest sources of sewage contamination are all located to the southeast of the mussel farm at The Rona. The largest discharge is the community septic tank to the head of Aith Voe, with two further private discharges one to Aith Voe and one to East Burra Firth. Any impact from these is likely to be substantially diluted before reaching the mussel farm and will contribute to background *E. coli* levels in the area. There is a marina at Aith, with boats

large enough to provide onboard toilet facilities, including tour boats. These are likely to pass relatively near to the fishery on their way out, and should they discharge overboard whilst passing the fishery could potentially pose a significant source of faecal contamination in the immediate vicinity of the discharge.

Figure 4.1 Map of discharges for The Rona

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 red and orange indicate poorly draining soils.

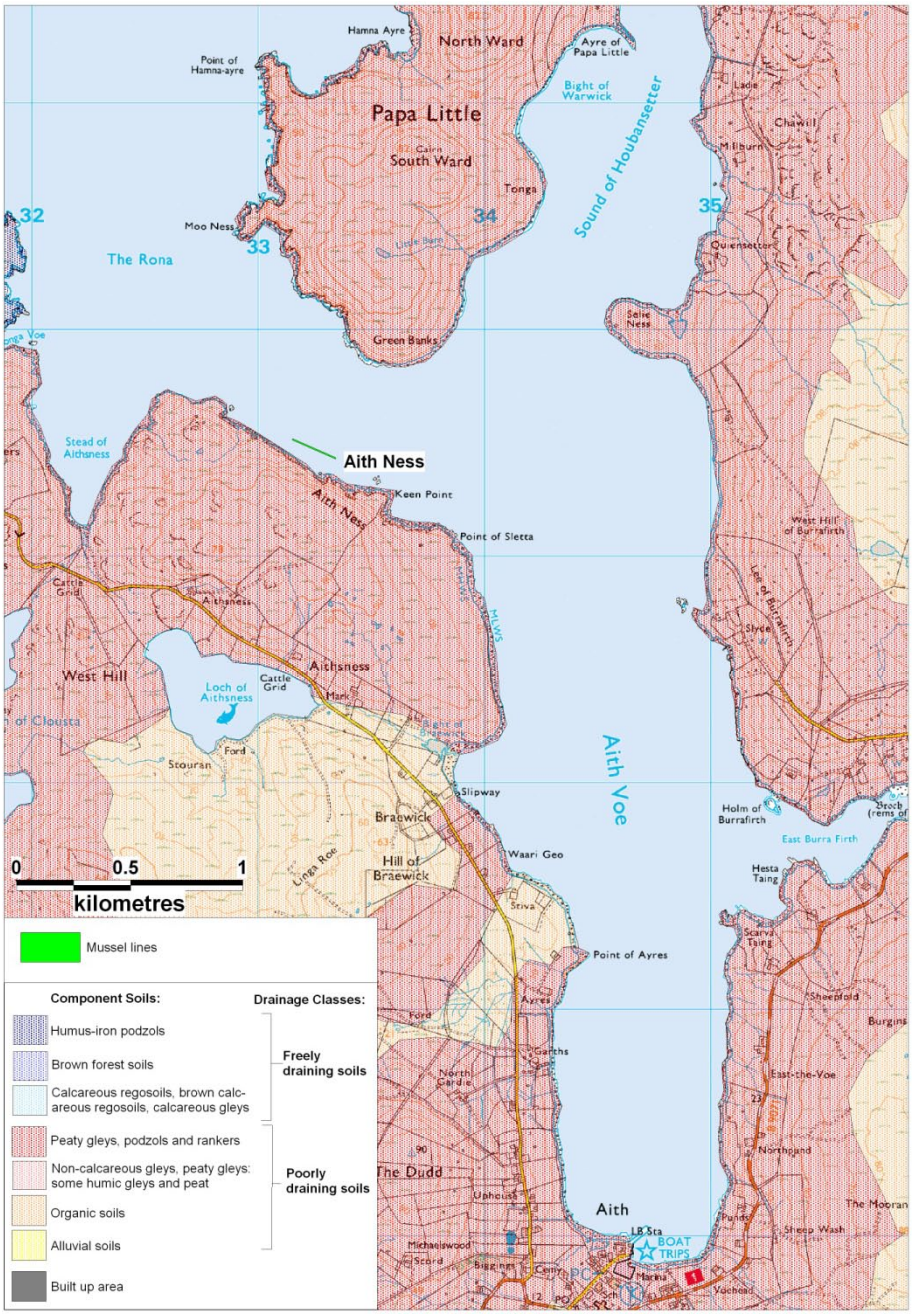

Figure 5.1 Component soils and drainage classes for The Rona

Two types of component soils are present in the area: peaty gleys, podzols and rankers and organic soils. Both of these soils are poorly draining. Therefore, the potential for runoff contaminated with *E. coli* from human and/or animal waste is high for all the land surrounding The Rona: Aith Ness fishery.

6. Land Cover

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

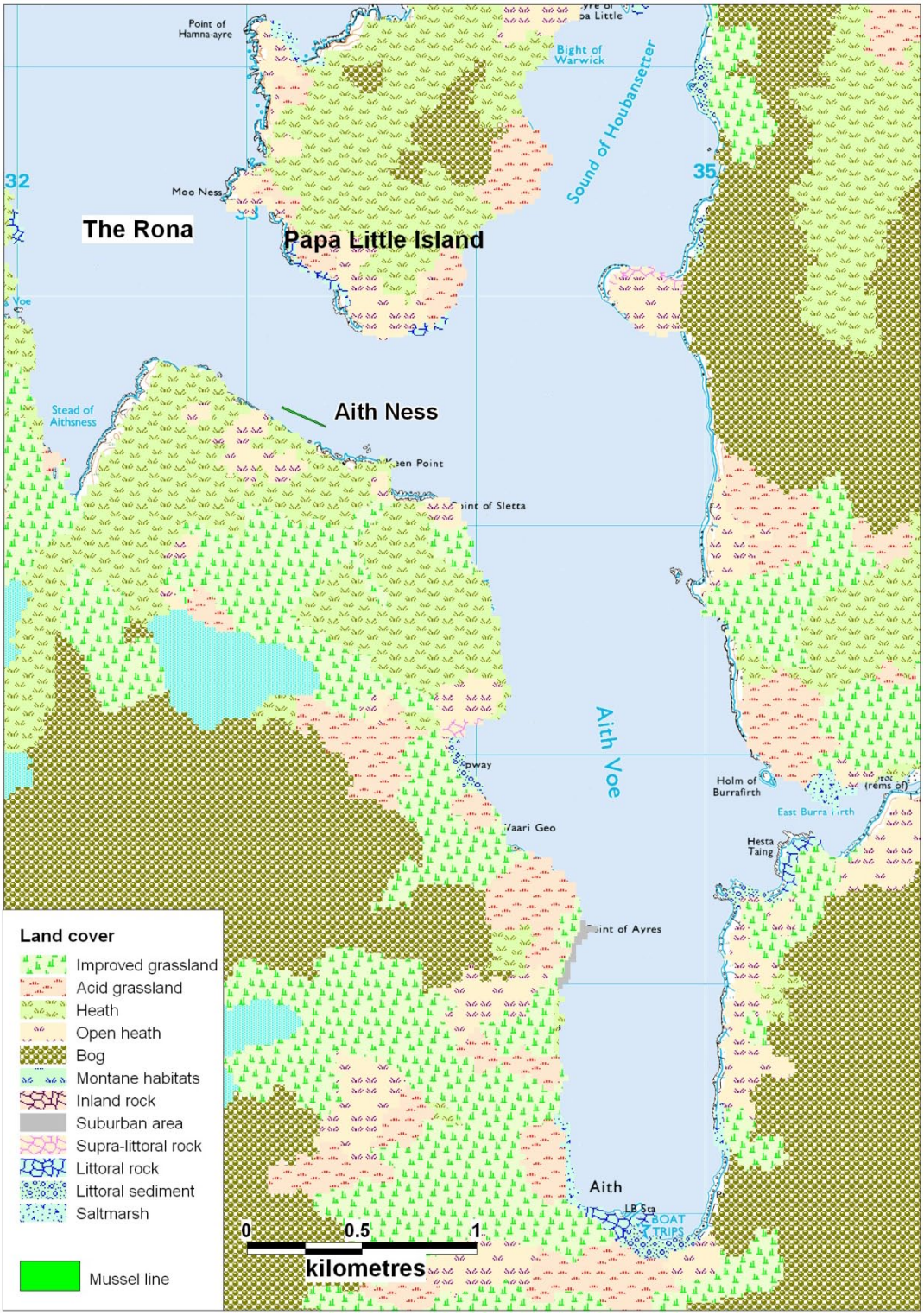

Figure 6.1 LCM2000 class land cover data for The Rona

The land south of Aith Ness and west of Aith Voe is predominantly bog inland with patches of improved and acid grassland and heath. To the west of Aith

Ness, an area of improved grassland lines the west shore of the Stead of Aithness. There are also areas of permanent freshwater south and west of Aith Ness. The island of Papa Little to the north of Aith Ness is predominantly heathland and bog, with patches of acid grassland and open heath along the shoreline. The eastern shoreline of Aith Voe and the Sound of Houbansetter is also composed of patches of acid grassland, improved grassland, heath and bog. Although no suburban or urban developed areas are shown in Figure 6.1, the village of Aith is actually developed.

The faecal coliform contribution would be expected to be highest from developed areas (approx 1.2 – 2.8x10^{9} cfu km^{-2} hr^{-1}), with intermediate contributions from the improved grassland (approximately 8.3x10^{8} cfu km^{-2} hr^{-1}) and lowest from the other land cover types (approximately 2.5x10^{8} 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, this being expected to be highest, at more than 100-fold, for the improved grassland.

Therefore, the overall predicted contribution of contaminated runoff from these land cover types would be expected to increase significantly following rainfall events. There is more improved grassland on the shore south of Aith Ness, compared to the north and east shore.

The highest predicted contribution of contaminated runoff should come from developed area (not shown) at the head of Aith Voe, though this lies 4 km from the fishery. Intermediate contributions are anticipated from the areas of improved grassland along the shores of Aith Voe and southeast of Aith Ness as well as to the west along the Stead of Aithness.

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 7.1Livestock numbers in Aithsting 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

Livestock production in Aithsting agricultural parish was significantly dominated by sheep, and reported numbers of all animals had remained mostly stable between 2008 and 2009. However, due to the large size of the parish (92.82 km^2), and the withheld data, an accurate representation of the number 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 18th – 20th May 2010. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 7.1 A total of 119 sheep were observed on Aith Ness and the island of Papa Little to the north, with no cattle or horses seen.

The area on which the sheep were seen is rough grazing and they are likely to present over much of the area over the course of the year. Numbers are likely to be significantly higher in summer, when lambs are present, than during winter. Sheep faeces are likely to be a significant source of faecal bacteria to rainfall runoff from land adjacent to the fishery.

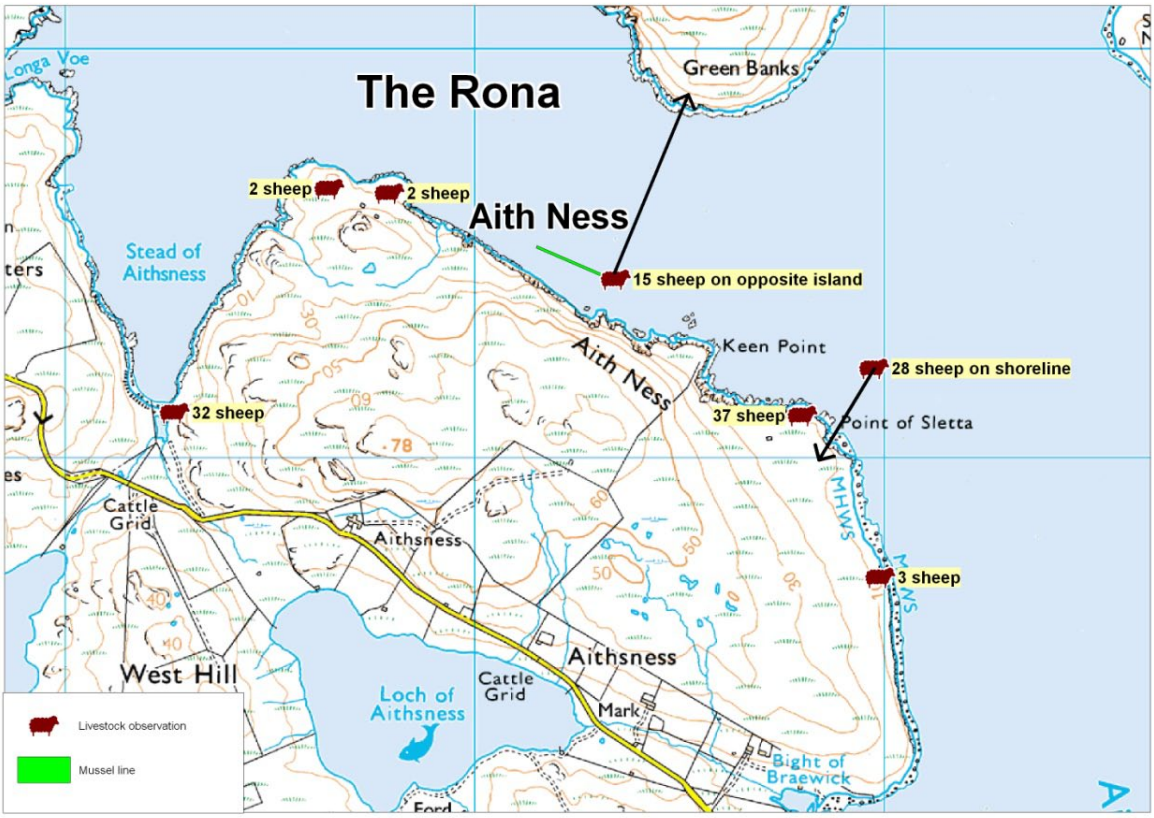

Figure 7.1 Livestock observations at The Rona

8. Wildlife

Loch of Clousta Site of Special Scientific Interest (SSSI) lies approximately 2 km southwest of The Rona site. 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 Aith Voe and East Burra Firth 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 The Rona. 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, at the mouth of Aith Voe, 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, less than 5 km to the north of The Rona. 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. Though no seals were observed during the shoreline survey at The Rona, 24 seals (species uncertain) were seen hauled out at Uyea Sound, about 3.5 km to the west of the mouth of Aith Voe, and one was seen in the water in the vicinity of Aith during the 2009 shoreline survey at Aith Voe and East Burra Firth.

