Scottish Sanitary Survey Project

Sanitary Survey Report

South Voe SI 421

South of Houss Holm SI 261

April 2009

Cefas

FOOD STANDARDS AGENCY SCOTLAND
Buidheann Inbhe-Bìdhe an Alba

Report Distribution – South Voe

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

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Table of Contents

1. General Description

The South Voe and South of Houss Holm production areas lie in the narrow body of water between East Burra and West Burra Islands along the southwest coast of Shetland. The northern half of this water body is called South Voe and the southern portion is called West Voe. The entire water body is approximately 5km long and at most 1km wide and contains a number of small islands and skerries. The southern end of the voe is open to seas from the south but the remainder of the voe is relatively well sheltered. South Voe is connected to Lang Sound to the north by a 10 metre wide channel.

Depths are less than 5 metres for most of the area, with the southern boundary of the South of Houss Holm production area just reaching the 10 metre depth curve. A sanitary survey of this production area was conducted after receipt of a standard application for classification of South Voe for mussels. South of Houss Holm was surveyed at the same time due to its proximity.

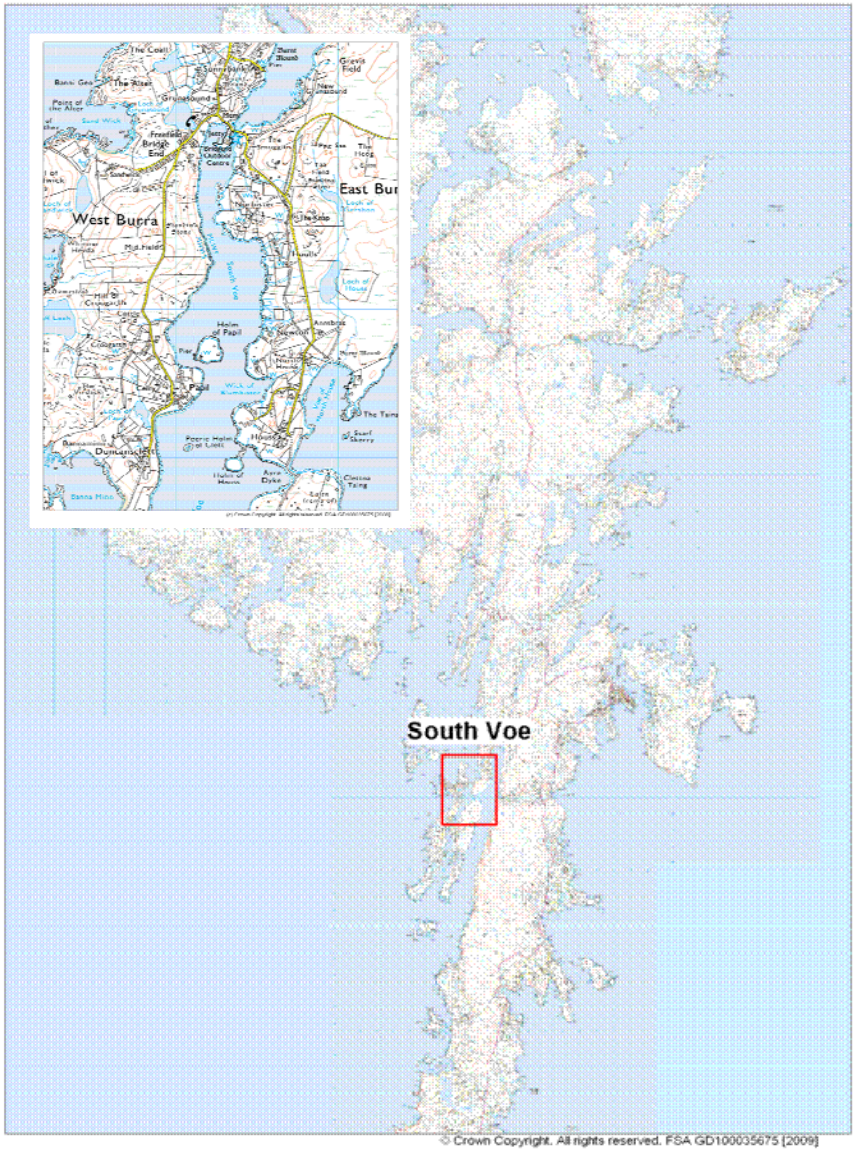

Figure 1.1 Location of South Voe, Shetland

2. Fishery

There are three shellfish farms in two production areas within the survey area, as listed in Table 2.1 below and shown on Figure 2.1.

Table 2.1 South Voe production areas

Production Area	Site	SIN	Species
South Voe	South Voe	SI 421 825 08	Common mussels
South of Houss Holm	South Houss of Holm	SI 261 444 08	Common mussels
South of Houss Holm	Houss	SI 261 739 13	Pacific oysters

Coordinates marking the outer boundaries of the actual shellfish farms in these production areas were recorded using handheld GPS receivers during the shoreline survey in August 2008. These recorded areas are represented in Figure 2.1 and in figures throughout this report.

The South Voe production area is currently established as the area within lines drawn between HU 3715 3150 to HU 3760 3152 and HU 3715 3260 to HU 3724 3260. The nominal RMP is located at HU 372 320.

At the time of survey, the South Voe production area consisted of one mussel farm of three long-lines, the droppers are 5 metres in length. This production area was originally classified for Pacific oyster production; however the harvester switched to mussel production and submitted a standard application for classification for mussels.

The South of Houss Holm production area is established as the area bounded by lines drawn between HU 3635 2980 and HU 3706 2980 and between HU 3715 3150 and HU 3760 3152. This production area contains two sites: an oyster farm at Houss and a long line mussel farm at South of Houss Holm.

The oyster farm at Houss consists of a single raft with oysters suspended beneath it in pouches at a depth of 3-4 metres. This site has mature stock and the harvester anticipates discontinuing production after this stock is sold due to slow growth of oysters in this area. The nominal RMP for the Houss site is identified as HU 375 315.

The long line mussel farm at South of Houss Holm is located to the south of the oyster raft. At the time of survey, there were 5 long lines with 5 metre droppers in place on the site. The nominal RMP is located at HU 373 307.

Seabed lease areas were provided by the Crown Estates Office and Shetland Island Council also provided information on areas with planning permission for shellfish farms. Both of these are mapped in Figure 2.1, where it can be seen that they correlate well.

In all three cases, the stated nominal RMPs do not agree with the locations of the actual shellfish farms, though they do all lie on the lease areas. Coordinates identifying exactly where monitoring samples are taken were provided by the sampling officer and these are displayed in Figure 2.1. For the most part, the differences in location are due to differences in specified accuracy of the monitoring point: the nominal RMP is stated to only 100 metre accuracy, whilst the actual sampling point is stated to 10 meter accuracy.

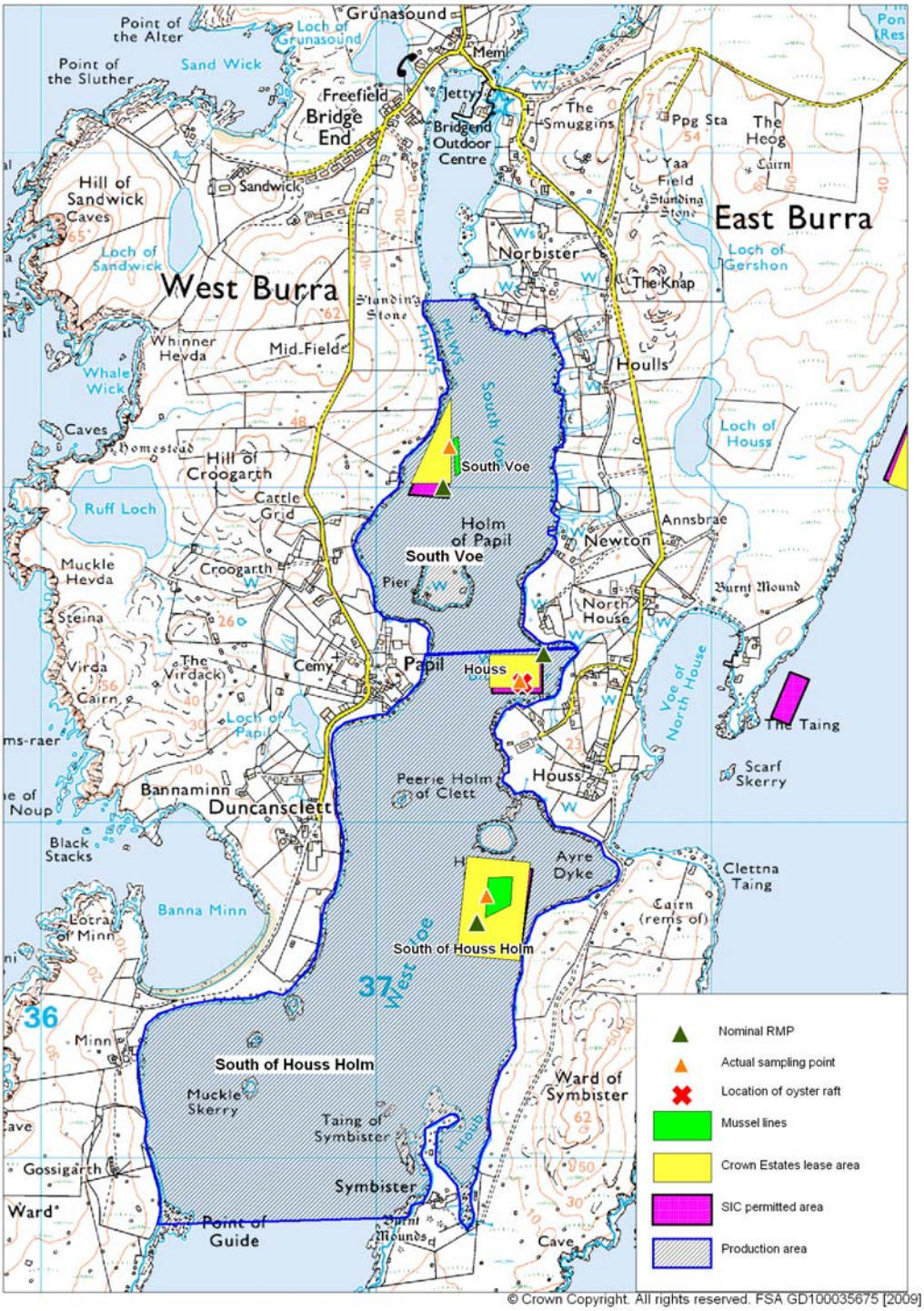

Figure 2.1 South Voe and South of Houss Holm fisheries

3. Human Population

The figure below shows information obtained from the General Register Office for Scotland on the population within census output areas bordering on South Voe.

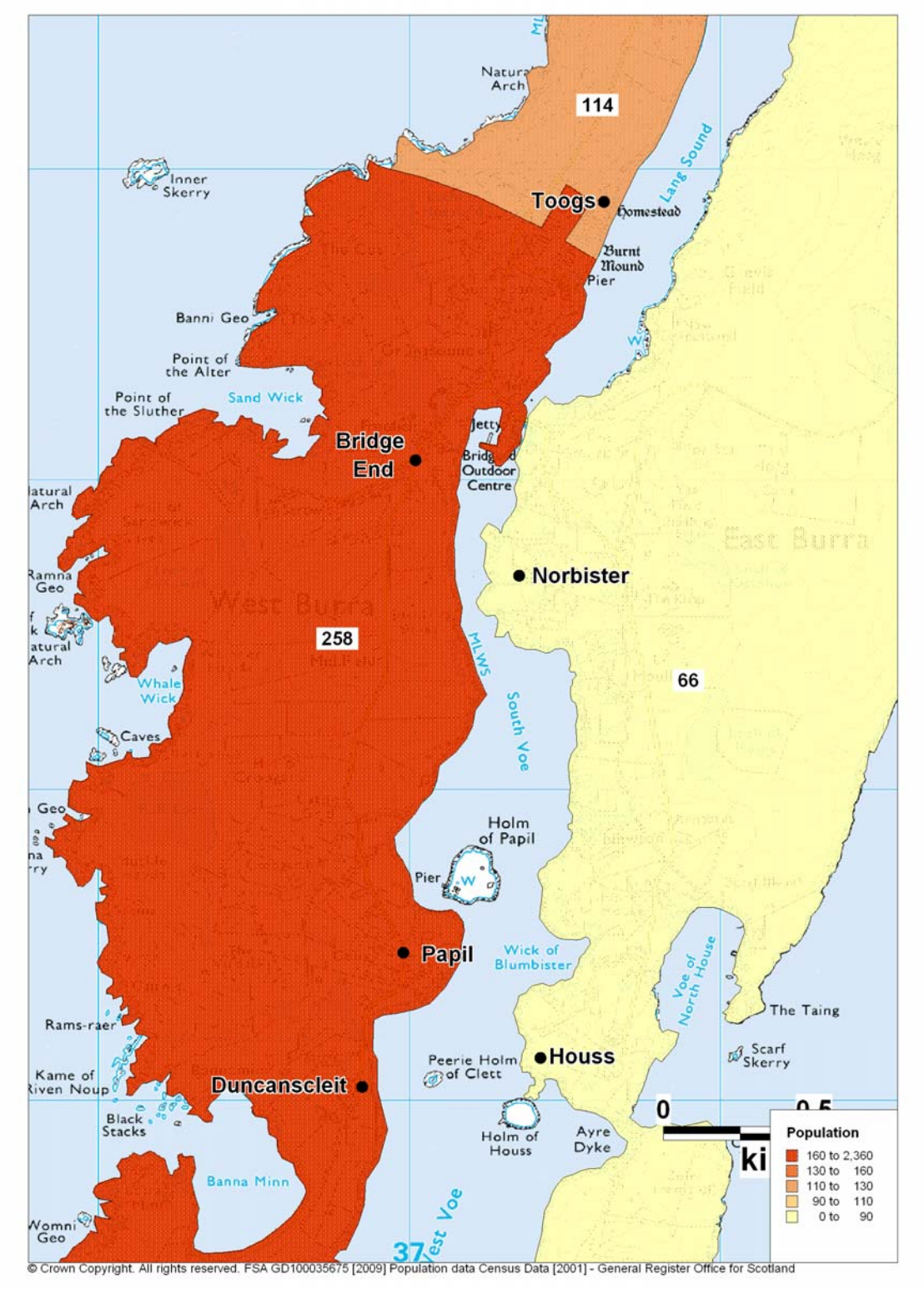

Figure 3.1 Population of South Voe

The populations for the three census output areas bordering South Voe are:

60RD000180	258
60RD000018	66
60RD000019	114
Total	438

There are several settlements on the western coastline of South Voe including Bridge End, Papil and Duncansclett. The larger settlement of Toogs lies just north of the bridge between South Voe and Lang Sound. Along the eastern side of South Voe are the settlements of Norbister, Houlls and Houss. The majority of the population is concentrated around Bridge End and Toogs n the north and Papil and Duncanscleit in the south, consequently it is likely that any associated faecal pollution from human sources is likely to be concentrated within these areas.