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

Although no otters were seen during the shoreline survey at The Rona, a family of three otters were observed at the north end of Aith Voe during the 2009 survey so they are known to be present in the area. 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. 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. This data is thematically mapped in Figure 8.1.

Table 8.1 Seabird counts within 5km of the Aith Ness mussel lines

Common name	Species	Total Count	Method
Black guillemot	*Cepphus grylle*	249	Individuals on land
Atlantic puffin	*Fratercula arctica*	90	Occupied burrows
Northern fulmar	*Fulmarus glacialis*	2914	Occupied sites
Herring gull	*Larus argentatus*	510	Occupied nests/occupied territory
Common gull	*Larus canus*	230	Occupied nests/occupied territory
Lesser black-backed gull	*Larus fuscus*	18	Occupied territory
Great black-backed gull	*Larus marinus*	170	Occupied nests/occupied territory
Black-headed gull	*Larus ridibundus*	86	Occupied territory
European shag	*Phalacrocorax aristotelis*	70	Occupied nests/Occupied sites
Kittiwake	*Rissa tridactyla*	246	Occupied nests
Arctic skua	*Stercorarius parasiticus*	6	Occupied territory
Great skua	*Stercorarius skua*	22	Occupied territory
Arctic tern	*Sterna paradisaea*	912	Occupied nests/occupied territory

Gulls, seabirds and geese were observed singly and in low numbers during the shoreline survey. No large aggregations of seabirds were seen.

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 were seen to the south of the Point of Sletta during the course of the shoreline survey, along with 20 gulls and 3 divers. Geese are likely to be present year-round, with highest numbers from October to February and lowest numbers May to July. They are most likely to be found on improved grassland near where they were observed during the survey. Wading birds would be concentrated on intertidal areas, such as that found at the head of East Burra Firth, but none were seen during the shoreline survey at The Rona.

Rabbits

Rabbits (and a hare) were noted as being frequently seen along the shore of The Rona, however rabbit faeces are not likely to be a significant source of *E. coli* in the environment.

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 rabbits are all likely to be present in the area year-round. Impacts from seals are likely to be minor and unpredictable, as there are no

identified haulout sites along Aith Ness. Rabbits are present along much of the Aith Ness shoreline and any faecal bacteria from this source is likely to be carried to the fishery in rainfall runoff with impact assumed to be even across the fishery. Geese are most likely to be present on improved grassland east of the fishery and so impact from their faeces is likely to be highest at the east end of the mussel farm. Seabird nesting sites are lie predominantly north of the fishery, with the nearest significant concentrations to the northeast along the Sound of Houbansetter.

Figure 8.1 Map of seabird distributions within 5km of fishery, wildlife observations and conservation areas near The Rona

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. Although general wind and rainfall patterns may be similar at Lerwick and the survey area, 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 The Rona.

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 at the midline. The whiskers extend to the largest or smallest observations up to 1.5 times the box height above or below the box. Individual observations falling outside the box and whiskers are represented by the symbol *.

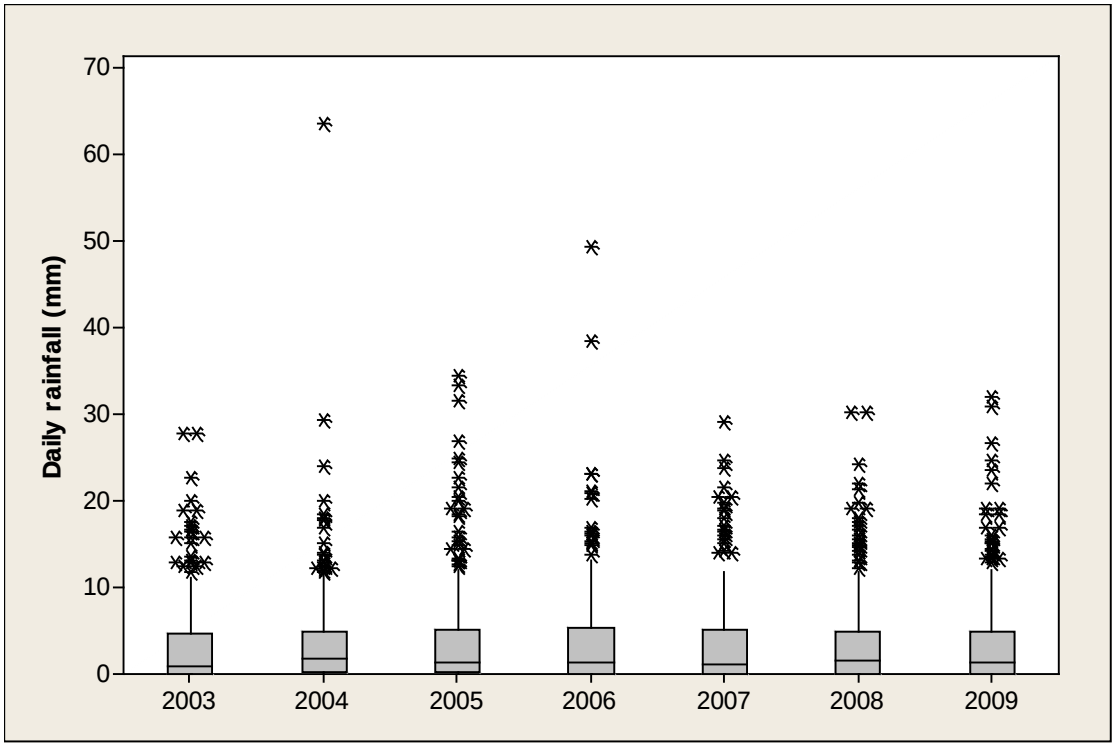

Figure 9.1 Box plot of daily rainfall values by year at Lerwick, 2003-2009

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

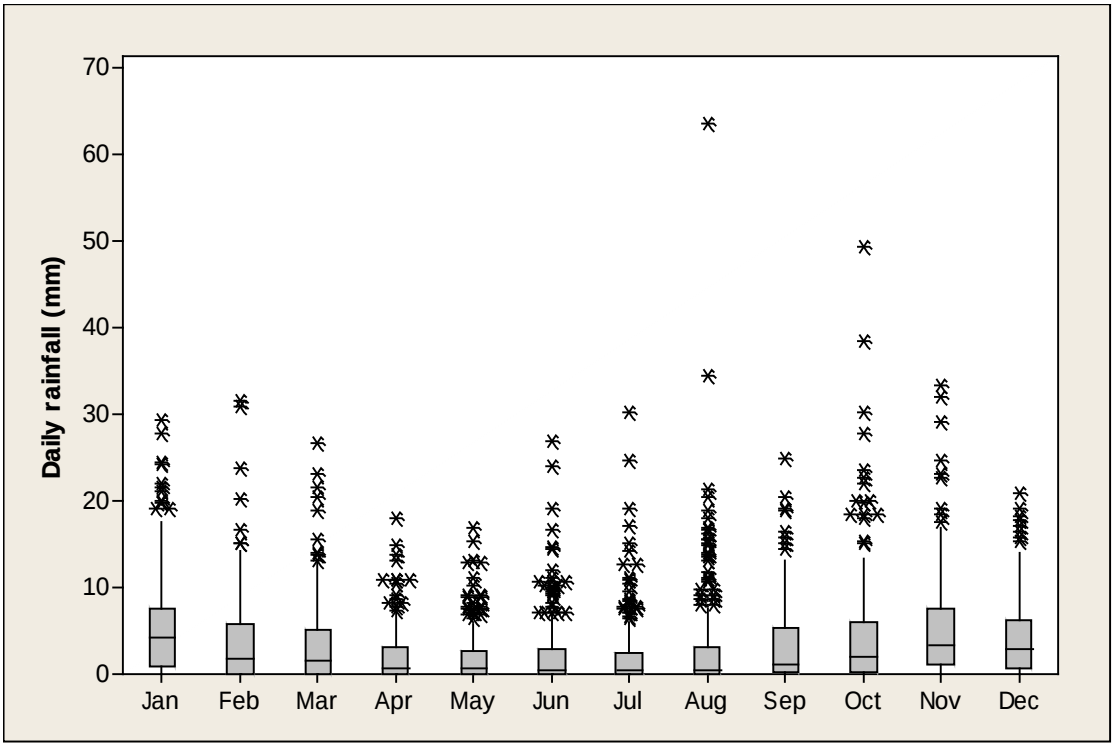

Figure 9.2 Box plot of daily rainfall values by month at Lerwick, 2003-2009

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 after a build-up of faecal matter on pastures during the drier months.

9.2 Wind

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

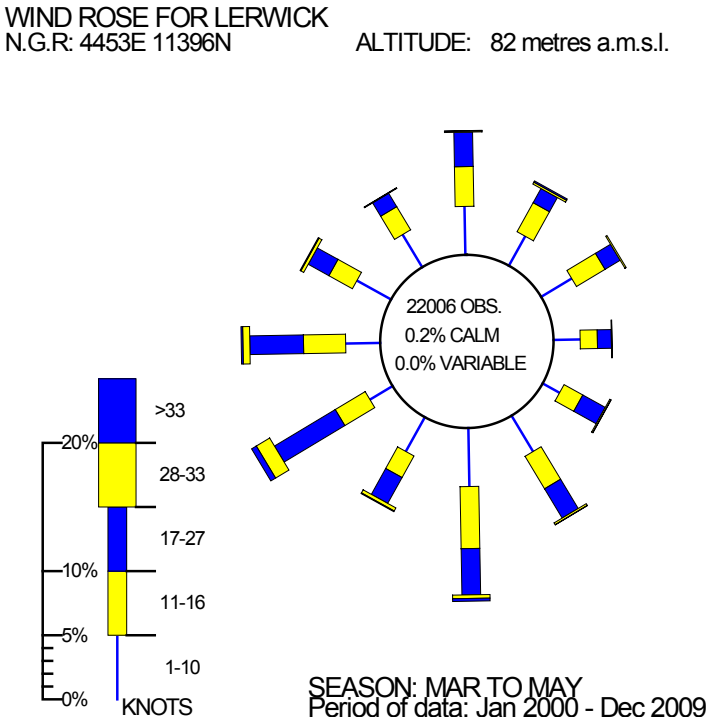

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Figure 9.3 Wind rose for Lerwick (March to May)

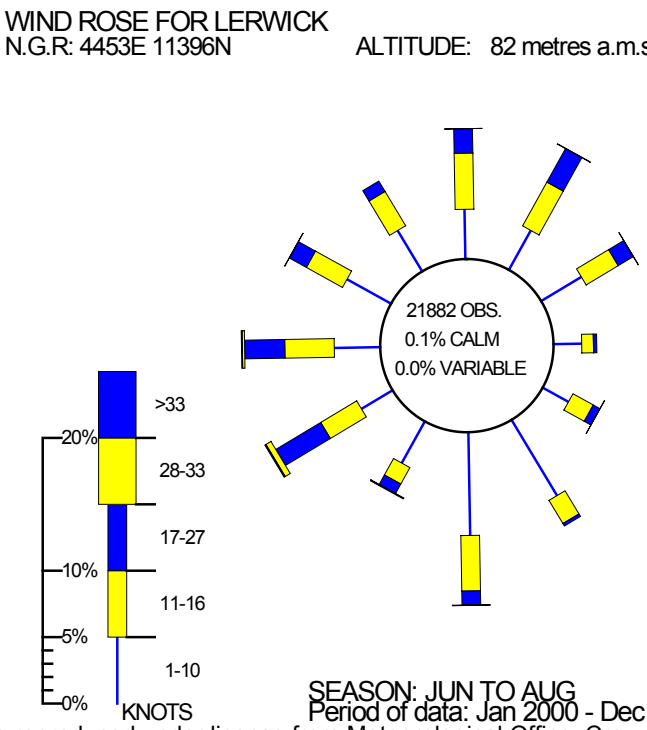

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Figure 9.4 Wind rose for Lerwick (June to August)

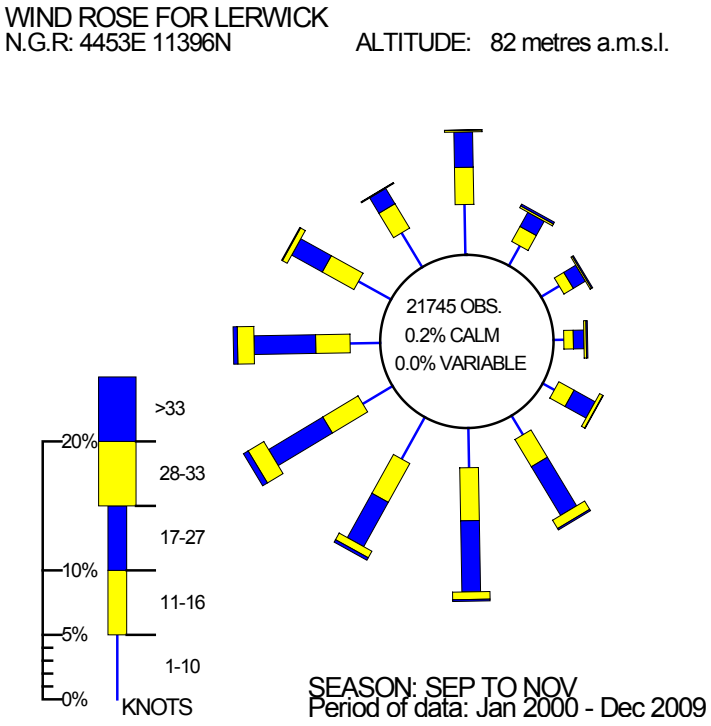

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Figure 9.5 Wind rose for Lerwick (September to November)

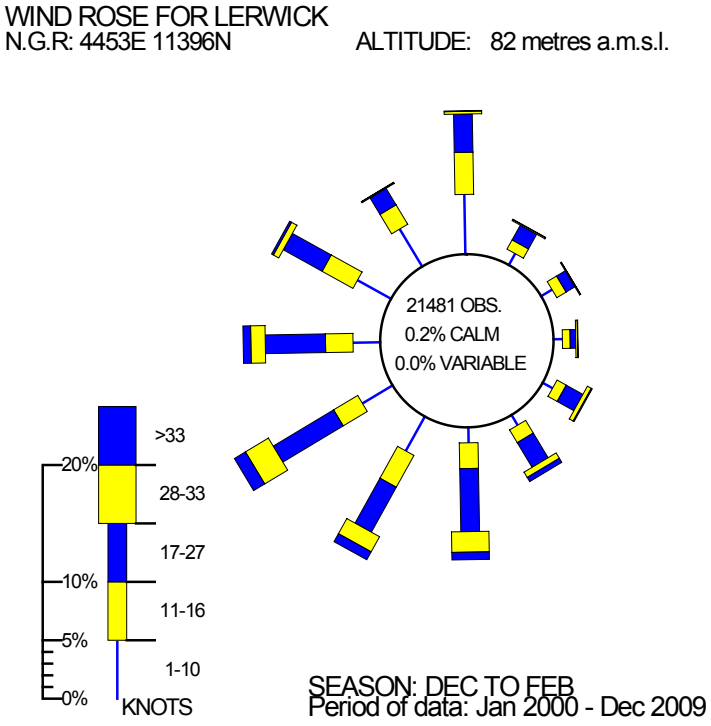

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Figure 9.6 Wind rose for Lerwick (December to February)

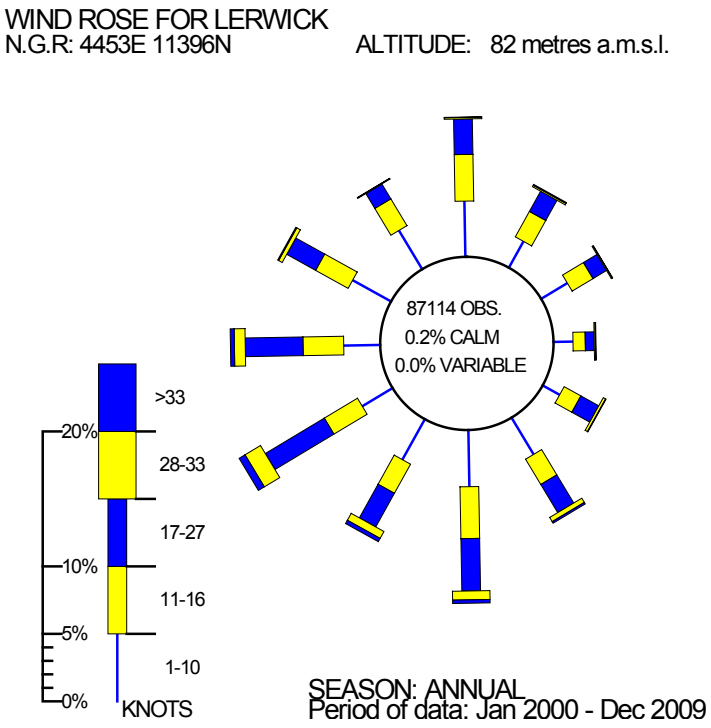

Figure 9.7 Wind rose for Lerwick (All year)

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

This area has not historically been classified.

11. Historical *E. coli* data

11.1 Validation of historical data

All shellfish samples taken at The Rona from the beginning of 2009 up to the 1st of October 2010 were extracted from the database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data.

No samples were excluded from the analysis on the basis of geographical or sampling date discrepancies. All samples were reported as having come from the same grid reference, HU 332 944, which lies within 100 m of the observed mussel line. Samples submitted for fast track classification were not included in this analysis. Five 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 (MPN) 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	The Rona
Site	Aith Ness
Species	Common mussel
SIN	SI 517 944
Location	HU 332 594
Total no of samples	13
No. 2009	3
No. 2010	10
Results Summary	
Minimum	<20
Maximum	460
Median	20
Geometric mean	33
90 percentile	290
95 percentile	380
No. exceeding 230/100g	2 (11%)
No. exceeding 1000/100g	0
No. exceeding 4600/100g	0
No. exceeding 18000/100g	0

11.3 Overall geographical pattern of results

Figure 11.1 shows the reported sampling location for monitoring samples collected from The Rona. As samples were only reported from one location, which plotted on shore approximately 80 m south of the location of the mussel line as recorded during the shoreline survey. Therefore, no inference can be made regarding geographical patterns in results or contamination levels at the fishery.

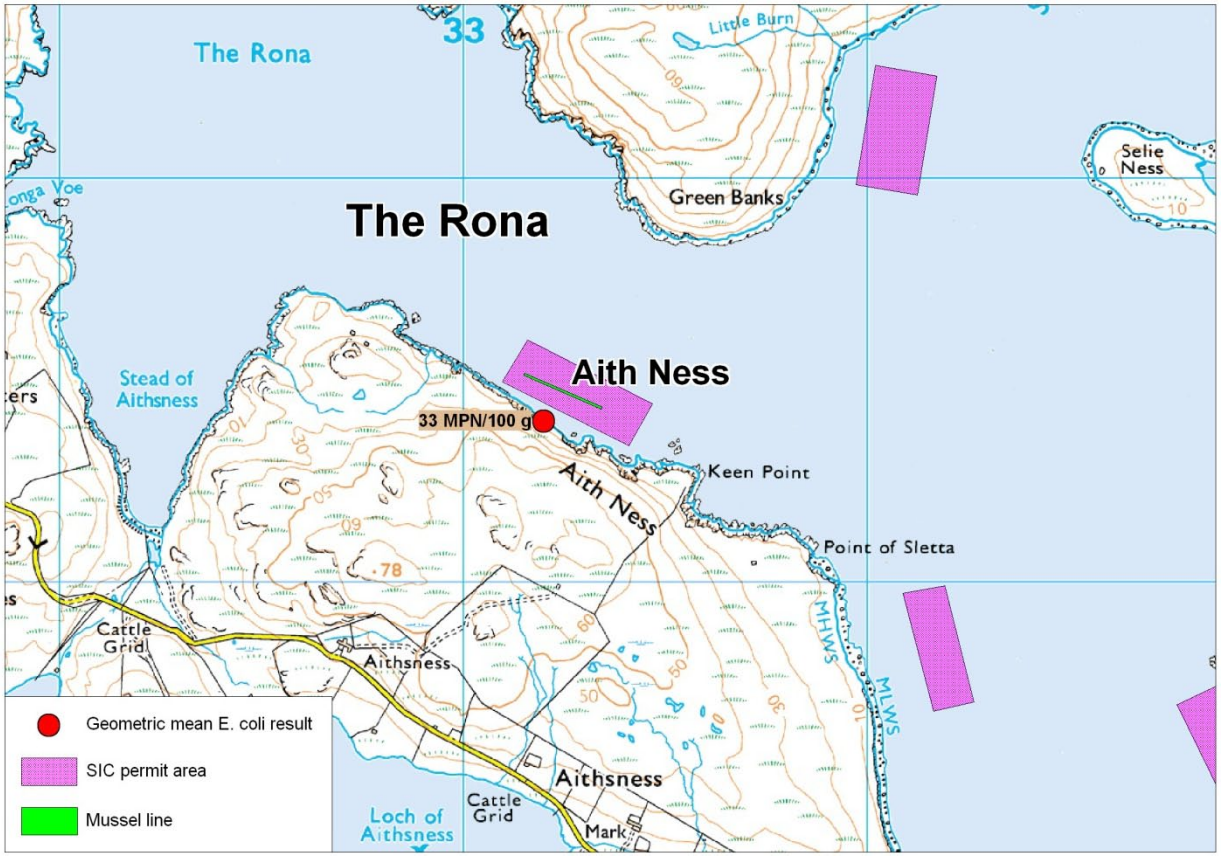

Figure 11.1 Monitoring results for Aith Ness

11.4 Overall temporal pattern of results

Figure 11.1 presents a scatter plot of individual results against date, fitted with a loess line, which stands for 'locally weighted regression scatter plot smoothing'. At each point in the data set an estimated value is fitted to a subset of the data, using weighted least squares. The approach gives more weight to points near to the x-value where the estimate is being made and less weight to points further away. In terms of the monitoring data, this means that any point on the loess line is influenced more by the data close to it (in time) and less by the data further away. This trend line helps to highlight any apparent underlying trends or cycles. However, caution should be exercised in interpretation of this graph due to the small sample size available.

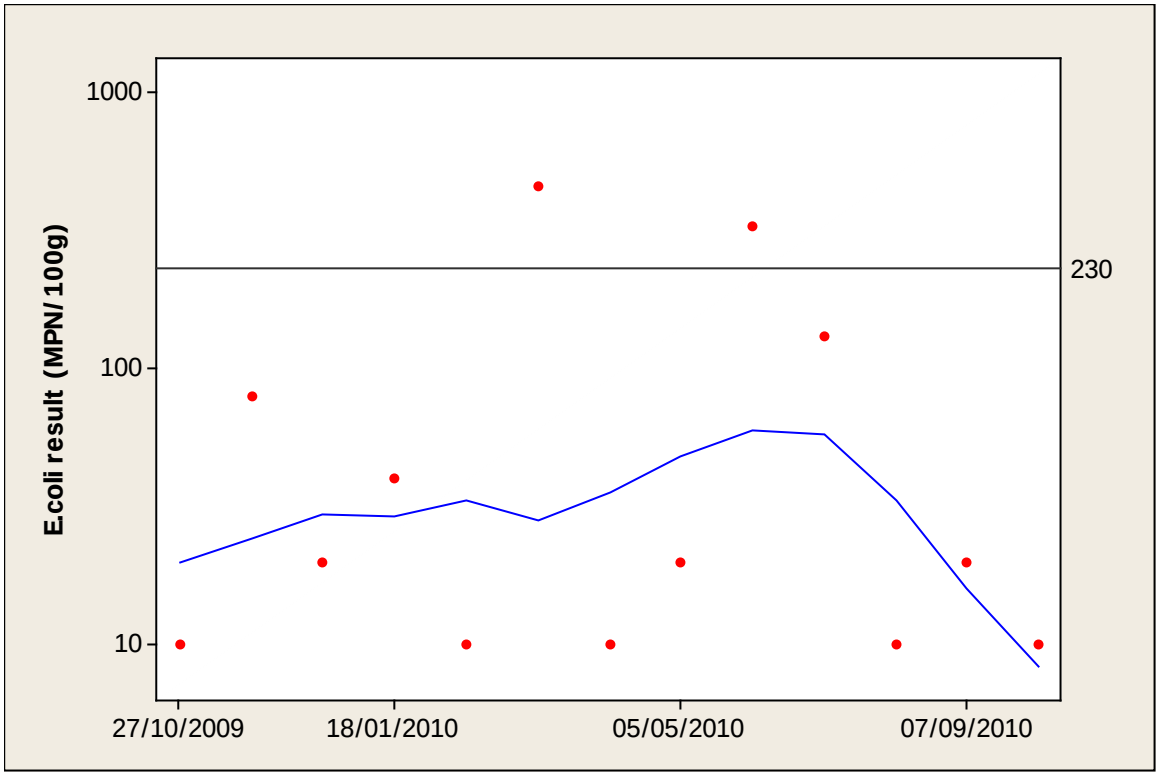

Figure 11.2 Scatterplot of E. coli results by date with Loess line

The graph above shows that results varied over course of the year, with peak results of greater than 230 *E. coli* MPN/100 g occurring in March and in June. Results were lower from August onward. As only one year of monitoring data is represented in Figure 11.2, it is not possible to say without further whether any apparent trends are due to seasonal fluctuations in contamination levels.