An outdoor education centre at Bridge End has accommodation and is used by school and scout groups during the summer months. There may be some holiday homes in the area, but little else in the way of tourist attraction or accommodation. Thus, aside from the Bridge End centre, population in the area is unlikely to fluctuate substantially throughout the year.

4. Sewage Discharges

Scottish Water identified one community septic tank and sewage discharge for the area. This was located at Toogs, on Lang Sound north of Bridge End. Details are provided in Table 4.1.

Table 4.1 Discharge identified by Scottish Water

NGR	Discharge Name	Discharge Type	Level of Treatment	Consented flow (DWF)	Consented Design PE	SEPA consent no.
HU 375 336	North Toogs ST, Burra	Continuous	Septic tank	NA	250	WPC-N-488 882

No sanitary or microbiological data were available for this discharge. Several vacuum sewer markers were identified around the area of Bridge End extending toward Toogs during the shoreline survey, indicating that this may be fed by a vacuum system.

Three discharge consents have been issued by SEPA for the area and these are listed in Table 4.2.

Table 4.2 SEPA discharge consents

Ref No.	NGR of discharge	Discharge Type	Discharges To	Treatment Level	Consented flow (DWF) m^3/d	Consented/ design PE
WPC-N-488 880	HU 378 339	Continuous	Lang Sound	Septic Tank	90	NA
WPC-N-488 882	HU 375 336	Continuous	Lang Sound	Septic Tank	NA	250
CAR/R/1015982	HU 3692 3128	Continuous	West Voe	Septic Tank	NA	13

In addition to the discharges noted, a number of private septic discharges were observed during the shoreline survey. These are listed in Table 4.3.

The discharge associated with WPC-N-488 880 was not observed during the shoreline survey. Permit WPC-N-488 882 applies to the septic tank at Toogs and CAR/R/1015982 to a septic tank at the southern end of Papil, both of which were observed. The outfall pipe from the south Papil tank appeared to be leaking and a foul odour was noted. Further along the shoreline here, a private outfall was observed to have human excrement deposited at the end of the pipe on the shoreline. Large patches of bright green algae observed in the area were indicative of high nutrient levels presumably from septic waste.

Many properties in the area appeared to have private septic tanks discharging to South Voe and West Voe that were in varying condition. There were raw outfalls noted adjacent to the pier north of Papil.

The positions of observed and reported discharges relative to the fishery can be seen on the map in Figure 4.1.

The mussel farm at the head of South Voe may be impacted by discharges from the head of the Voe, and possibly those in southern Lang Sound when water flows southward through the channel at Bridge End. The toilet block at the Bridge End outdoor centre discharges directly to South Voe south of the bridge and this is likely to be used primarily in summer. The farm may also be impacted by an outfall pipe (Table 4.3, No. 13) located 300 metres east of the mussel lines on the eastern shore of the voe.

Table 4.3 Discharges and septic tanks observed during shoreline surveys

No.	Date	NGR	Description
1	12/08/08	HU 37820 74673	Septic tank approximately 100 m beyond fence
2	12/08/08	HU 37555 33657	Toogs septic tank, outfall pipe below tank
3	12/08/08	HU 37523 33622	Post marked vacuum sewer
4	12/08/08	HU 37331 33096	Outfall pipe, flowing
5	12/08/08	HU 37493 32902	Septic tank
6	12/08/08	HU 37706 31093	Septic tank
7	13/08/08	HU 37353 32991	Septic tank
8	13/08/08	HU 37356 32926	Septic tank inspection pipe, flowing
9	13/08/08	HU 37360 32912	Inspection cover, no apparent pipes
10	14/08/08	HU 37536 31379	Outfall pipe, flowing
11	14/08/08	HU 37471 31548	Septic tank, no apparent pipe
12	14/08/08	HU 37534 31808	Septic tank, no apparent pipe
13	14/08/08	HU 37554 32146	Outfall pipe, flowing
14	14/08/08	HU 37595 31437	Septic tank, odorous, no apparent pipes
15	14/08/08	HU 36850 31185	Outfall pipe, flowing
16	14/08/08	HU 36913 31275	Outfall pipe, appears to be leaking, foul odour
17	14/08/08	HU 36970 31297	Plastic outfall pipe encased in wood and concrete. Solid waste evident at opening of pipe.
18	14/08/08	HU 37074 31350	Outfall pipe, flowing
19	14/08/08	HU 37018 31604	Three outfall pipes under the pier, one ends underwater, second flows onto gravel and the third has solid waste evident in pipe
20	14/08/08	HU 37012 31609	Outfall pipe, dribbling
21	14/08/08	HU 37225 33242	Outfall pipe, foul odour
22	14/08/08	HU 37219 33253	Vacuum sewer marker, septic tank and outfall pipe, flowing
23	14/08/08	HU 37184 33192	Septic tank and dry outfall pipe
24	14/08/08	HU 37162 33118	Two outfall pipes, one underwater extending 3 m out from cliff face the other above water and dry
25	14/08/08	HU 37150 33096	Septic discharge
26	14/08/08	HU 37262 33249	Inspection cover
27	14/08/08	HU 37327 33194	Vacuum sewer marker
28	14/08/08	HU 37111 33064	Air vent and inspection cover for septic tank
29	14/08/08	HU 37125 33067	Vacuum sewer marker
30	14/08/08	HU 37138 33068	Plastic outfall pipe
31	14/08/08	HU 37142 33061	Iron outfall pipe
32	14/08/08	HU 37137 32985	Two ceramic outfall pipes with no apparent flow
33	14/08/08	HU 37132 32951	Broken pipe, not flowing
34	14/08/08	HU 36786 32933	Septic tank
35	28/08/08	HU 37158 33116	Outfall pipes with no apparent flow
36	28/08/08	HU 37140 33111	Tank covers
37	28/08/08	HU 36855 31196	Tank with iron discharge pipe
38	28/08/08	HU 37014 31603	Underwater outfall pipe, discharge apparent as grey 'cloud'
39	28/08/08	HU 37013 31606	Outfall pipe, dribbling

The shellfish farms in South of Houss Holm production area are more likely to be impacted by discharges in and around Papil as well as single discharges along the eastern shore of the voe. Two small bays, one north and one south of Papil, are severely impacted by human sewage. The bay north of the settlement and just southwest of Holm of Papil receives raw sewage via

outfalls that appear to serve multiple dwellings. The bay to the south of Papil receives discharge from the Loch of Papil as well as what appeared to be raw sewage via pipes along its northern shore. Anecdotal evidence was obtained of illness related to consumption of razor fish collected from this bay, though this cannot be confirmed.

The oyster raft, particularly, is likely to be impacted by an outfall pipe (Table 4.3, No. 10) that discharges within 100 meters, just inshore of the raft. Positive norovirus results in oysters sampled from this raft indicate that human sewage is present in the water here.

The mussel farm at South of Houss Holm is the least likely to be impacted by sewage waste as it lies furthest from the known and observed sources of sewage in the area.

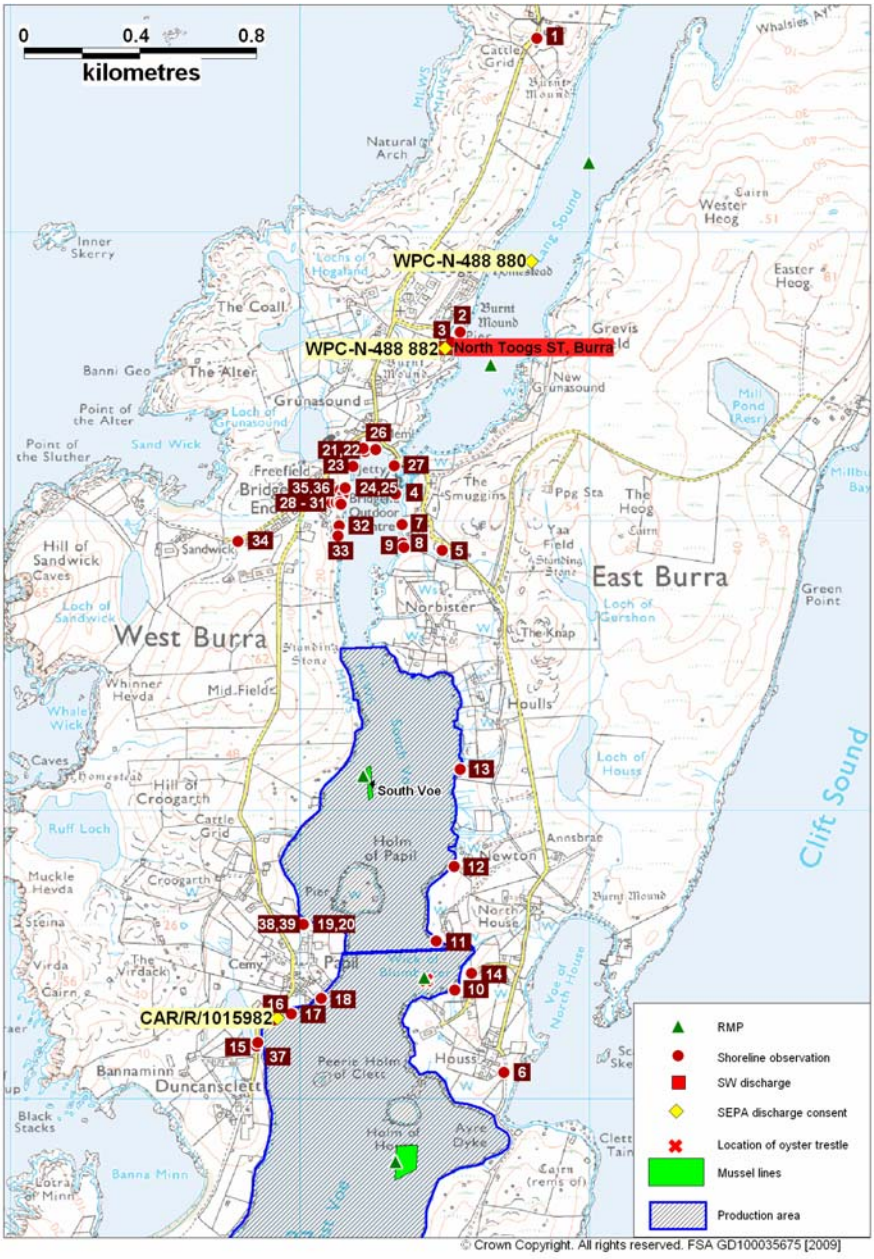

Figure 4.1 Sewage discharges at South voe

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 indicate poorly draining soils while areas shaded blue indicate more freely draining soils.