11.5 Seasonal pattern of results

There are insufficient data on which to carry out an evaluation of seasonality in results at this time.

11.6 Analysis of results against environmental factors

There are insufficient data on which to conduct an analysis of results against environmental factors at this time.

11.7 Summary

Limited monitoring to date reveals overall contamination levels have been relatively low, with 2 out of 13 results exceeding 230 *E. coli* MPN/100 g and no results exceeding 1000 *E. coli* MPN/100 g. There was insufficient sampling history on which to base an assessment of seasonality. The two highest results occurred in March and June.

12. Designated Shellfish Growing Waters Data

The site at The Rona does not lie within a designated Shellfish Growing Water.

13. River Flow

There are no gauging stations on streams along the The Rona:Aith Ness coastline.

The streams listed in Table 13.1 were measured and sampled during the shoreline survey. The locations are 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 x 10^3, in digital format it is written as 1E+3.

The listed streams represent the most significant freshwater inputs into the production area. The weather was dry during the survey and had been relatively dry in the days preceding the survey: there had been snow, rain and sleet showers the week before. Two streams were too small to measure and sample. A number of land drains were observed during the survey but these were dry at the time.

Table 13.1 Stream loadings for The Rona: Aith Ness

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 3384 5811	Stream	0.80	0.05	0.028	96.8	<10	<9.7x10^6
2	HU 3291 5954	Stream	0.15	0.07	0.049	44.5	20	8.9x10^6
3	HU 3254 5953	Stream	0.22	0.04	0.063	47.9	<10	<4.8x10^6
4	HU 3243 5943	Stream	0.27	0.04	0.015	14.0	<10	<1.4x10^6
5	HU 3243 5941	Stream	Not measured	Not measured	Not measured	-	-	-
6	HU 3230 5915	Stream	Not measured	Not measured	Not measured	-	-	-
7	HU 3224 5900	Stream	0.15	0.05	0.089	57.7	20	1.20x10^7

The loadings of all of these streams were very low. The loadings would be expected to increase significantly following moderate to heavy rainfall and thus their potential effects on the microbiological quality of the mussels would also increase. However, given the low measured loadings, even a tenfold increase in loading would not be expected to cause marked deterioration of water quality except around the immediate area of the mouth of the stream. The dry land drains would be expected to flow under rainfall conditions and could also cause localised deteriorations in water quality. Most of these were located around the Point of Sletta, southeast of the mussel farm or along the Stead of Aithsness, to the west of the mussel farm. However, one land drain was noted near the northwest end of the mussel lines, and this would be most likely to affect water quality at the fishery after rainfall.

Stream 2 discharged approximately 200 m west-northwest of mussel line, and it is expected that should this carry higher loadings after rainfall it would affect water quality at the northwestern end of the mussel farm.

Figure 13.1 Map of stream loadings at The Rona: Aith Ness

14. Bathymetry and Hydrodynamics

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Figure 14.1 OS map of The Rona

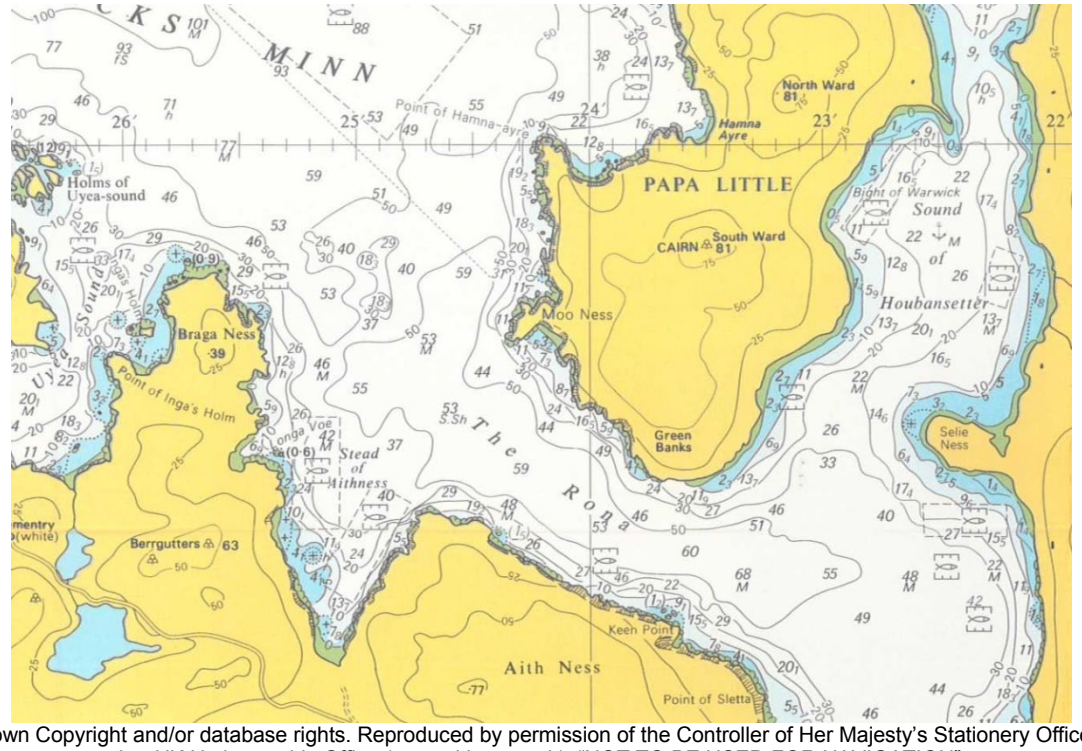

Figure 14.2 Bathymetry at The Rona

The Rona is an area of water between Aith Ness and Papa Little on the north-west side of Mainland. It runs approximately WNW to ESE. At the western end, it joins Swarbacks Minn. At the eastern end, it joins Aith Voe (to the south) and the Sound of Houbansetter (to the north). The channel shelves steeply from very close to shore. In the centre is a basin which is marked at 68 m at the deepest point. The OS map (Figure 14.1) and Hydrographic Chart (Figure 14.2) show a very narrow drying area around the edges.

14.1 Tidal Curve and Description

The two tidal curves below are for West Burra Firth, a straight line distance of approximately 8.5 km from the survey area, and approximately 14 km by sea. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 BST on 18/05/10 and the second is for seven days beginning 00.00 BST on 25/05/10. 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.

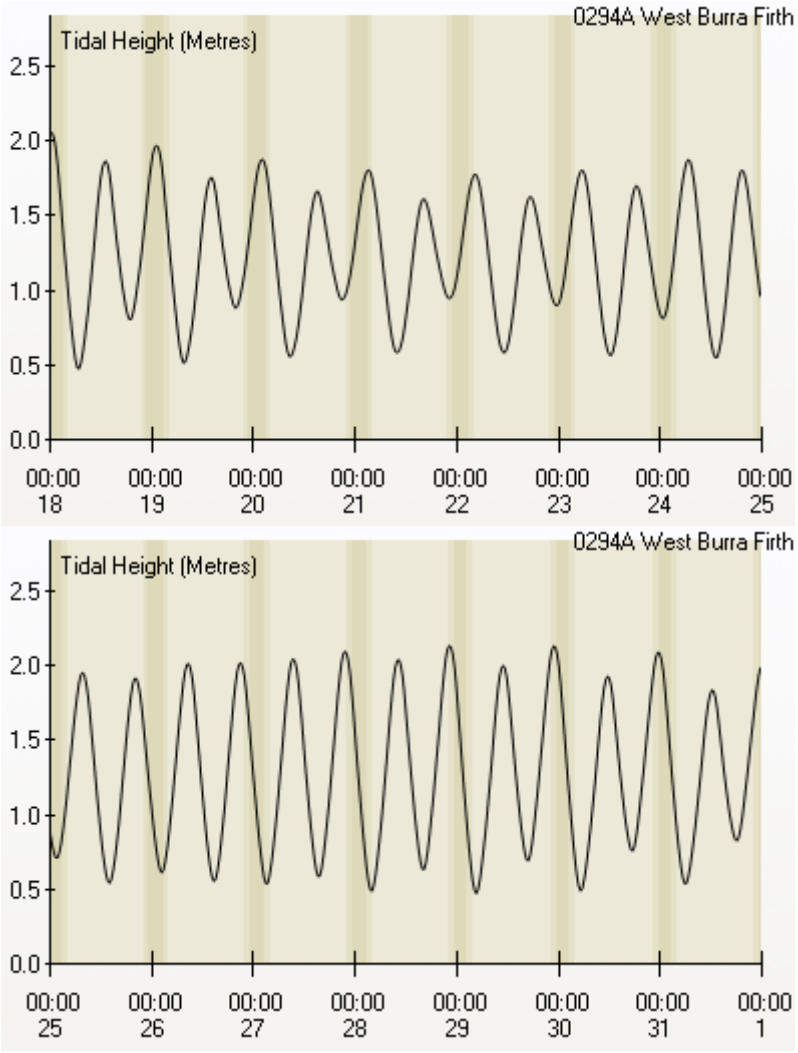

Figure 14.3 Tidal curves for West Burra Firth

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 The Rona.

Shetland Seafood Quality Control had undertaken two current meter studies within the general area of the mussel farm in order to provide information in support of an application to SEPA to discharge from marine cage fish farms. These studies were undertaken on behalf of Mainstream Scotland Ltd. 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 period for the fish farm current meter study

Location	NGR	Survey period
Stead of Aithsness	HU 3245 6007	9/03/2005 – 25/03/2005
Selliness	HU 4717 9346	04/04/2006 – 21/04/2006

Plots of the current direction and speed at these locations, together with the wind direction and speed over the relevant period, are shown in Figure 14.5. For both Stead of Aithness and Selliness, the surface data is from 38.7 m above the seabed, the mid-depth from 28.7 m above the seabed and the near-bottom from 2.7 m above the seabed. Information from the current meter study at Bight of Braewick was included in the sanitary survey report for East Burra Firth and further details can be found there. It is noted here for reference in relation to discharges from further south in Aith voe.

The data from the studies indicate that the currents in the area are less than 20 cm/s (less than approximately 0.4 knots). There is some difference in current direction and speed with depth at both sites with potentially some influence of wind towards the surface – this is to be expected given the generally weak currents. Given the differences in current direction at the two survey locations, it is difficult to interpolate to the location of the mussel lines. However, it would be expected that there would be a component parallel to the shore.

Data from the Bight of Braewick study showed both bottom and surface currents to have a strong northeasterly skew, which was most likely influenced by strong southwesterly winds that coincided with the study period.

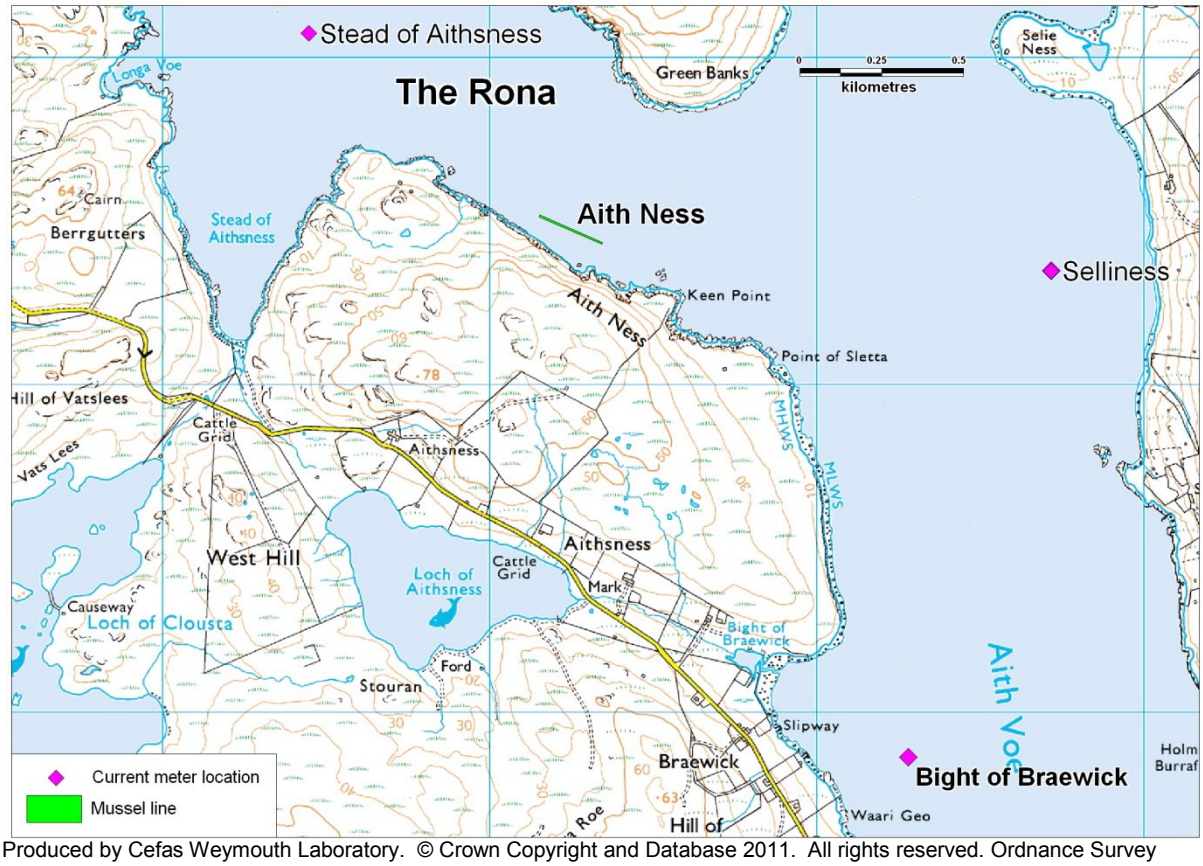

Figure 14.4 Current meter locations in The Rona

14.3 Conclusions

The area in the vicinity of the mussel lines is steeply shelving and the depth will mean that any contamination will potentially be subject to significant dilution. The weak currents in the area means that contamination will not be transported any significant distance from source, nor will it be dispersed to any great extent. Therefore, any impact of contamination on the mussel lines is likely to come from sources near to the lines.

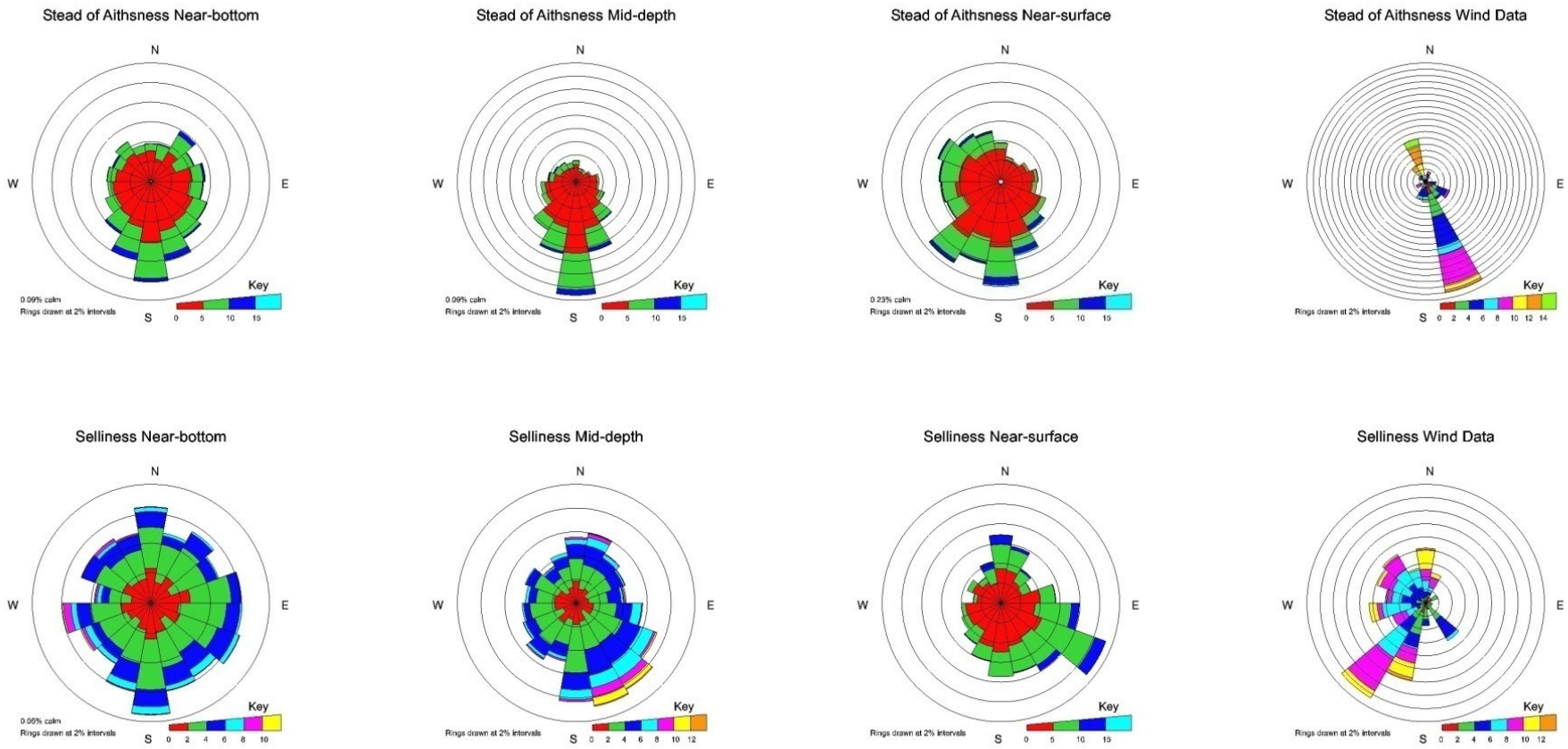

Figure 14.5 Current and wind plots for the Stead of Aithsness fish farm survey

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 shoreline survey was conducted on the 18th 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 fishery consisted of one double-headed long line mussel site, with 10 m droppers. There was no stock on the site at the time of the shoreline survey as the line had been recently harvested under a fast track application. Bagged mussels had been placed at either end of the site two weeks prior to the shoreline survey to allow for sampling. Since the shoreline survey, an additional four long lines have been installed with 10 m droppers. The harvester has consent to install ten lines in total, although is undecided if the other five will be put in place in the near future. The site will be next harvested in two and a half years time.

No septic tanks, outfall pipes or sewage debris were observed during the shoreline survey. There are no large settlements in the area directly adjacent to The Rona: Aith Ness mussel site. There were a few dwellings scattered along a road, located approximately 1 km inland from the fishery. No boats were observed on The Rona at the time of the shoreline survey.

During the shoreline survey, sheep and lambs were observed grazing along most of the shoreline. In most places, fences or steep cliffs prevented livestock from accessing the shoreline. Approximately 30 sheep were observed at the beginning of the survey in a field next to the shoreline at the Bight of Braewick. Another group of approximately 37 sheep were observed grazing close to the Point of Sletta. On the day of the boat trip, approximately 28 sheep were observed from the boat grazing in the same area. Thirty sheep were observed on the west shore at the head of the Stead of Aithsness, to the west of the fishery. In addition to the three main flocks of sheep, scattered pairs of sheep were also observed. Gulls, divers and geese were observed during the survey, but no major aggregations of wildlife were recorded. Rabbits were observed along much of the shoreline and a single hare was seen. Seals are reported to frequent the area, although none were seen during the course of the survey.

Seawater samples taken during the shoreline survey contained low levels of *E. coli*, with seawater samples taken offshore in the vicinity of the mussel lines containing no detectable *E. coli*. Levels of *E. coli* in the two additional sea water samples taken from the shore were also relatively low, with results of 10 to 20 *E. coli* cfu/100ml. The higher result (20 *E. coli* cfu/100 ml) was from a sample taken offshore from the Bight of Braewick. Salinity profiles taken at the mussel sites indicated that there was no freshwater influence or stratification at the time, with all measurements indicative of full strength seawater.

Freshwater samples and flow measurements were taken at most streams draining into the survey area. These streams contained very low levels of contamination (<1-20 *E. coli* cfu/100 ml). Most were small and drained areas of heathland and/or improved pasture.

Shellfish samples were taken from both ends of the Aith Ness mussel line at two different depths. At the east end of the long line the result for the sample taken on the surface was lower (20 *E. coli* MPN/100 g) compared to the sample taken at a 3 m depth that had a result (140 *E. coli* MPN/100 g). At the western end of the long line the results were more similar, with the surface sample returning a result of 110 *E. coli* MPN/100 g and the 4 m depth sample returning a result of 130 *E. coli* MPN/100 g.

The main findings from the shoreline survey are represented geographically in Figure 15.1.

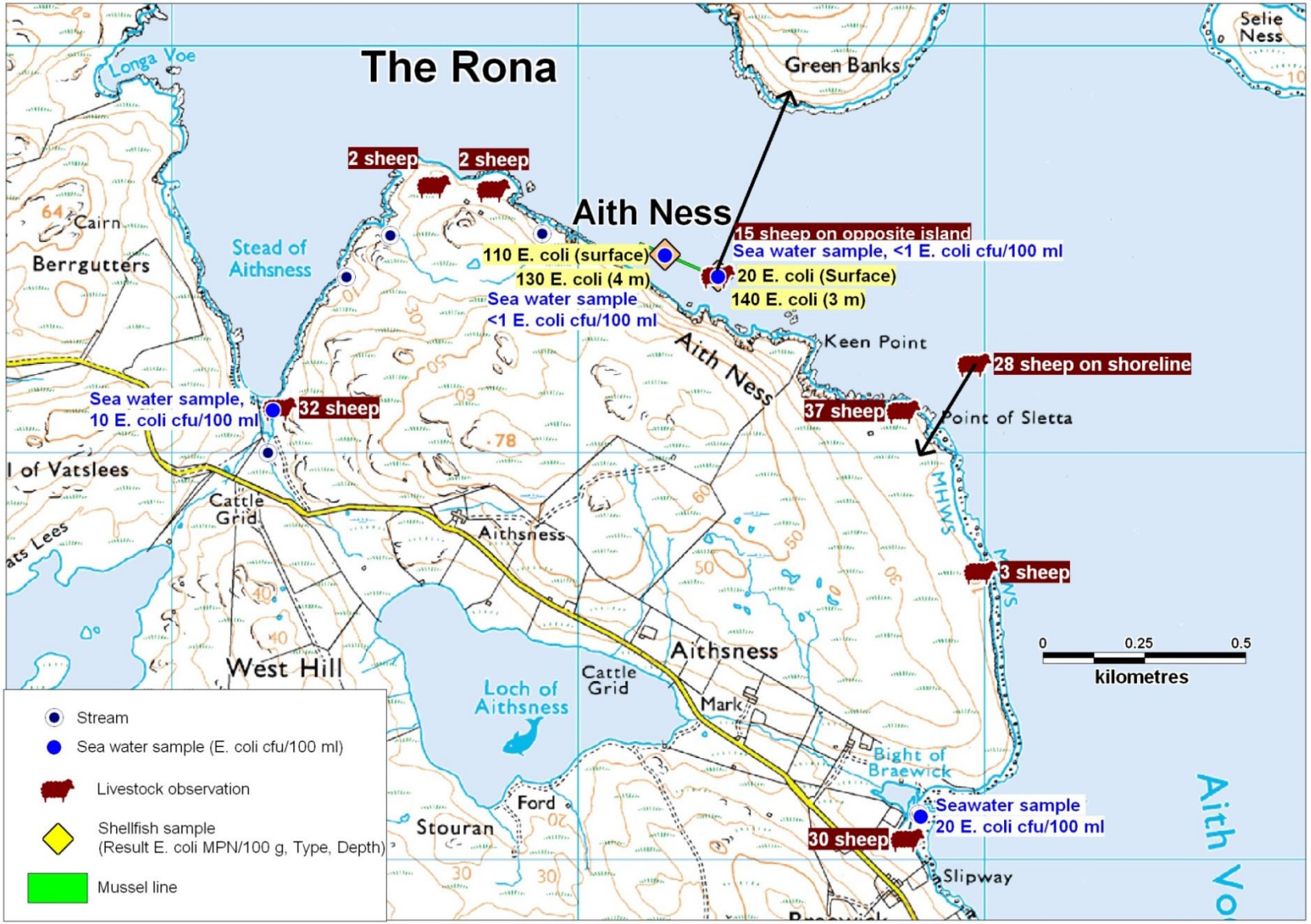

Figure 15.1 Summary of shoreline survey findings for The Rona

16. Overall Assessment

Human sewage impacts

There is little in the way of human sewage impact to the fishery area. The nearest identified community sewage discharge is over 4km away at the head of Aith Voe, and is likely to be significantly diluted before reaching the fishery. Two small private septic tanks discharge to the sea approximately 3 km southeast of the fishery at East Burra Firth. All of the sewage discharges are sufficiently far away that their impact is most likely to be on background levels of *E. coli* in the area. There is likely to be a small increase in human impact during the summer months, when tour boats operate out of Aith marina.