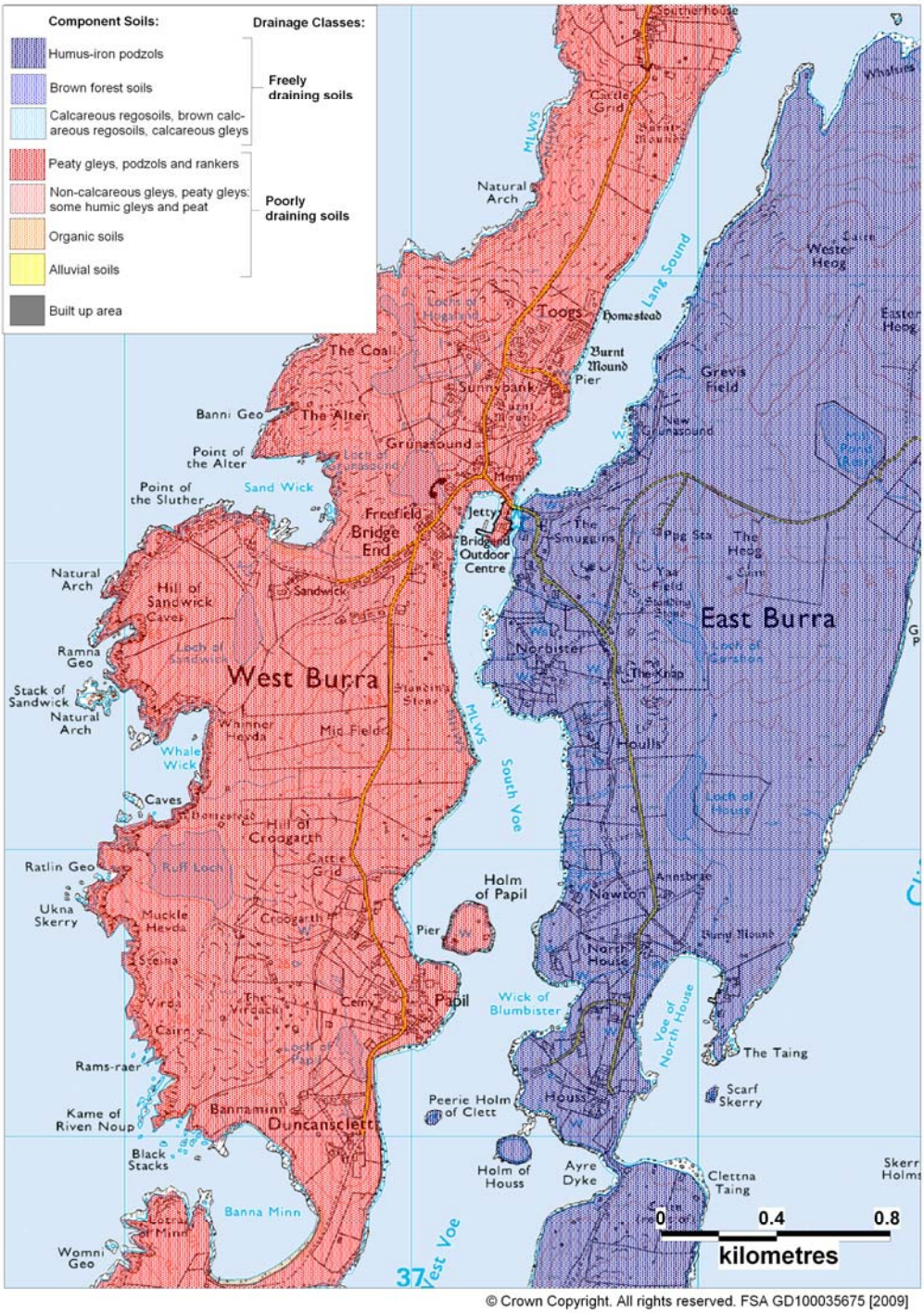

Figure 5.1 Component soils and drainage classes for South Voe.

Two types of component soil predominate in this area. The majority of the island of West Burra on the western side of the voe is covered by poorly drained peaty gleys, podzols and rankers. Soils on the island of East Burra on the eastern side of the voe are composed of freely draining humus-iron podzols.

The potential for runoff contaminated with *E. coli* from human and/or animal waste is likely to be higher along the western coastline of South Voe compared to the eastern coastline. This is likely to compound contamination problems around the area of Papil.

6. Land Cover

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

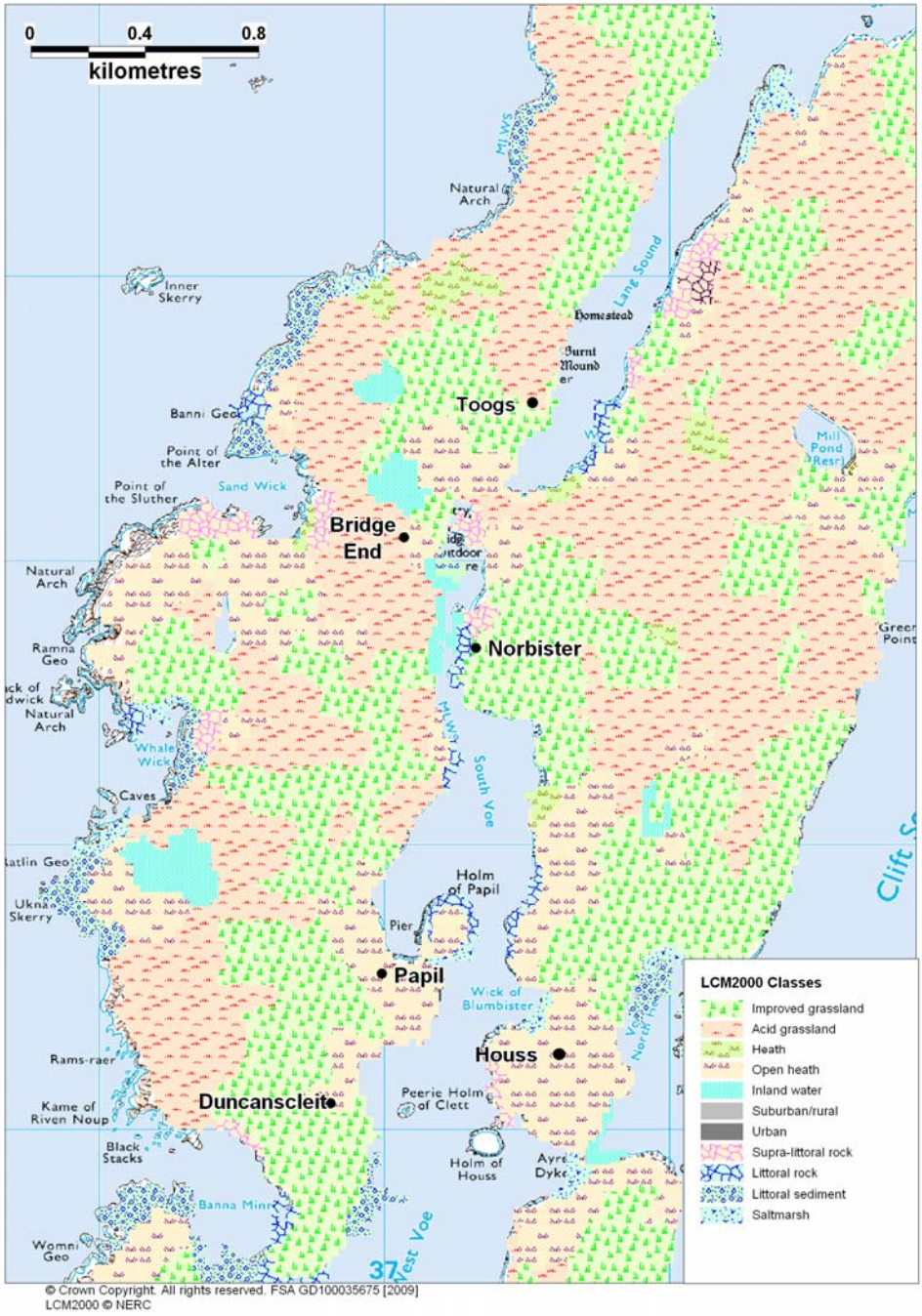

Figure 6.1 LCM2000 class land cover data for South Voe

Three main land cover types predominate on the surrounding area of South Voe: improved grassland, heath land and acid grassland. There are also some small areas of inland water. On parts of the coastline there are areas of littoral sediment and littoral rock. Although not identified by the LCM2000 class data, there are several settlements in the area, the largest of which are Toogs, Bridge End, and Papil. These should be considered areas of suburban/rural development. Development at Bridge End and Toogs is the

most intensive of these, however still only covers a relatively small area of land (<1 km^2).

Significant areas of improved grassland are present on both East Burra and West Burra, the largest of which are located around Duncanscleit and Norbister and to the northeast of Houss.

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.

It could be expected that faecal coliform contributions to the voe in the vicinity of the South Voe mussel farm would be in the intermediate range, with higher impacts expected after significant rainfall events. The oyster raft may also be impacted as there is some improved grassland around a stream on the adjacent shoreline.

Faecal bacteria contributions from the improved grassland areas around Norbister and to the northeast of Houss may contribute significantly to the faecal load in the vicinity of the mussel farm at South Voe and the oyster raft at Houss, respectively. However, the freely draining soils present here will reduce the amount of runoff thereby reducing the bacterial input.

7. Farm Animals

With regard to potential sources of pollution of animal origin, agricultural census data was requested from the Scottish Government. Agricultural census data was provided by RERAD for the parish of Burra Isles. This parish covers East Burra, West Burra and Trondra, encompassing a total land area of 1533 hectares. Reported livestock populations for the parish in 2007 and 2008 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.

Table 7.1 Livestock census data for Burra Isles for 2008

	Holdings	Numbers	Number per Holding	Number per Hectare
Total pigs	0	-	-	-
Total poultry	15	185	12	<1
Total cattle	*	*	*	*
Total sheep	50	3845	77	3
Deer	0	-	-	-
Horses and Ponies	5	17	3	<1

* Data withheld on confidentiality basis.

Both deer and pigs are reported as being farmed within the parish. These figures relate to census numbers reported by farms, and may not represent all livestock present in the area. Due to the large area of the parish, this data does not provide specific information on livestock numbers present in the area immediately surrounding South Voe. The only information specific to the area near the shellfishery was therefore the shoreline survey (see Appendix), which only relates to the time of the site visit on 12th – 14th August 2008. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 7.1.

During the course of the shoreline survey, 416 sheep, 25 horses, 5 cattle, 26 chickens and 1 goat were observed along the shoreline. These numbers may also be an underestimation as the observations are dependent upon the point of view of the surveyor and some animals may have been obscured from view. Animals were more frequently observed near areas with crofts or houses and a higher proportion were observed on the east side of the voe than on the west side. Sheep are grazed widely around the islands and so it cannot be presumed that they will be present only in the areas observed during the survey.

Sheep were by far the most numerous type of livestock observed in the area, and according to the WHO, one sheep's contribution to faecal coliform loads is estimated to be nearly 10 times that of a person. As sheep faeces are deposited directly to the environment without treatment, this is likely to be a significant source of faecal contamination in the survey area.

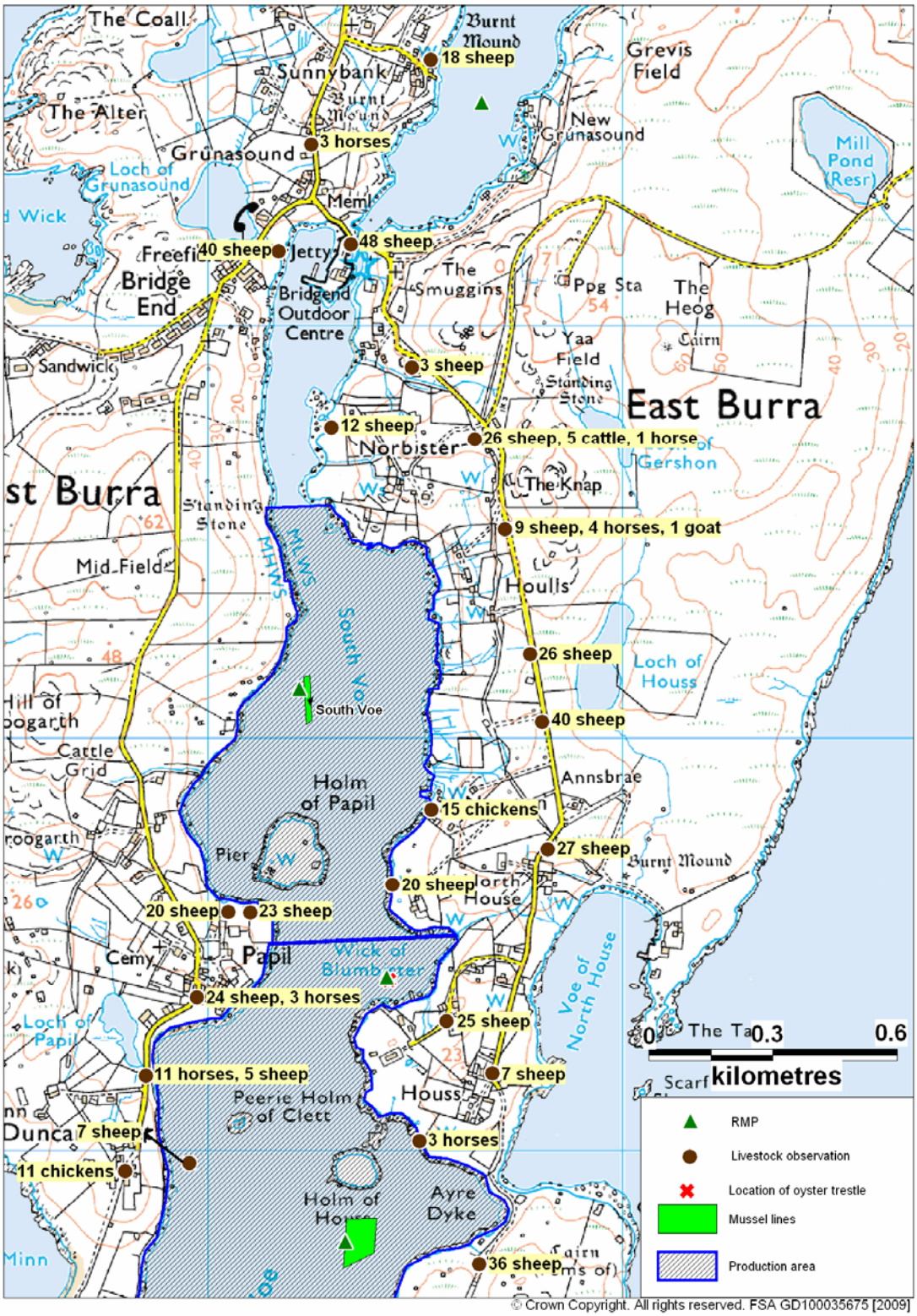

Figure 7.1 Livestock observations at South Voe

Generally, numbers of livestock in the area are expected to be higher in spring and summer than in winter as the arrival of lambs generally doubles the sheep population.

8. Wildlife

General information related to potential risks to water quality by wildlife can be found in Appendix 3. A number of the wildlife species present or likely to be present in and around South Voe and West Voe could potentially affect water quality in the vicinity of the fisheries

Seals

Common seals surveys are conducted every 5 years and an estimate of minimum numbers is available through Scottish Natural Heritage. The Shetland-wide count in 2006 was 3021 harbour seals, though this was anticipated to be an underestimation of the total population (Sea Mammal Research Unit 2007). More detailed information from the previous count (2001) identified a haulout site for this species in West Voe, near the mussel farm at South of Houss Holm.

Minimum grey seal pup production in Shetland was estimated as 943 in 2004. Adult numbers are estimated to be 3.5 times the pup population (Callan Duck, Sea Mammal Research Unit, personal communication).

Around a dozen seals were observed basking during the course of the shoreline survey, and the locations of these are mapped in Figure 7.1. One of the harvesters reported having seen as many as 30 seals near the South of Houss Holm site though numbers had dropped somewhat in recent years. The impact of faecal contamination from seals is likely to be felt most acutely at the South of Houss Holm mussel farm, though it is not possible to quantify.

Seals will range widely while hunting for food so it is likely they will feed near the other shellfish farms in the area at some point in time. However, the seal population is highly mobile therefore it is likely that any impact from seals feeding in the area will be limited and unpredictable.

Whales and Dolphins

A variety of cetacean species are routinely observed near Shetland. It is highly likely that whales and dolphins will be found from time to time in the area, although the larger species are less likely to pass near the shore. As with seals, these are highly mobile animals and any impact from their presence is likely to be limited in duration and unpredictable.

Birds

A number of seabird species breed in Shetland. These were the subject of a detailed census carried out in sections during the late spring of 1998, 1999, 2000 and 2002 (Mitchell et al. 2004). Total counts of all species recorded within 5km of the mussel lines are presented in Table 8.1. For most species, each count represents a breeding pair of birds.

Table 8.1 Seabird counts within 5km of South Voe.

Common name	Species	Count	Method	Individuals/ Pairs
Northern Fulmar	*Fulmarus glacialis*	2837	Occupied sites	Pairs
Arctic Tern	*Sterna paradisaea*	937	Occupied nests/individuals on land	Pairs
Black Guillemot	*Cepphus grylle*	466	Individuals on land	Individuals
Herring Gull	*Larus argentatus*	347	Occupied nests/territories/individuals on land	Pairs
Common Gull	*Larus canus*	252	Occupied territories/individuals on land	Pairs
Great Black-backed Gull	*Larus marinus*	160	Occupied nests/territories/individuals on land	Pairs
Black-headed Gull	*Larus ridibundus*	139	Occupied territories/individuals on land	Pairs
Kittiwake	*Rissa tridactyla*	123	Occupied nests	Pairs
European Shag	*Phalacrocorax aristotelis*	49	Occupied nests	Pairs
Atlantic Puffin	*Fratercula arctica*	46	Individuals on land	Pairs
Great Skua	*Stercorarius skua*	23	Occupied territory	Pairs
Common Tern	*Sterna hirundo*	22	Individuals on land	Pairs
Lesser Black-backed Gull	*Larus fuscus*	10	Individuals on land	Pairs
Arctic skua	*Stercorarius parasiticus*	4	Occupied territory	Pairs

There is a high density of breeding seabirds in the general area. A map of total counts (assuming that a pair equates to two individuals) are presented in Figure 8.1. Significant numbers of seabirds were observed on both East Burra and West Burra islands. The largest counts near the fisheries were at the southern end of the South of Houss Holm production area and on the eastern side of Ayre Dyke, 0.5 km east of the mussel farm. During the shoreline survey, Northern Fulmars were observed on nests along the western side of West Voe, beyond the southern boundary of the South of Houss Holm production area.

Significant inputs from seabirds may be expected, particularly during the breeding season. Faecal material from the nesting areas will be carried to the sea via rainfall runoff, and birds will also deposit faeces directly to the sea whilst feeding or flying. Both impacts would tend to be seasonal, with a likely lag between direct impacts and those carried via runoff from land. Direct inputs from feeding birds will be spatially diffuse while impacts from the nesting areas will tend to be concentrated around the nests and any streams carrying runoff from the nesting areas.

Breeding occurs during the summer, after which most species disperse though some, such as gulls, will remain in the area throughout the year.

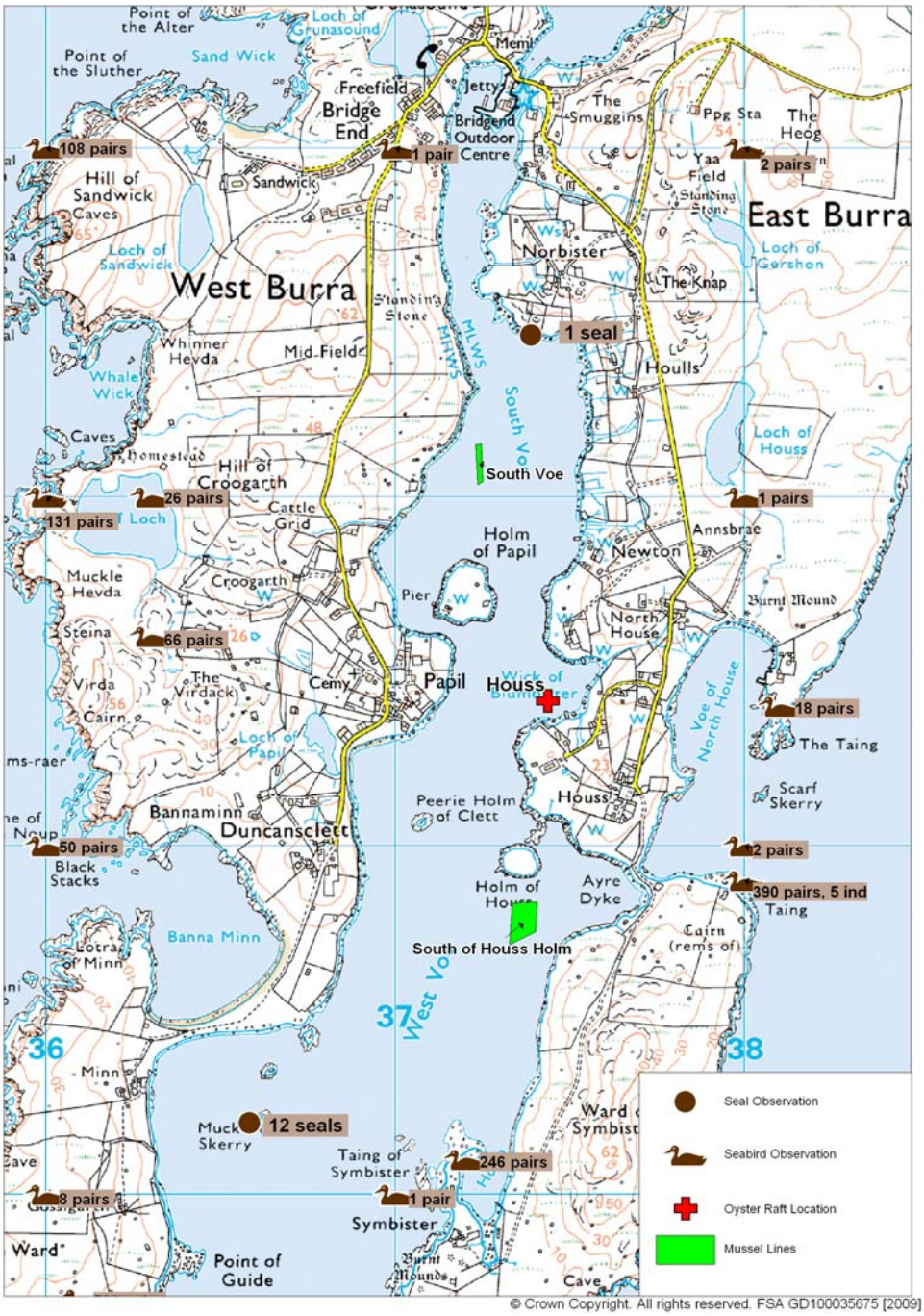

Figure 8.1 Seabird 2000 survey counts

Waterfowl (ducks and geese) are present in Shetland at various times of the year. Eider ducks feed on mussel lines and are present in the Shetlands throughout the year, although none was observed during the shoreline survey. Geese tend to pass through the Shetland Islands during migrations but do not linger in very large numbers as they do further south.

Otters

There is a significant population of European Otters (*Lutra lutra*) present in Shetland, though none were observed during the shoreline survey. Overall

densities of otters are low relative to livestock and seabirds, so it is unlikely that otter faeces will be a significant source of contamination to the fishery.

Summary

The main wildlife species potentially impacting on the production areas are seals and sea birds. The impacts of these on the fishery will be largely unpredictable and deposition of faeces by most wildlife is likely to be widely distributed around the area.

However, impacts from nesting seabirds may be concentrated near the nesting areas and watercourses draining those areas. Any resulting increase in contamination levels at the fishery is most likely to occur during and immediately after the summer breeding season (May-July) and would most likely impact the southern end of the South of Houss Holm production area, though direct impacts from birds are likely to be broadly distributed throughout the area. Given the large numbers of birds and their habit of resting on floats and buoys, there is likely to be a significant impact to the mussel farms which may be more pronounced in summer.

9. Meteorological data

The nearest weather station is located at Lerwick, approximately 8 km to the north east of the production areas, for which uninterrupted rainfall data is available for 2003-2007 inclusive. It is likely that the rainfall patterns at Lerwick are very similar but not identical to those on South Voe and South of Houss Holm and surrounding land due to their proximity, but it is not certain whether the local topography may result in differing wind patterns (Lerwick is on the east coast, the production areas are on the west coast). This section aims to describe the local rain and wind patterns and how they may affect the bacterial quality of shellfish within South Voe and South of Houss Holm.

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 summarise the pattern of rainfall at Lerwick by year and by month respectively.

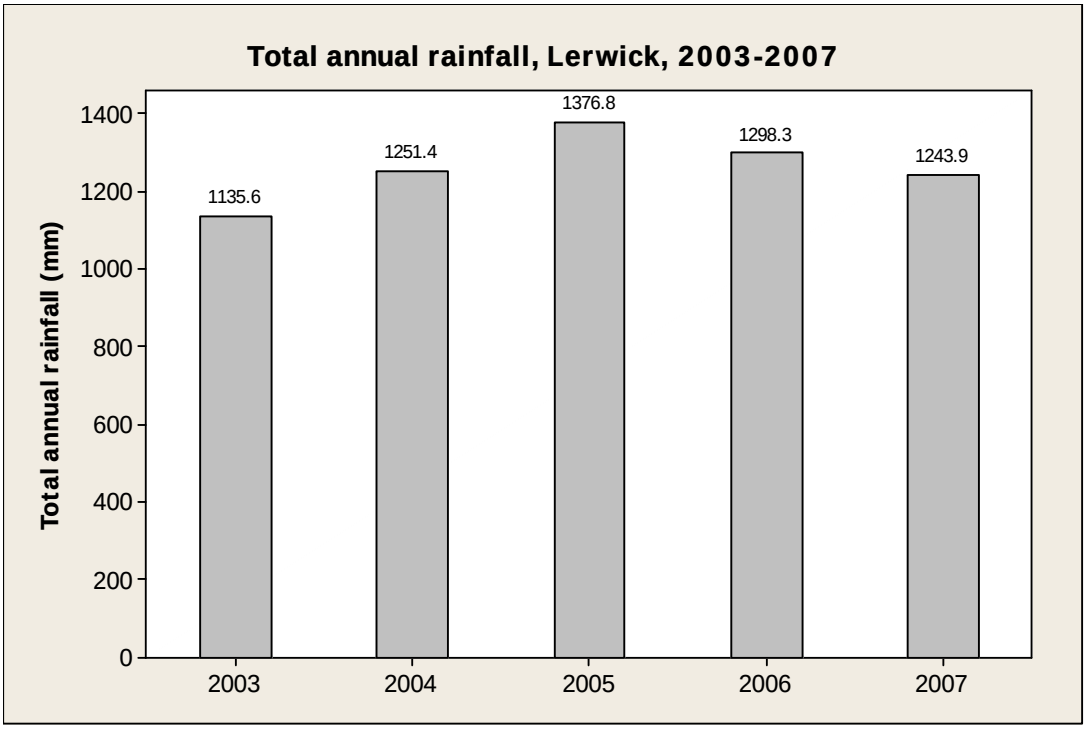

Figure 9.1 Bar chart of annual rainfall at Lerwick 2003-2007

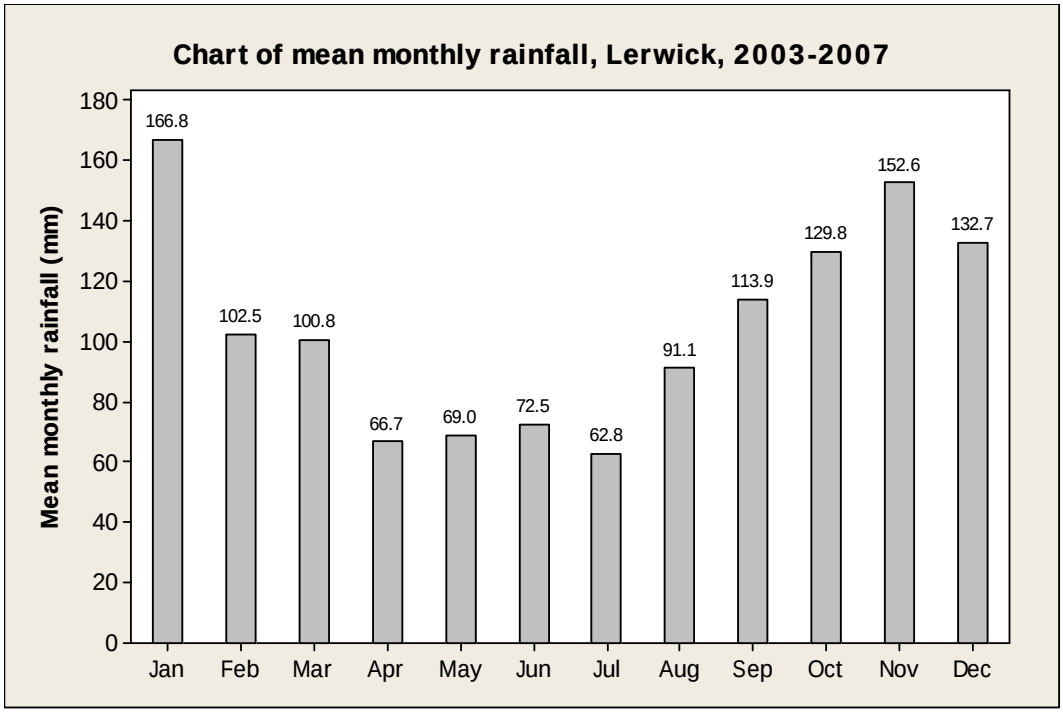

Figure 9.2 Bar chart of mean monthly rainfall at Lerwick 2003-2007

The wettest months were November and January. For the period considered here (2003-2007), only 12.9% of days experienced no rainfall, 44.6% of days experienced rainfall of 1mm or less. The driest months were April to July, inclusive.