Agricultural impacts

Sheep were the only livestock observed in the area during the shoreline survey, with 104 counted along the shore of Aith Ness. Although they were observed to both the east and west of the mussel farm, it is likely that sheep are allowed to graze land adjacent to much of the Aith Ness shoreline over time, though they are generally prevented from accessing the shoreline itself by topography and fencing. A smaller number of sheep (15) were observed on Papa Little island to the north. As the mussel farm is located along the south shore, faecal contamination from animals on Papa Little is less likely to affect water quality at the fishery than that arising on the south shore. Deposition of faeces onto grazing areas is likely to be higher in summer, when the number of sheep is likely to be higher due to the presence of lambs. Therefore, sheep faeces are likely to be a significant source of faecal bacteria carried via streams or direct runoff from land adjacent to the fishery and this effect may be most acute following heavy rainfall during the summer and early autumn months.

Areas of improved pasture, which may be preferentially grazed and are expected to contribute more significantly to faecal bacteria concentrations in rainfall runoff, are located both to the west at the Stead of Aithness and to the east around the Point of Sletta.

Wildlife impacts

Wildlife impacts are likely to vary across the year, with some species such as gulls, geese and seals present year-round. The most likely impact to the fishery will be from direct deposition of faeces into or around the fishery by birds resting on the mussel floats or by seals passing through the area. This is no more likely to impact one part of the mussel farm than another, and the timing of impacts is likely to be unpredictable. Seabird nesting areas to the north and east of the fishery are likely to be a source of faecal contamination in summer, when they are occupied, though the nearest of these at Selie Ness lies nearly 1.5 km east northeast of the mussel farm. Direct deposition of faeces is likely from these birds as they fly through the area, however this is not likely to affect one part of the fishery any more than another. Geese were observed on or near areas of improved pasture to the east of the mussel farm, where their faeces will be deposited on land and subject to runoff after rainfall. Numbers of geese present are likely to be lowest during the summer and

highest during winter, so any impacts from this source are likely to higher during winter and at the eastern end of the mussel farm.

Seasonal variation

There is a small amount of tourism in the area and so there may be a consequent seasonal variation in contamination arising from the human population during the summer months. There are likely to be more livestock present from late spring until autumn due to the presence of lambs. Impacts from seabirds are likely to be higher during the summer nesting period, roughly May-August. Rainfall tends to be higher from September to March. However, high rainfall events tend to occur through most of the year and the highest *E. coli* loadings to The Rona may occur after high rainfall events that follow periods of dry weather between May to September, when livestock numbers are highest.

Rivers and streams

The loadings of all sampled streams discharging to The Rona were low at the time of shoreline survey. Given the low measured loadings, even a tenfold increase in loading would not be expected to cause marked deterioration of water quality except around the immediate area where the streams discharge. A dry land drain was observed near the northwest end of the mussel lines and when flowing could be expected lead to localised deterioration of water quality at this end of the fishery.

A stream was found to discharge approximately 200 m west-northwest of mussel line, and it is expected that under higher flow conditions this would significantly affect water quality at the northwestern end of the mussel farm. However, given the limited sources of contamination observed in the area, it is not expected that contamination levels would be especially high even under higher flow conditions.

Hydrography and movement of contaminants

Water depth in the vicinity of the fishery will mean that any contamination will potentially be subject to significant dilution. Further, it is not expected that contamination will not be transported a significant distance from source nor will it be dispersed to any great extent due to relatively weak currents. Therefore, any impact of contamination on the mussel farm is likely to come from sources near to the lines, such as the dry land drain and stream identified above or from direct run-off from land.

Contamination arising from sources further to the south in Aith Voe are most likely be significantly diluted before reaching the northern part of the voe. Currents observed near the Bight of Braewick indicated heavy influence of wind on both surface and bottom currents. Prevailing winds over Shetland are generally southwesterly, therefore it is likely at least under prevailing conditions the time contaminants would be carried to the northeast and away from the fishery.

Temporal and geographical patterns of sampling results

Monitoring samples were taken at a single grid reference, so no geographic analysis of the results was possible. Monthly samples have been taken since October 2009 and during that time, two results greater than 230 *E. coli* MPN/100 g were obtained during the months of March and June 2010. After June, the results trended downward indicating that peak contamination levels were observed during the summer months in 2010. It is not clear whether this will represent a consistent trend over time, however it is consistent with observations at most other mussel fisheries in Shetland.

During the shoreline survey, samples were taken from either end of the mussel line and at two depths. These showed that contamination levels were roughly similar at both ends of the fishery on the day of survey and all were under 230 *E. coli* MPN/100 g.

Conclusions

Although there are community and private sewage sources to the southeast, these are relatively small and sufficiently distant to be substantially diluted before reaching the fishery. However, they may contribute to background levels of contamination in the general area. Faecal contamination to the mussel farm at Aith Ness is most likely to come from livestock and carried to the fishery via rainfall runoff to land drains and streams. This is likely to show some seasonality, with higher rates of faecal deposition onto land during the summer and potentially higher loadings in runoff when rainfall follows dry periods in summer. The limited monitoring history available seems to suggest a seasonal variation in contamination levels, though this is only based on 1 year's data and so should be treated with caution.

Analysis of hydrographic information indicated that sources very near the fishery were most likely to impact on water quality there, and the nearest sources were a stream and a land drain noted toward the northwestern end of the mussel farm. Additional mussel lines have been placed since the shoreline survey, and these are most likely to have expanded the fishery area northward, toward the centre of The Rona. Therefore, contamination levels are still likely to be highest near shore and near the northwestern end of the lines where the nearest stream is located.

17. Recommendations

Production area

It is recommended that the production area boundaries be set to include the full area represented by the seabed lease and also exclude the areas the nearest streams, which are likely to have higher levels of contamination after rainfall than where the shellfish farm is located. As there are no significant sources on the south shore of Papa Little, the boundaries are extended to the southern tip of the island for convenience. The recommended production area boundaries are described as the area bounded by lines drawn between HU 3300 5954 to HU 3340 5994 and between HU 3368 5986 to HU 3359 5927, extending to MHWS.

RMP

As the nearest local source of faecal contamination is located near the northwestern end of the fishery, it is recommended that the RMP be placed toward that end of the mussel lines, and on the line nearest the shore. The recommended RMP is therefore HU 3317 5951.

Frequency

Due to the limited sampling history and suggestion of seasonal variation in monitoring results, it is recommended that monthly monitoring be maintained.

Depth of sampling

As the most likely sources of faecal contamination to the fishery are either deposited from the surface or to reach the fishery via surface water runoff, it is recommended that the sampling depth be 1-3 m.

Tolerance

Currents are predicted to be slight in the area of the fishery, therefore a 20 m sampling tolerance is recommended as this should be sufficient to allow for movement of the lines.

A map showing the recommended production area boundaries and RMP is provided in Figure 17.1.

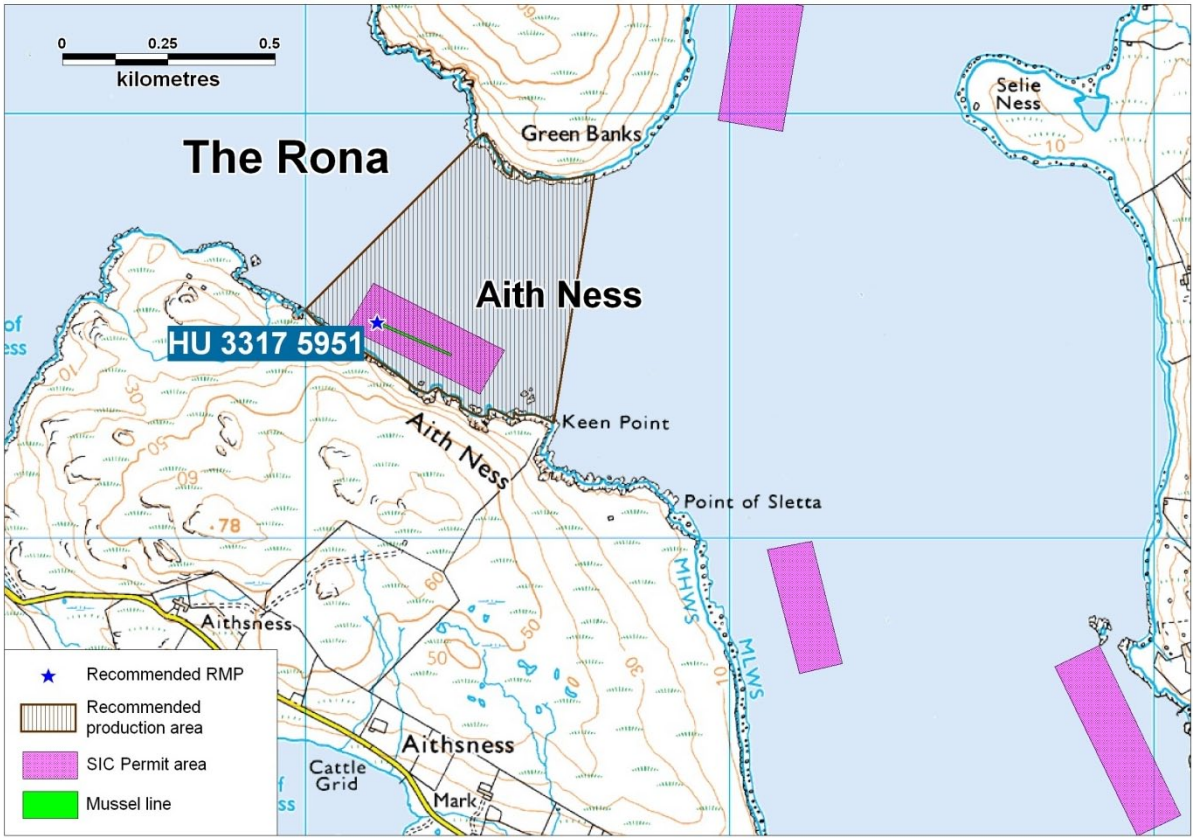

Figure 17.1 Map of recommendations at The Rona

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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. **Hydrographic Methods**
7. **Shoreline Survey Report**

Sampling Plan for The Rona

PRODUCTION AREA	The Rona
SITE NAME	Aith Ness
SIN	SI
SPECIES	Common mussel
TYPE OF FISHERY	Longline aquaculture
NGR OF RMP	HU 3317 5951
EAST	433170
NORTH	1159510
TOLERANCE (M)	20
DEPTH (M)	1
METHOD OF SAMPLING	Hand
FREQUENCY OF SAMPLING	Monthly
LOCAL AUTHORITY	Shetlands 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	The Rona
SPECIES	Common mussel
SIN	SI
EXISTING BOUNDARY	Not yet defined
EXISTING RMP	Not yet assigned
RECOMMENDED BOUNDARY	Area bounded by lines drawn between HU 3300 5954 to HU 3340 5994 and between HU 3368 5986 to HU 3359 5927 extending to MHWS
RECOMMENDED RMP	HU 3317 5951
COMMENTS	Includes entire seabed lease and stops short of identified freshwater-courses. RMP set at NW end of line nearest shore.

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

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

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

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

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

Other

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

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

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.

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.

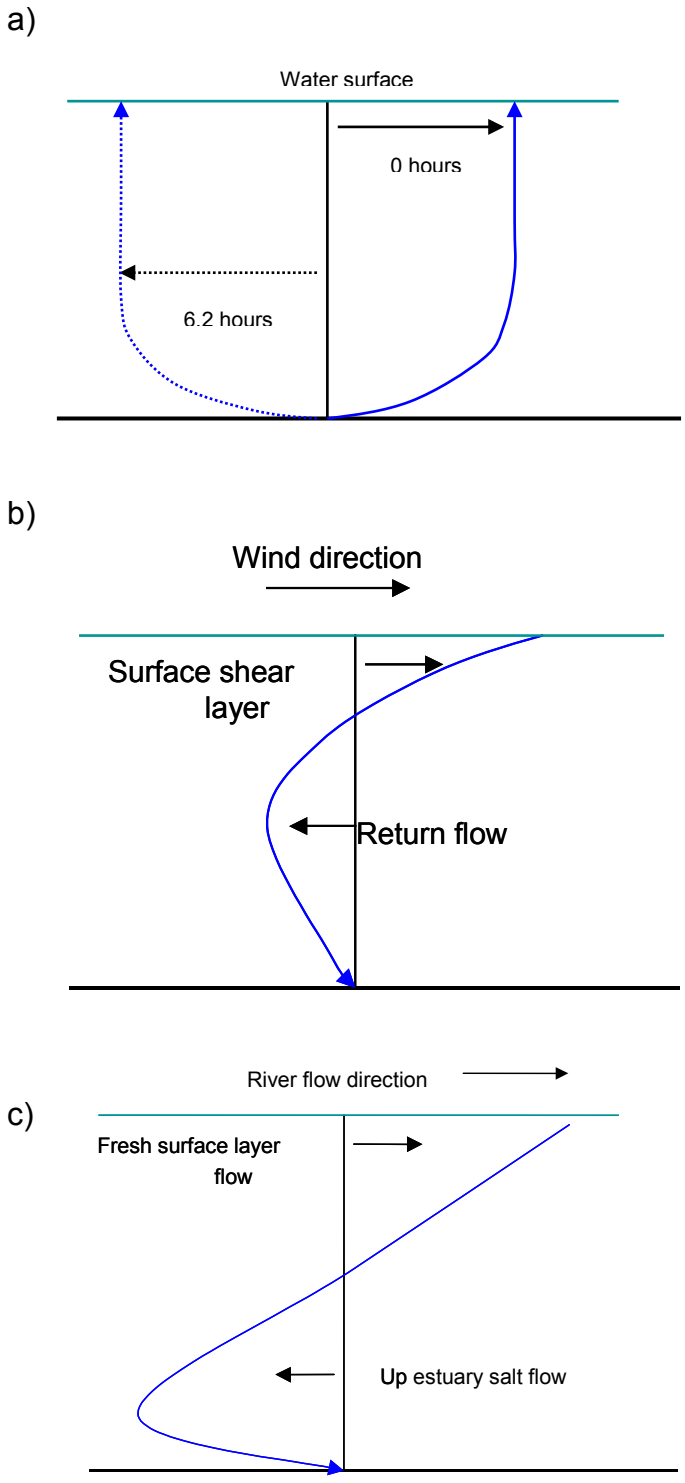

Figure 1. Typical vertical profiles for water currents. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction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

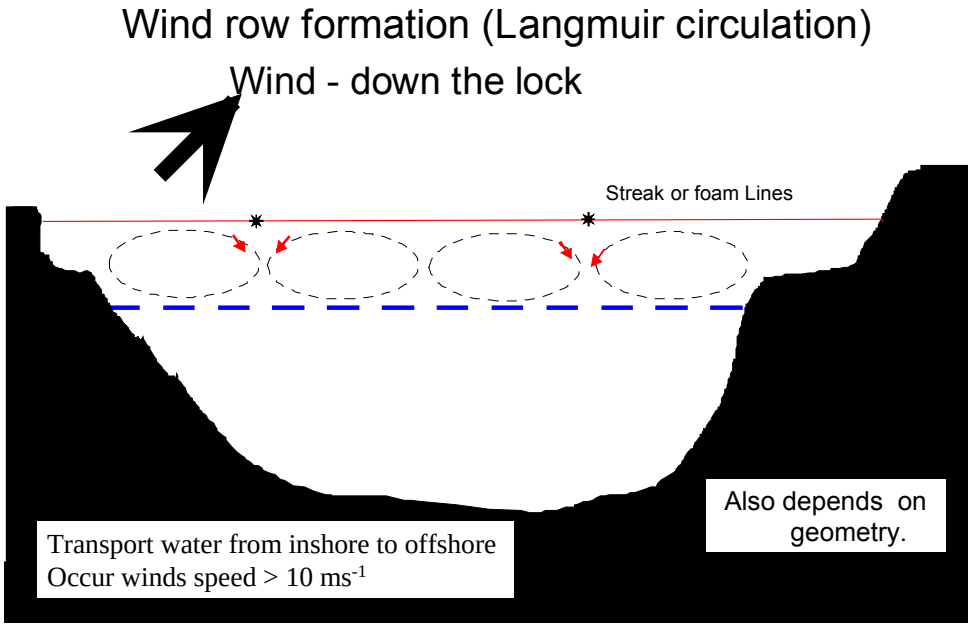

Figure 2. Schematic of wind driven 'wind row' currents. The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

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
The Rona	Aith Ness	SI 517 944 08	Mussels

Harvester: Stephen Anderson (Demlane)
Status: New application
Date Surveyed: 18/5/10 and 20/5/10
Surveyed by: Sean Williamson, Jessica Larkham, Frances Hockley
Sampling Point: Fast track monitoring point HU 332 595
Area Surveyed: See Figure 1.

Weather Observations

18/5/10 Calm/light breeze sunny and dry
20/5/10 Calm/light breeze slightly overcast and dry
The weather had been relatively dry in the days preceding the survey. Snow, rain and sleet showers, the week before.

Site Observations

Specific observations made on site are mapped in Figure 1 and listed in Table 1. Water and shellfish samples were collected at sites marked on Figures 2 and 3. Bacteriology results are given in Tables 2 and 3. Salinity profiles are presented in Table 4. Photographs are presented in Figures 4-12.

Fishery

The Rona: Aith Ness (SI 517 944 08). This site consisted of one double long line, with 10 m droppers. There was no stock on the site at the time of the shoreline survey as the line was recently harvested under a fast track application. For the shoreline survey, bagged mussels were placed at alternative ends of the site, two weeks prior to the survey to allow sampling. Since the shoreline survey, an additional four long lines have been installed with 10 m dropper nets. The harvester has consent to install ten lines in total, although is undecided if the other five will be put in place in the near future. The site will be next harvested in two and a half years time.

Sewage/Faecal Sources

Human – There are no large settlements in the area surrounding The Rona: Aith Ness mussel site. There are a few dwellings scattered along a road, located approximately 1 km inland from the fishery. No septic tanks, sewage outfall pipes or sanitary debris were observed during the shoreline survey.

Livestock – The land surrounding the production area was mainly heath land with some areas of improved pastures. Sheep and lambs were grazing along most of the shoreline. In most places fences or steep cliffs prevented livestock from accessing the shoreline. Approximately 30 sheep were observed at the beginning of the survey in a field next to the shoreline at the Bight of Braewick. Another group of approximately 37 sheep were observed grazing close to the Point of Sletta. On the day of the boat trip, approximately 28 sheep were observed from the boat grazing in the same area. At the head of the Stead of Aithsness on the west coast an additional 30 sheep were observed. In addition to the three main flocks of sheep, scattered pairs of sheep were also observed.

A few small streams discharge into The Rona and these drain areas of pasture and the heath land. Water samples were taken, and discharge estimated where the streams were of sufficient size for flow to be measured. The stream inputs had low levels of *E. coli* (<10-20 cfu/100ml). There were also a lot of land drains leading from the fields into The Rona, these were recorded but not sampled or measured. It is likely that land runoff is an important pathway for moving contamination from livestock into The Rona.

E. coli levels in 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, with results of 10 to 20 *E. coli* cfu/100ml. The higher result (20 *E. coli* cfu/100 ml) was taken offshore from the Bight of Braewick.

The four shellfish samples taken from bagged mussels hung from two different ends of the long line, gave *E. coli* results ranging from 20 to 140 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 are no 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 The Rona is very light and limited to small fishing boats, mussel and salmon boats and small pleasure boats and yachts. No boats were observed on The Rona at the time of the shoreline survey. There is a small pier, slipway and RNLI lifeboat station in the village of Aith, located 4 km south of The Rona at the head of Aith Voe. There is also a marina in Aith Voe which provides berths for up to 40 boats.

Land Use

The land surrounding The Rona is primarily heath land with some areas of improved pasture, which is grazed by sheep.

Wildlife/Birds

A flock of approximately 11 gulls were observed close to the western end of the Aith Ness mussel lines from the shore. Fulmars were observed nesting on the steep cliffs at Keen Point (Figure 7).

Individual gulls, divers and geese were also observed during the survey, but no major aggregations of wildlife were recorded. Rabbits were observed along much of the shoreline and a single hare was also spotted. Seals are reported to frequent the area, although none were seen during the course of the survey.

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.