A comparison of Lerwick rainfall data with Scotland average rainfall data for the period of 1970-2000 is presented in Table 9.3 (Data from Met office website © Crown copyright). This indicates that rainfall in Lerwick was lower than the average for the whole of Scotland for every month of the year, but there were fewer dry days in Lerwick during the autumn, winter and spring.

Table 9.1 Comparison of Lerwick mean monthly rainfall with Scottish average 1970-2000.

Month	Scotland rainfall (mm)	Lerwick rainfall (mm)	Scotland - days of rainfall >= 1mm	Lerwick - days of rainfall >= 1mm
Jan	170.5	135.4	18.6	21.3
Feb	123.4	107.8	14.8	17.8
Mar	138.5	122.3	17.3	19
Apr	86.2	74.2	13	14.4
May	79	53.6	12.2	10.1
Jun	85.1	58.6	12.7	11.3
Jul	92.1	58.5	13.3	11
Aug	107.4	78.3	14.1	12.5
Sep	139.7	115.3	15.9	17.4
Oct	162.6	131.9	17.7	19.4
Nov	165.9	152.4	17.9	21.5
Dec	169.6	150	18.2	22.2
Whole year	1520.1	1238.1	185.8	197.9

Faecal matter can build up on pastures during the drier summer months when livestock populations are at their highest which can result in more significant faecal runoff at the onset of the wetter months.

Periods of increased rainfall are generally associated with higher levels of contaminated surface water runoff. However, the catchment area for the voe and its streams is small and contamination via these sources may be present at any time of year after marked rainfall.

Faecal contaminants from other sources may be independent of rainfall and so episodes of contamination may occur outside identified periods of higher rainfall, for example when livestock are present on the shoreline.

9.2 Wind

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

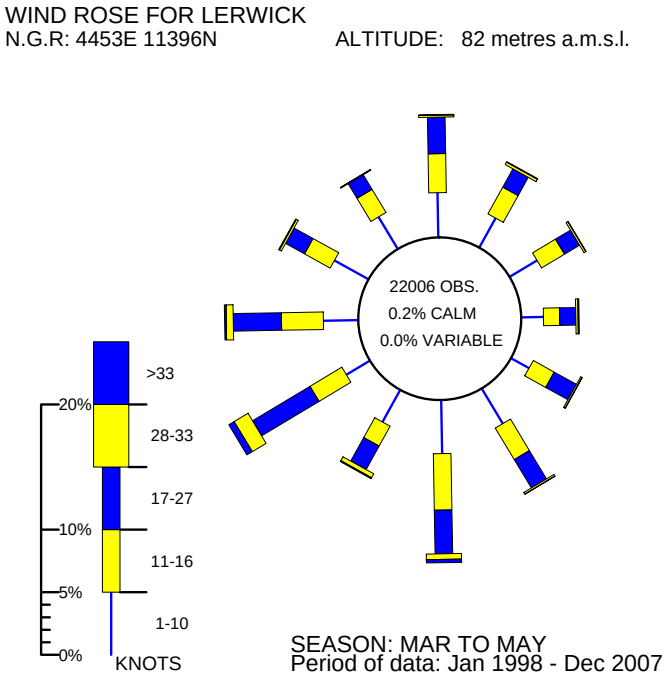

Figure 9.3 Wind rose for Lerwick (March to May)

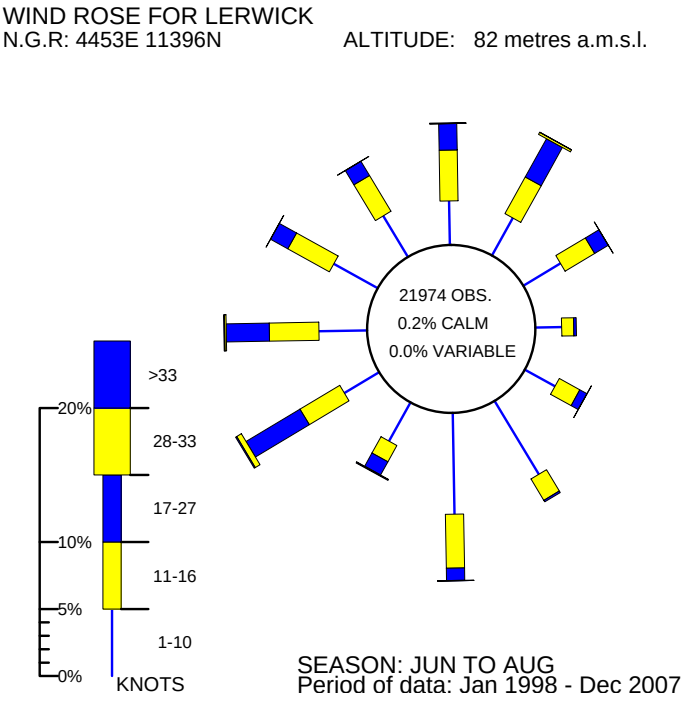

Figure 9.4 Wind rose for Lerwick (June to August)

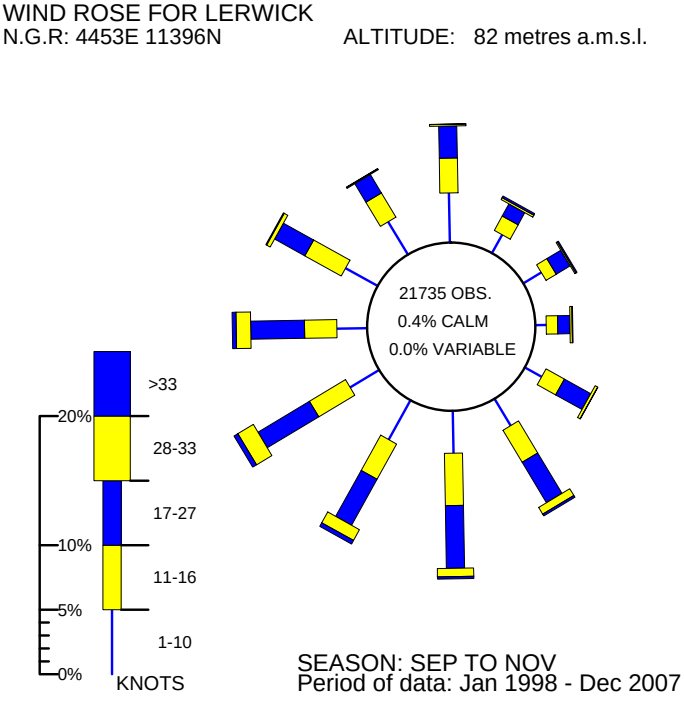

Figure 9.5 Wind rose for Lerwick (September to November)

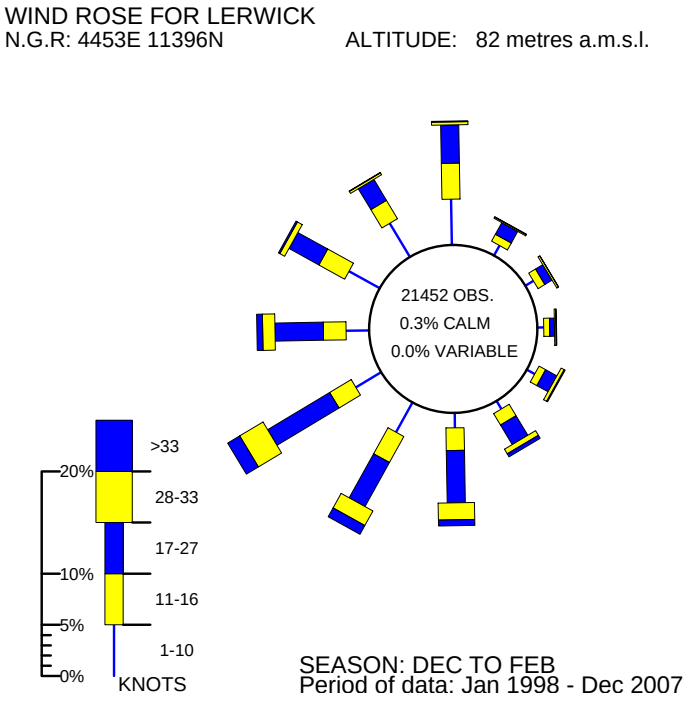

Figure 9.6 Wind rose for Lerwick (December to February)

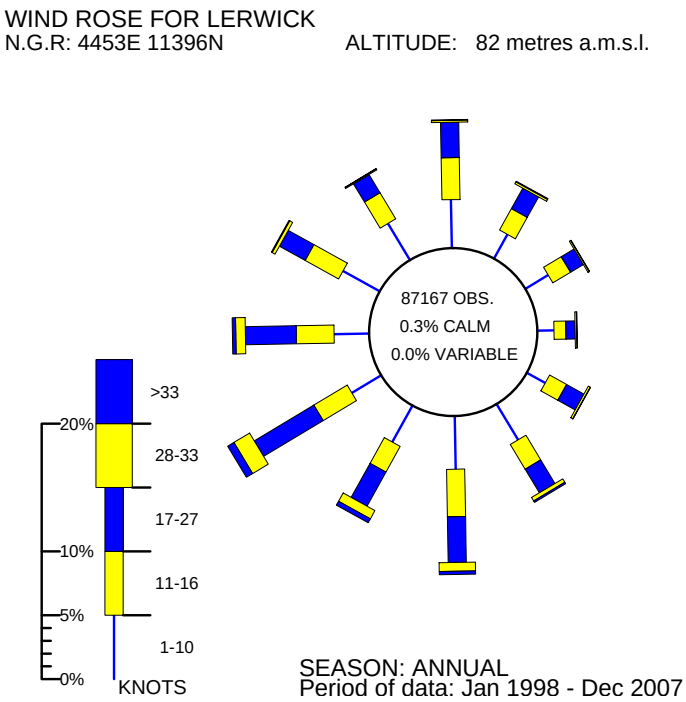

Figure 9.7 Wind rose for Lerwick (Annual)

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

South Voe and South of Houss Holm are part of the same water body, which has a north-south aspect, and is sheltered from the open sea from all directions by land apart from the south. The surrounding land may have the effect of channelling northerly or southerly winds up or down the Voe.

A strong southerly wind combined with a spring tide may result in higher than usual tides which could carry accumulated faecal matter from livestock from above the normal high water mark into the production area. However, South and West Voes have relatively little foreshore on which this could occur.

Wind effects are likely to cause significant changes in water circulation within the voe as tidally influenced movements of water are relatively weak. 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. These surface water currents create return currents which may travel along the bottom or sides of the water body depending on bathymetry. Exact effects will be difficult to predict given the complex shape of the voe. Strong winds will increase the circulation of water and hence dilution of contamination from point sources within the voe. Wind effects are likely to be greatest with either a northerly or southerly wind which will blow along the length of the voe.

10. Current and historical classification status

The survey area consists of two adjacent production areas: South Voe (currently classified for mussels and previously classified for Pacific oysters) and South of Houss Holm (currently classified for both Pacific oysters and mussels). A map of the production areas is presented in Figure 10.1.

South Voe was classified for the production of Pacific oysters from 2004 to 2008, when it was declassified as insufficient samples were submitted during 2007 (oyster production has now been abandoned). The classification history is presented in Table 10.1. Up to 2006, the area was classified as a seasonal A/B, but since 2006 it has been classified as a year round A. There is currently no RMP for oysters within the production area.

Table 10.1 Classification history, South Voe, Pacific oysters

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

South Voe has been classified for the production of mussels since 2008. The classification history is presented in Table 10.2. During its first year of classification, it was classified as seasonal A/B. It's B classification was extended by two months for 2009. The official RMP for mussels in this production area lies within 10m of the Crown Estates lease, and within 50m of the mussel lines.

Table 10.2. Classification history, South Voe, mussels

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008				A	A	A	A	B	B	A	A	A
2009	A	A	A	A	A	A	A	B	B	B	B	A
2010	A	A	A									

South of Houss Holm has been classified for the production of Pacific oysters since 2007. The classification history is presented in Table 10.3. Throughout the period of classification, it was classified as an A. The official RMP lies within 10m of the relevant Crown Estates lease, and within 100m of the oyster raft.

Table 10.3. Classification history, South of Houss Holm, Pacific oysters

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007	A	A	A	A	A	A	A	A	A	A	A	A
2008	A	A	A	A	A	A	A	A	A	A	A	A
2009	A	A	A	A	A	A	A	B	B	B	B	B
2010	B	B	A									

South of Houss Holm has been classified for the production of mussels since 2004. The classification history is presented in Table 10.4. Throughout the period of classification, it was classified as an A. The official RMP lies within the relevant Crown Estates lease, and within 30m of the mussel lines.

Table 10.4. Classification history, South of Houss Holm, mussels

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	A	A	A	A	A	A	A	A	A	A	A	A
2005	A	A	A	A	A	A	A	A	A	A	A	A
2006	A	A	A	A	A	A	A	A	A	A	A	A
2007	A	A	A	A	A	A	A	A	A	A	A	A
2008	A	A	A	A	A	A	A	A	A	A	A	A
2009	A	A	A	A	A	A	A	A	A	A	A	A
2010	A	A	A									

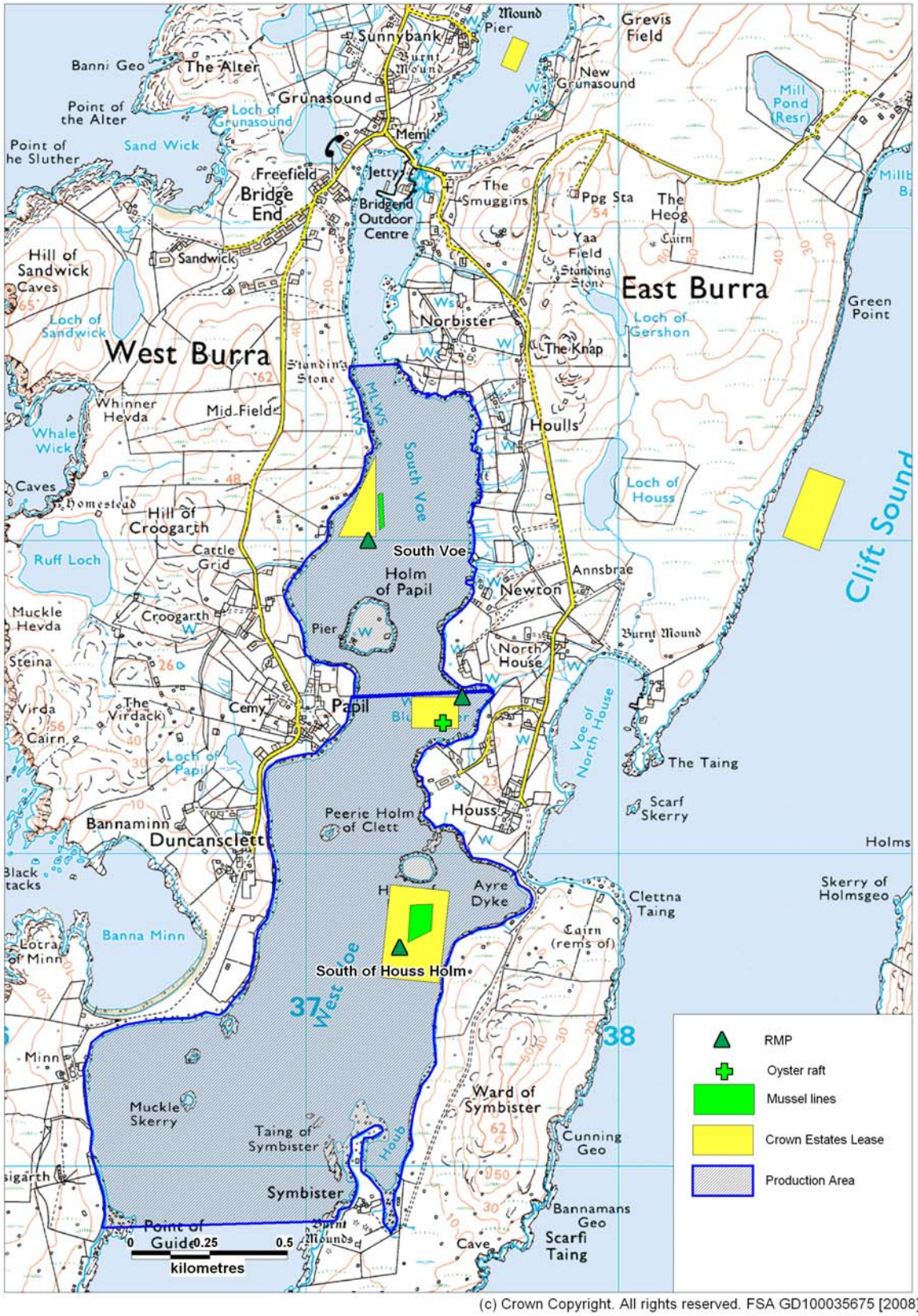

Figure 10.1 Current production areas at South Voe and South of Houss Holm

11. Historical *E. coli* data

11.1 Validation of historical data

All shellfish samples taken from South Voe and South of Houss Holm from the beginning of 2002 up to the end of 2007 were extracted from the database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data.

One mussel sample reported as originating from South of Houss Holm but with a reported sampling location within South Voe production area was excluded from the analysis. Two oyster samples were excluded from the analysis: One reported as originating from South Voe but with a reported sampling location within South of Houss Holm production, and one reported as originating from South Voe but with no reported sampling location.

Three cockle samples were rejected as they had no recorded sampling location. A further cockle sample was rejected as the reported sampling location fell 3.7 km outside the production area.

A total of 9 oyster and 20 mussel samples had the result reported as <20, and were assigned a nominal value of 10 for statistical assessment and graphical presentation. One oyster sample had the result reported as >18000, and this was assigned a nominal value of 36000.

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 by sampling location and species

A summary of all sampling and results by is presented in Table 11.1.

Table 11.1 Summary of results from South Voe and South of Houss Holm

Sampling Summary					
Production area	South Voe	South of Houss Holm	South Voe	South of Houss Holm	South of Houss Holm
Site	South Voe	Houss	South Voe	South of Houss Holm	South of Houss Holm
Species	Pacific oysters	Pacific oysters	Common mussels	Common mussels	Common mussels
SIN	SI-264-445-13	SI-261-739-13	SI-264-445-8	SI-261-444-8	SI-261-444-8
Location	HU372320	HU375315	HU372320	HU373307	HU373308
Total no of samples	28	21	7	53	6
No. 2002	0	0	0	0	5
No. 2003	2	0	0	11	1
No. 2004	12	0	0	11	0
No. 2005	9	0	0	11	0
No. 2006	5	12	0	11	0
No. 2007	0	9	7	9	0
Results Summary					
Minimum	<20	<20	<20	<20	<20
Maximum	>18000	1300	1100	310	110
Median	125	40	40	40	75
Geometric mean	103	52.3	68.4	34.5	41.8
90 percentile	500	220	740	220	110
95 percentile	663	750	920	248	110
No. exceeding 230/100g	5 (18%)	2 (10%)	2 (29%)	3 (6%)	0 (0%)
No. exceeding 1000/100g	1 (4%)	1 (5%)	1 (14%)	0 (0%)	0 (0%)
No. exceeding 4600/100g	1 (4%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
No. exceeding 18000/100g	1 (4%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

11.3 Overall geographical pattern of results

Figure 11.1 presents a map showing geometric mean result by reported sampling locations for oyster samples (with OS grid reference, site, number of samples and sampling dates) and Figure 11.2 presents the same for mussel samples.

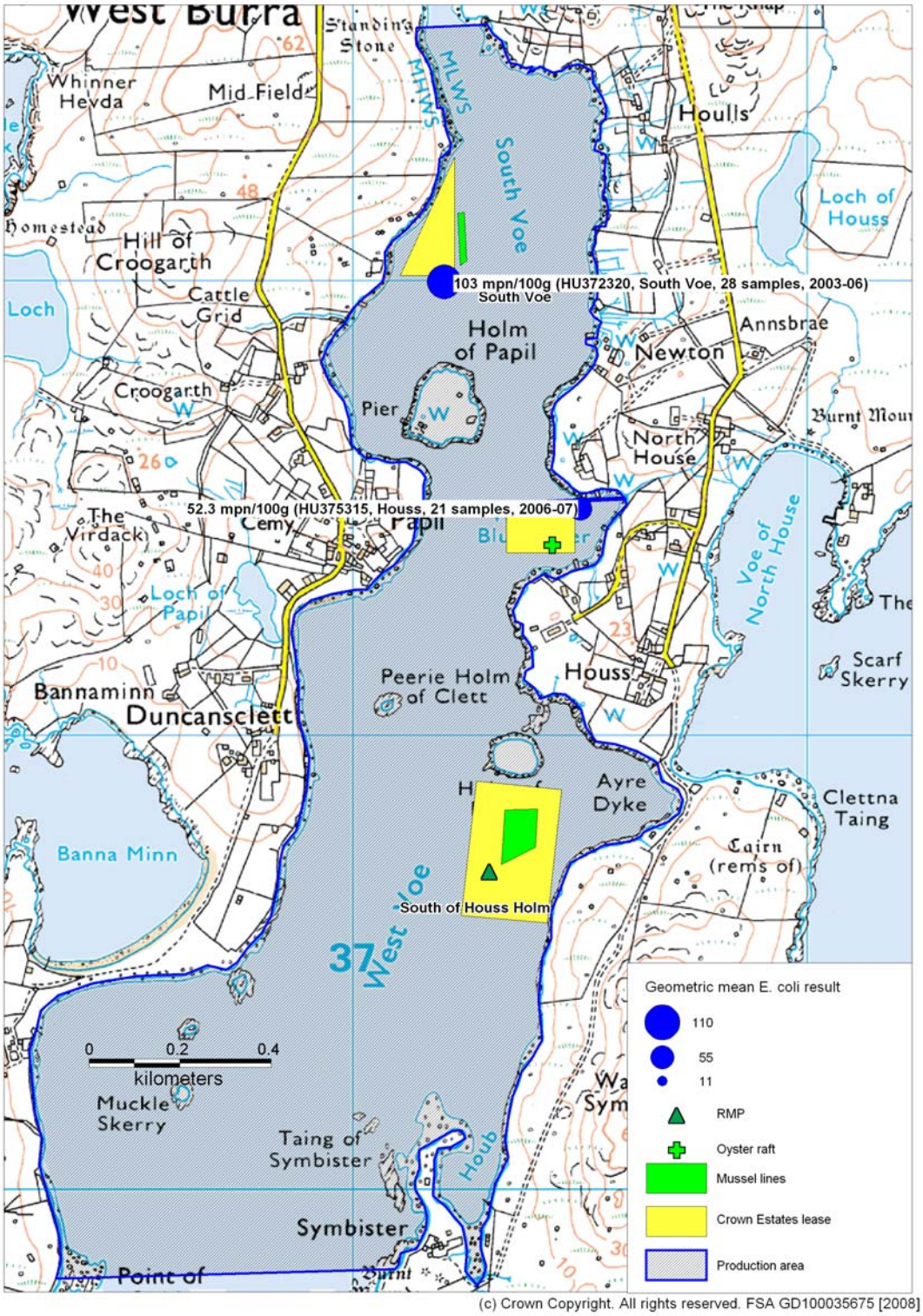

Figure 11.1 Sampling points and geometric mean result for oysters

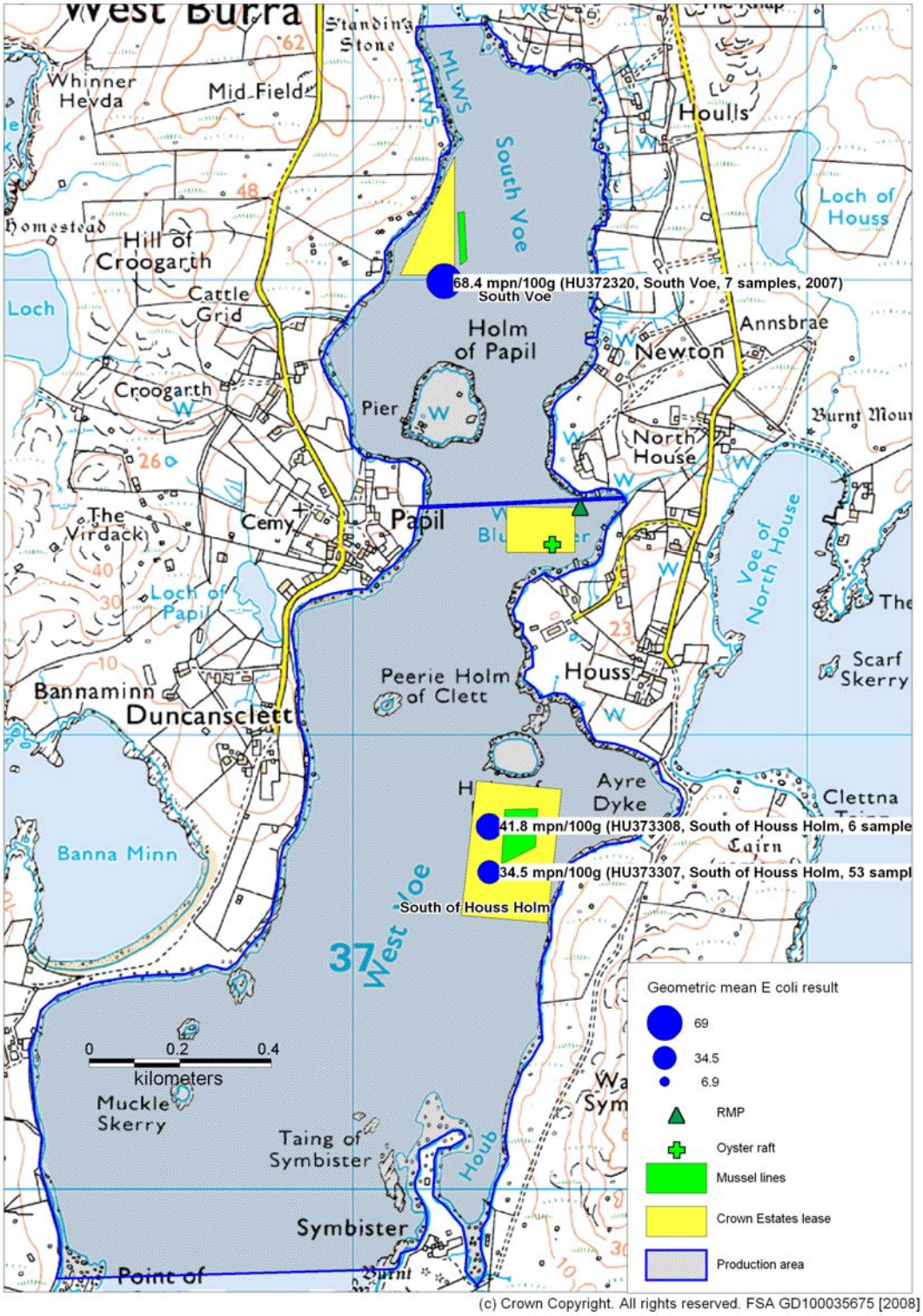

Figure 11.2 Sampling points and geometric mean result for mussels

The geometric mean result was twice as high in the South Voe production area as in South of Houss Holm for both shellfish species. However the difference was not significant for either oysters (T-test, T=-1.51, p=0.139, Appendix 6) or mussels (T-test, T=-1.51, p=0.139, Appendix 6). The highest individual result for both species came from South Voe. South Voe also had the highest proportion of results over 230 *E. coli* MPN/100g for both species but the sample sizes (<5) were too small to