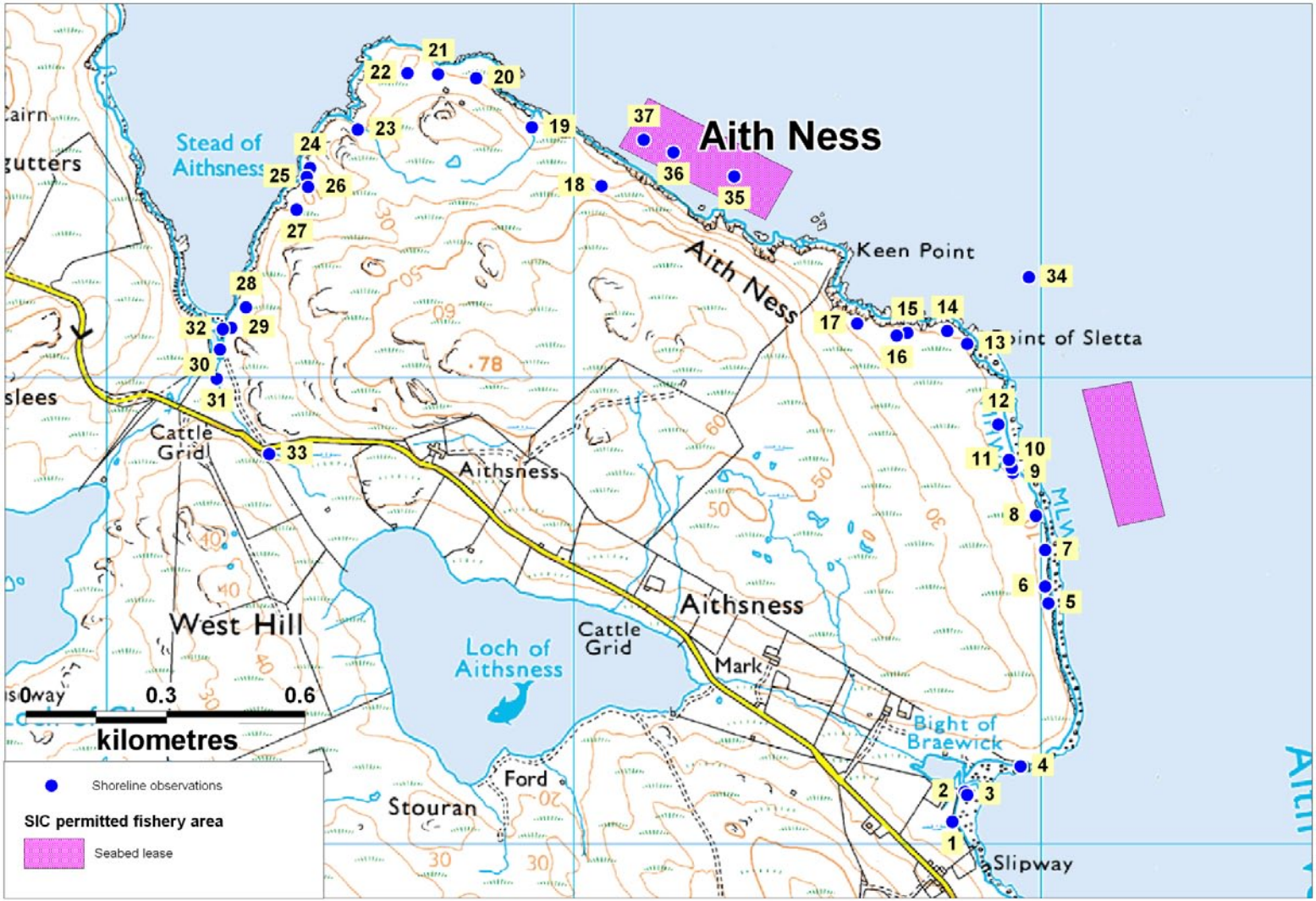

Figure 1. Shoreline Observations at The Rona

Table 1. Shoreline observations

No.	Date	Time	Position	Photograph	Associated sample	Observation
1	18/05/2010	10:53	HU 33812 58049	Figure 4		Start of survey, 30 sheep in a field next to the shoreline
2	18/05/2010	10:56	HU 33839 58113	Figure 5	ANFW1	Stream 80cm wide, 5cm deep, flow 0.028 m/sec,4 geese
3	18/05/2010	11:00	HU 33844 58107		ANSW1	Mussel and scallop shells on shore
4	18/05/2010	11:05	HU 33958 58168			Sheep droppings
5	18/05/2010	11:13	HU 34018 58518			Land drain
6	18/05/2010	11:14	HU 34011 58554			Land drain
7	18/05/2010	11:15	HU 34011 58632			Land drain
8	18/05/2010	11:16	HU 33991 58706			Land drain, 3 sheep
9	18/05/2010	11:18	HU 33941 58798			7 geese, 3 divers
10	18/05/2010	11:19	HU 33939 58808			Land drain
11	18/05/2010	11:19	HU 33933 58826			Land drain
12	18/05/2010	11:21	HU 33910 58901			Land drain, likely to become stream during rainfall
13	18/05/2010	11:24	HU 33844 59074			3 geese and 2 goslings
14	18/05/2010	11:27	HU 33801 59102			37 sheep
15	18/05/2010	11:28	HU 33716 59098			Land drain
16	18/05/2010	11:29	HU 33693 59092			Land drain
17	18/05/2010	11:31	HU 33608 59118	Figure 7		Fulmars nesting at Keen Point
18	18/05/2010	11:53	HU 33061 59413			Land drain. 11 gulls on western end of lines
19	18/05/2010	11:59	HU 32912 59539	Figure 6	ANFW2	Stream 15cm wide, 7cm deep, flow 0.049m/sec
20	18/05/2010	12:05	HU 32793 59645			2 sheep
21	18/05/2010	12:07	HU 32711 59654			Land drain, likely to become stream during rainfall
22	18/05/2010	12:10	HU 32646 59656			2 sheep, 1 hare, rabbits all along shoreline
23	18/05/2010	12:15	HU 32539 59534	Figure 8	ANFW3	Stream, 22cm wide, 4cm deep, flow 0.063m/sec
24	18/05/2010	12:23	HU 32437 59452	Figure 9		3 salmon cages adjacent to shore
25	18/05/2010	12:24	HU 32430 59433	Figure 10	ANFW4	Stream, 27cm wide, 4cm deep, flow 0.015m/sec
26	18/05/2010	12:28	HU 32433 59411			Stream (too small to sample)
27	18/05/2010	12:30	HU 32408 59362			Land drain
28	18/05/2010	12:36	HU 32300 59153			Small stream
29	18/05/2010	12:38	HU 32268 59109			2 sheep, also 30 sheep on opposite shore, land drain to beach
30	18/05/2010	12:41	HU 32244 59062			Pond with stream leading to voe
31	18/05/2010	12:44	HU 32237 59000		ANFW5	Stream, width 15cm, depth 5cm, flow 0.089m/sec

No.	Date	Time	Position	Photograph	Associated sample	Observation
32	18/05/2010	12:48	HU 32250 59106		ANSW2	Sea water sample
33	18/05/2010	12:55	HU 32349 58838			End of shoreline walk
34	20/05/2010	09:10	HU 33976 59217			Puffin, 28 sheep, 20 gulls
35	20/05/2010	09:13	HU 33345 59434	Figure 11	ANSW3 ANMUSSEL1 (3m) ANMUSSEL2 (<1m)	End of Aith Ness mussel lines, 50 fulmars on shore, 15 sheep on opposite island (Papa Little - Green Banks)
36	20/05/2010	09:30	HU 33215 59486	Figure 12	ANSW4 ANMUSSEL3 (<1) ANMUSSEL4 (4 m)	Middle of lines
37	20/05/2010	09:39	HU 33151 59512			End of mussel lines

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. These results are shown in Table 2.

Table 2. Water sample *E. coli* results

No.	Sample Ref.	Date	Time	Position	Type	*E. coli* (cfu/100 ml)	Salinty (ppt)	Salinity (ppt)
1	ANFW1	18/05/2010	10:56	HU 3384 5811	Fresh water	<10		
2	ANFW2	18/05/2010	11:59	HU 3291 5954	Fresh water	20		
3	ANFW3	18/05/2010	12:15	HU 3254 5953	Fresh water	<10		
4	ANFW4	18/05/2010	12:24	HU 3243 5943	Fresh water	<10		
5	ANFW5	18/05/2010	12:44	HU 3224 5900	Fresh water	20		
6	ANSW1	18/05/2010	11:00	HU 3384 5811	Sea water	20	37	34.87
7	ANSW2	18/05/2010	12:48	HU 3225 5911	Sea water	10	36	33.47
8	ANSW3	20/05/2010	09:13	HU 3335 5943	Sea water	<1	38	35.36
9	ANSW4	20/05/2010	09:30	HU 3322 5949	Sea water	<1	38	35.39

Table 3. Shellfish sample *E. coli* results

No.	Sample Ref.	Date	Time	Position	Species	Depth	Result (*E. coli* MPN/100 g)
1	AN MUSSEL 1	20/05/2010	09:17	HU 3335 5943	Mussels	3 m	140
2	AN MUSSEL 2	20/05/2010	09:17	HU 3335 5943	Mussels	Surface	20
3	AN MUSSEL 3	20/05/2010	09:33	HU 3322 5949	Mussels	Surface	110
4	AN MUSSEL 4	20/05/2010	09:33	HU 3322 5949	Mussels	4 m	130

Table 4. Salinity profiles

Profile	Date	Time	Position	Depth (m)	Salinity (ppt)
1	20/05/2010	09:13	HU 3335 5943	0	37.14
				3	37.15
				5	37.09
				10	37.15
2	20/05/2010	09:30	HU 3322 5949	0	37.05
				3	37.14
				5	37.11
				10	37.14

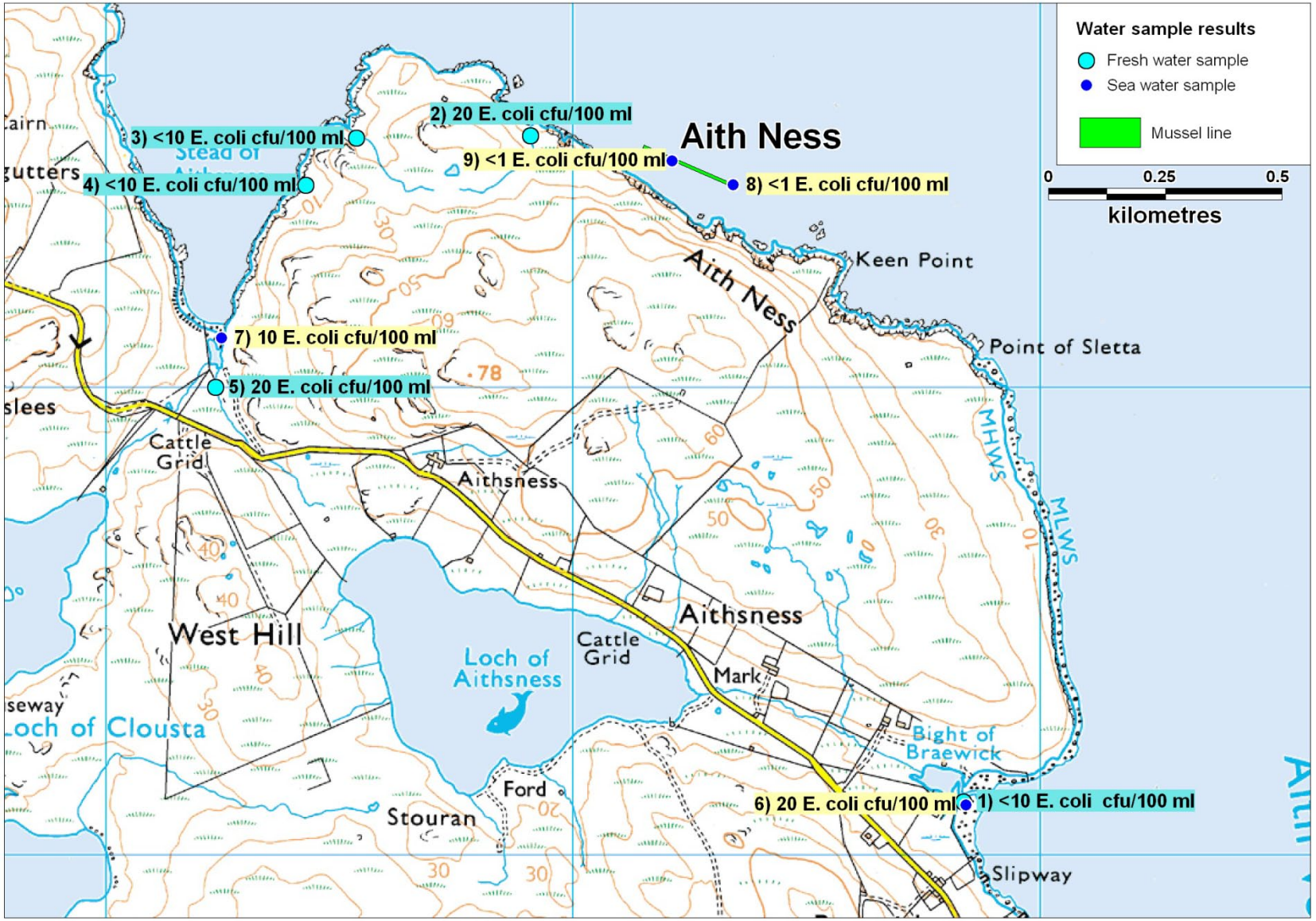

Figure 2. Water sample results

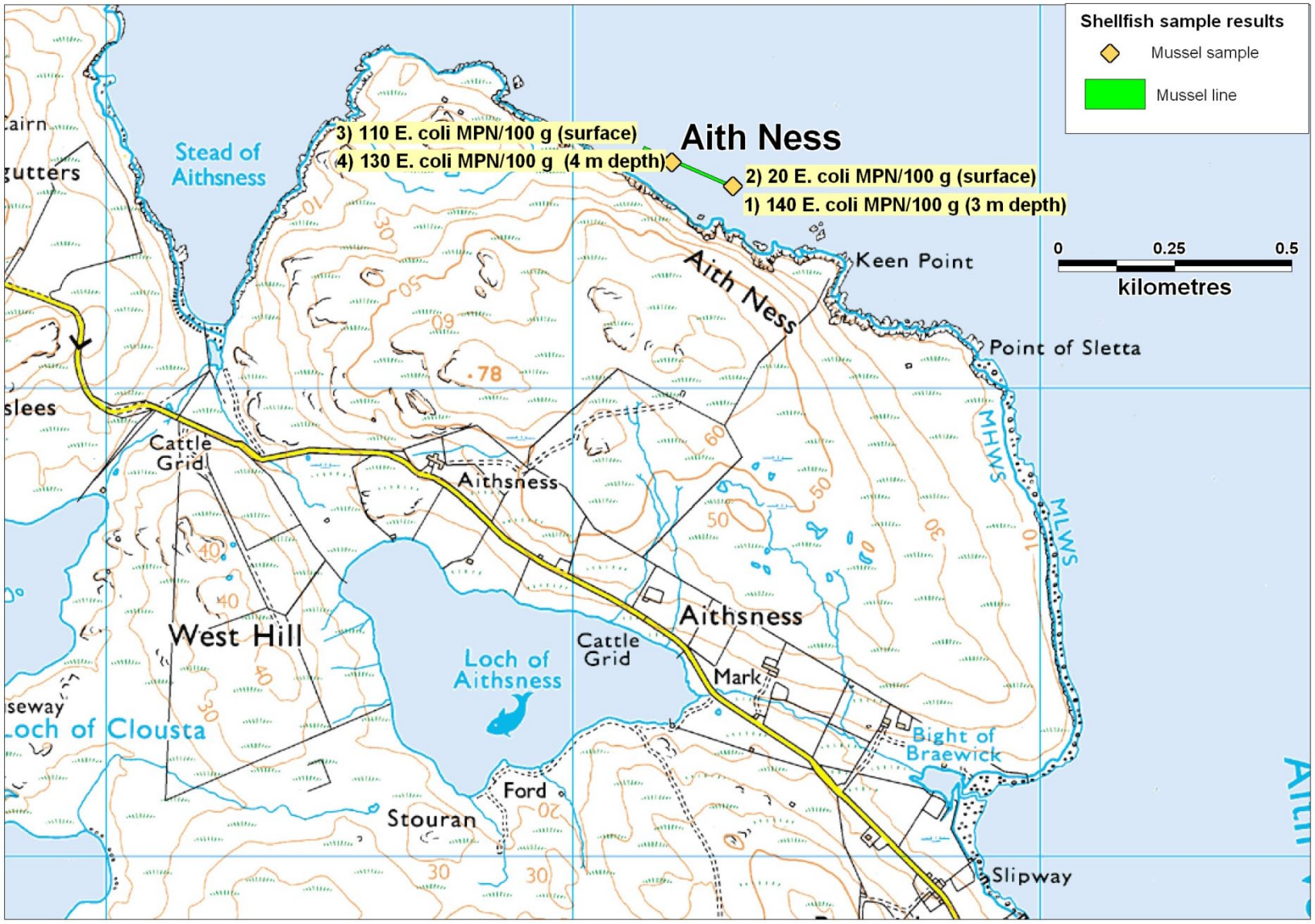

Figure 3. Shellfish sample results

Photographs

Figure 4. 30 sheep in field adjacent to shoreline

Figure 5. Location of fresh water sample ANFW1

Figure 6. Location of fresh water sample ANFW2

Figure 7. Fulmars nesting on cliff at Keen Point

Figure 8. Location of fresh water sample ANFW3

Figure 9. Salmon cages offshore

Figure 10. Location of fresh water sample ANFW9