test for statistical significance. It must be noted that the two production areas were sampled through different periods. Shellfish samples of the same species were only sampled from the two production areas on the same day on two occasions, so a more robust comparison under the same environmental conditions was not possible. Only seven mussel samples were collected from South Voe so more detailed analysis of results for mussels from this production area was not possible.

11.4 Overall temporal pattern of results

Figures 11.3 and 11.4 present scatter plots of individual results against date for all oyster samples taken from South Voe and South of Houss Holm. Both are fitted with trend lines to help highlight any apparent underlying trends or cycles. Figure 11.2 is fitted with lines indicating the geometric mean of the previous 5 samples, the current sample and the following 6 samples. Figure 11.3 is fitted with Loess lines, a regression based smoother line calculated by the Minitab statistical software. Figures 11.5 and 11.6 present the same for mussels from South of Houss Holm only.

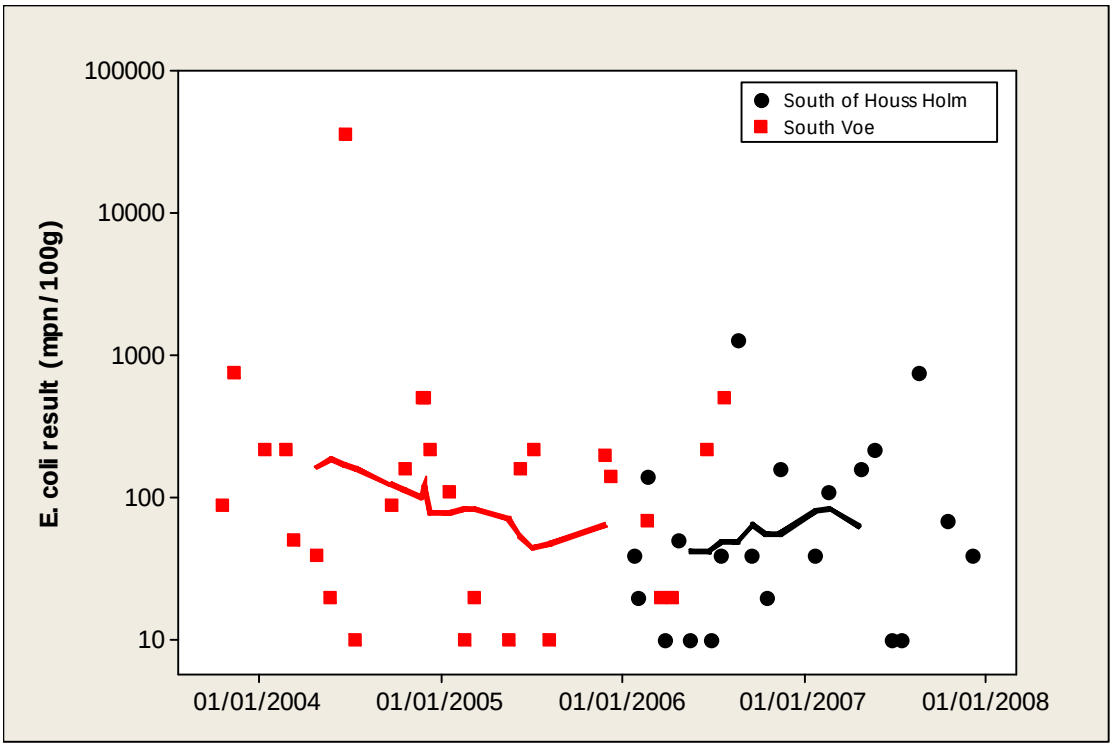

Figure 11.3 Scatterplot of oyster results by production area and by date with rolling geometric mean

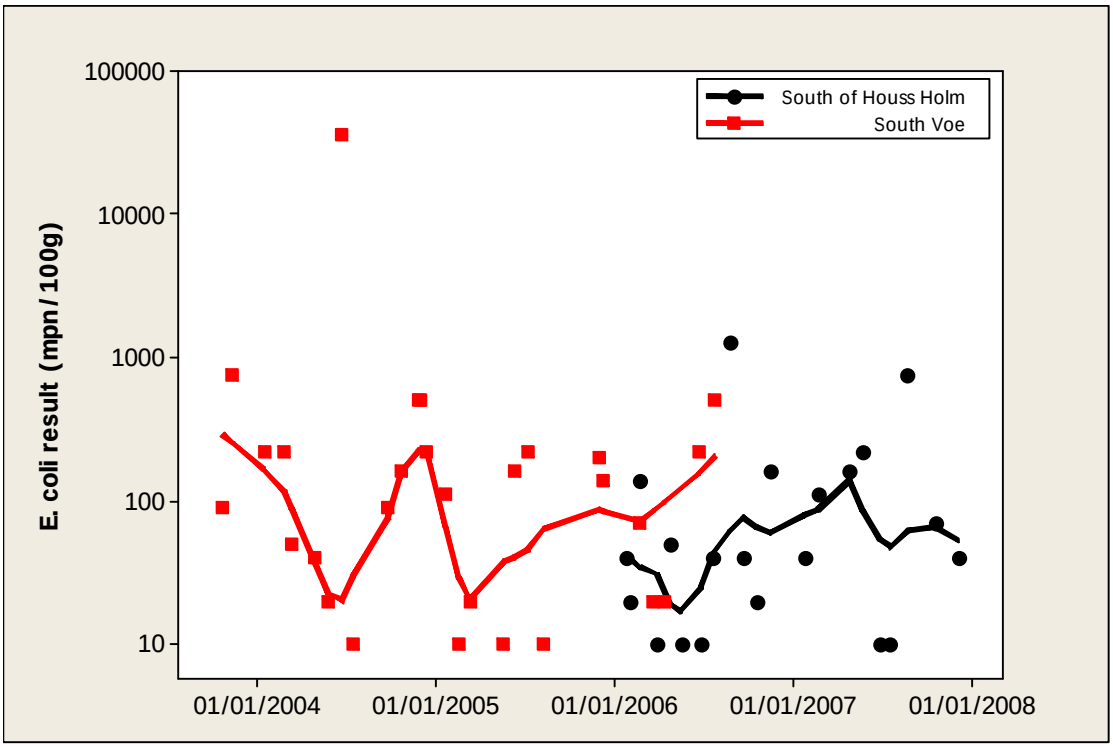

Figure 11.4 Scatterplot of oyster results by production area and by date with loess smoother

No particular trends or cycles are apparent in Figures 11.3 or 11.4.

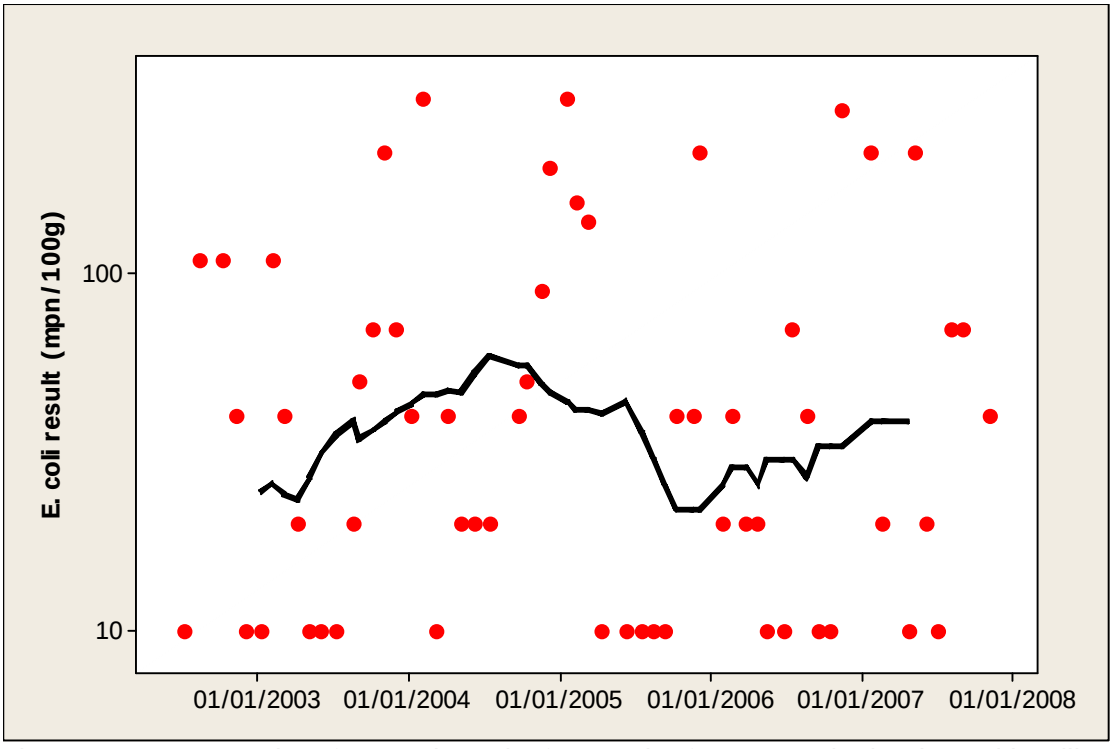

Figure 11.5 Scatterplot of mussel results for South of Houss Holm by date with rolling geometric mean

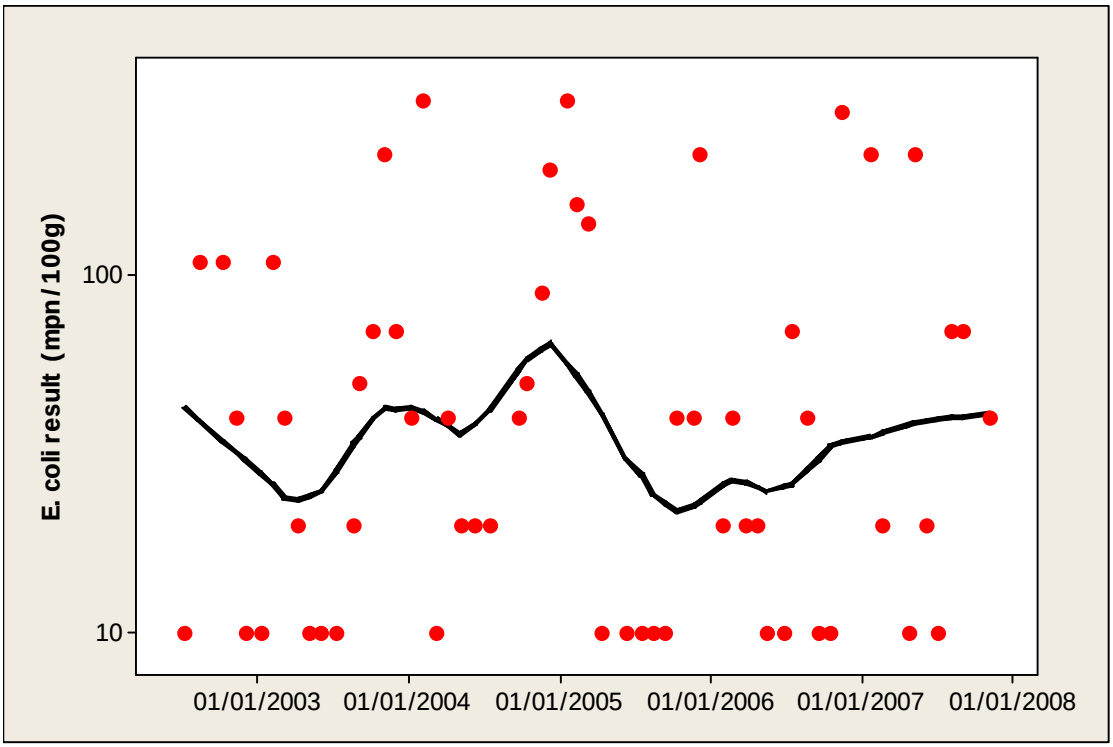

Figure 11.6 Scatterplot of mussel results by production area and by date with Loess smoother

The Loess line shows that overall the results appear to be lower than the peak reached in late 2004, but the range in the scatterplot shows the high results may not have declined by much. No discernable trends were observed in mussel contamination levels.

11.5 Seasonal pattern of results

Season dictates not only weather patterns and water temperature, but livestock numbers and movements, presence of wild animals and patterns of human occupation. All of these can affect levels of microbial contamination, and cause seasonal patterns in results. Figure 11.7 presents the geometric mean *E. coli* result by month for all oyster samples from South Voe (+ 2 times the standard error), Figure 11.8 presents the same for all oyster samples from South of Houss Holm, and Figure 11.9 presents the same for all mussel samples from South Voe and Figure 11.10 presents the same for all mussel samples from South of Houss Holm.

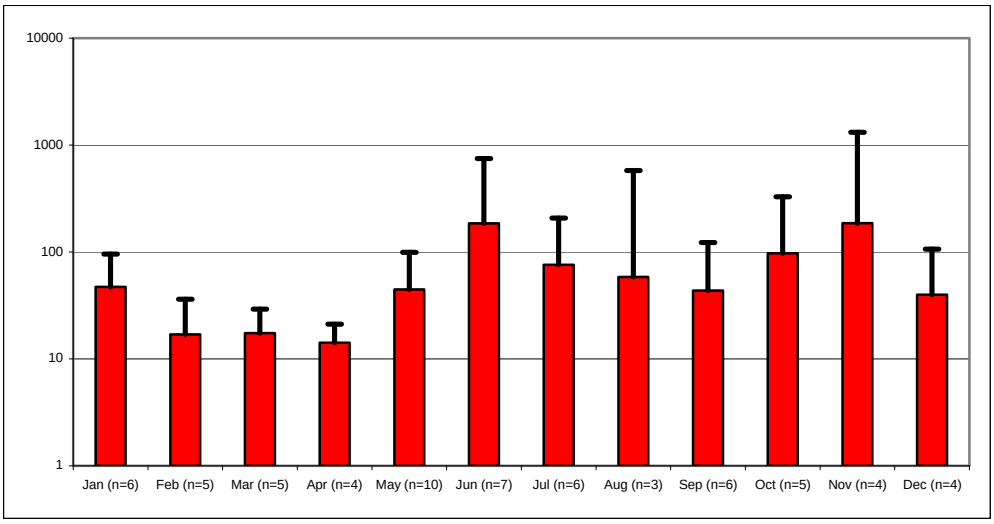

Figure 11.7 Geometric mean *E. coli* result for South Voe oysters by month

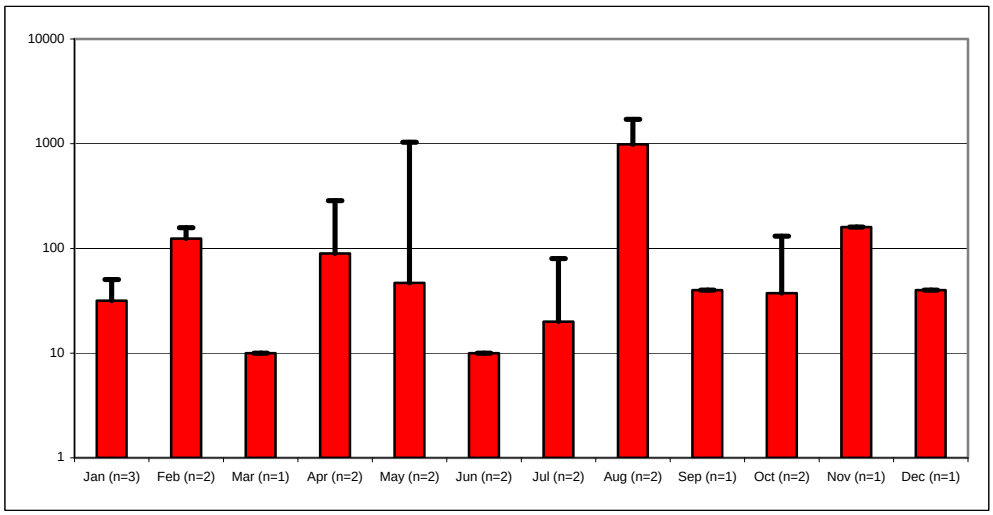

Figure 11.8 Geometric mean *E. coli* result for South of Houss Holm oysters by month

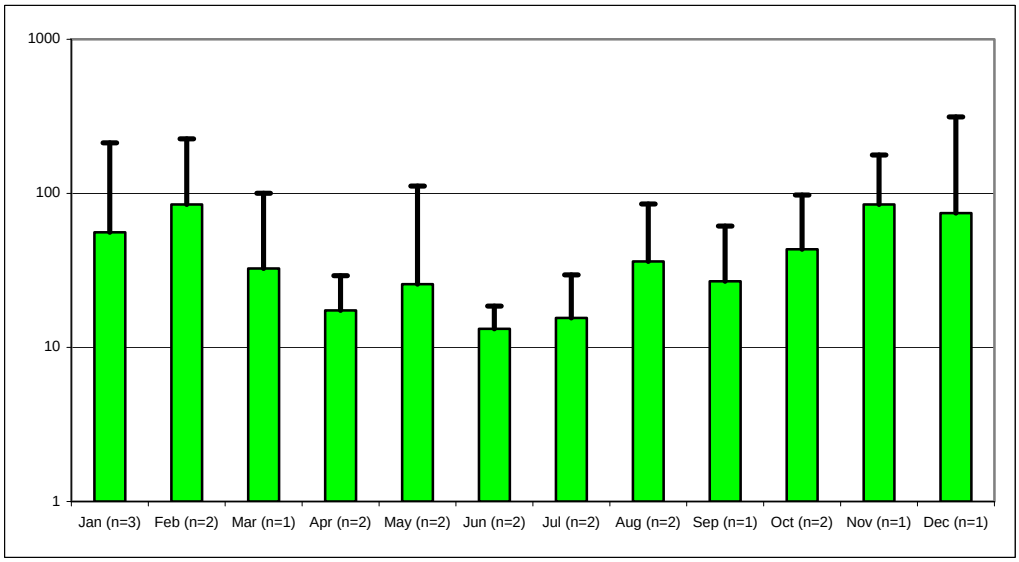

Figure 11.9 Geometric mean *E. coli* result for South of Houss Holm mussels by month

Sample numbers for Figures 11.7 and 11.8 were low making interpretation difficult. For South Voe, oyster results appeared to be higher between June and November. Four South of Houss Holm, there is no apparent pattern in oyster results, and mussel results were higher between November and February.

For statistical evaluation, seasons were split into spring (March - May), summer (June - August), autumn (September - November) and winter (December - February).

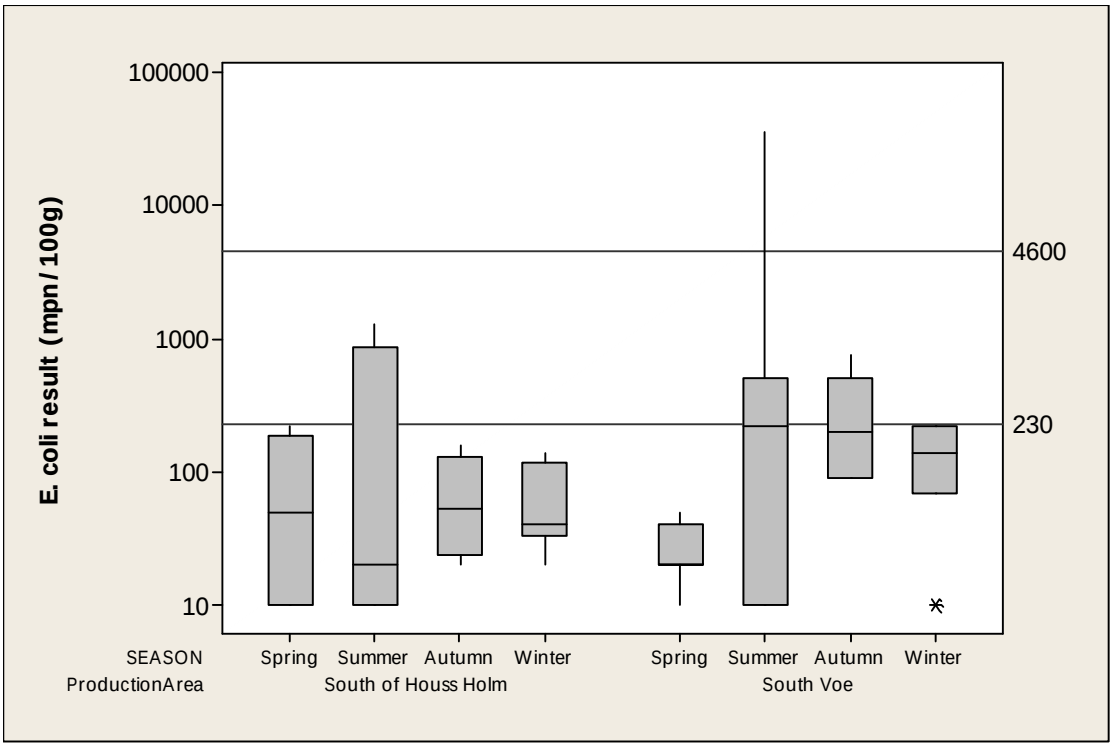

Figure 11.10 Boxplot of result by season (oysters)

A significant difference was found between results by season for South Voe oysters (One-way ANOVA, p=0.039, Appendix 4). A post ANOVA test (Tukeys comparison, Appendix 6) indicated that results for the autumn were significantly higher than those in the spring. No significant difference was found between results by season for South of Houss Holm oysters (One-way ANOVA, p=0.993, Appendix 6). However, it is interesting to note that the box range for summer results is very similar between the two sites, and the highest results at South Voe would have occurred during this period. While there may not have been a statistically significant difference between results obtained during spring and summer at South Voe, it is the graph in Figure 10.1 shows that higher levels of contamination may be present during the summer at this site.

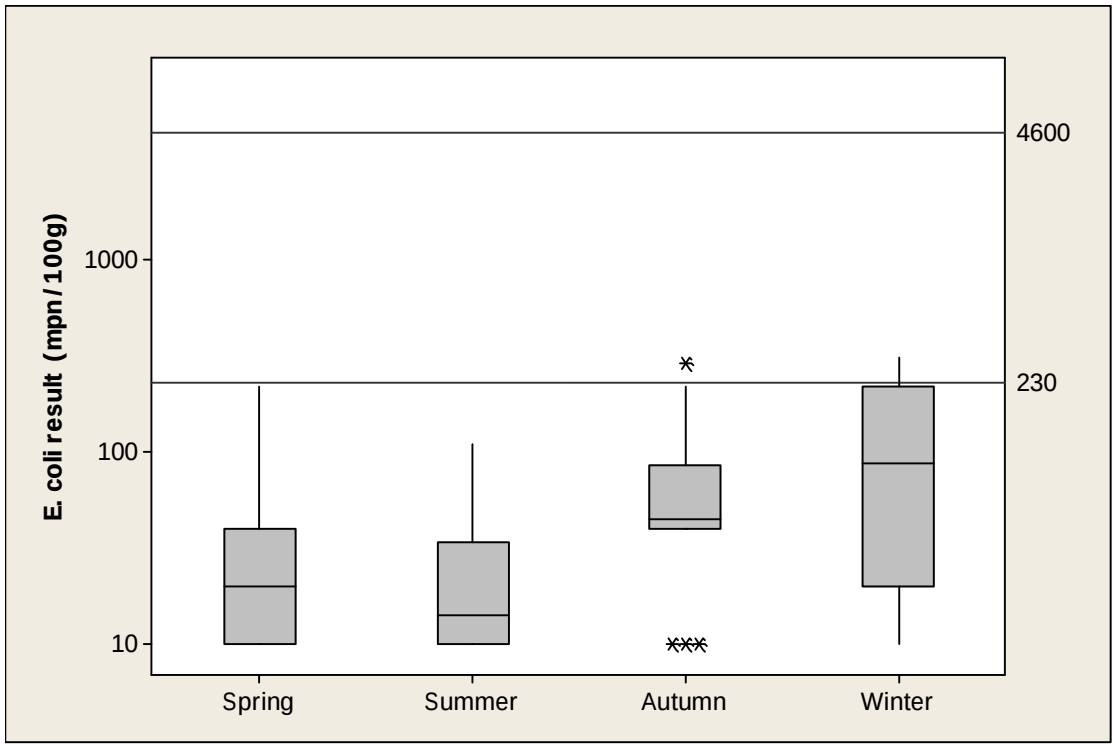

Figure 11.11 Boxplot of result by season (South of Houss Holm mussels)

A significant difference was found between results by season for South of Houss Holm mussels (One-way ANOVA, p=0.003, Appendix 6). A post ANOVA test (Tukeys comparison, Appendix 6) indicated that results for the winter were significantly higher than those in the spring and summer.

11.6 Analysis of results against environmental factors

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

11.6.1 Analysis of results by recent rainfall

The nearest weather station is Lerwick, approximately 8 km to the north east of the production areas. Rainfall data was purchased from the Meteorological Office for the period 1/1/2003 to 31/12/2007 (total daily rainfall in mm). Figure 11.13 and 11.14 present a scatterplots of oyster and mussel *E. coli* results respectively against 2 day rainfall. Spearmans rank correlations were carried out between rainfall and microbiological data.

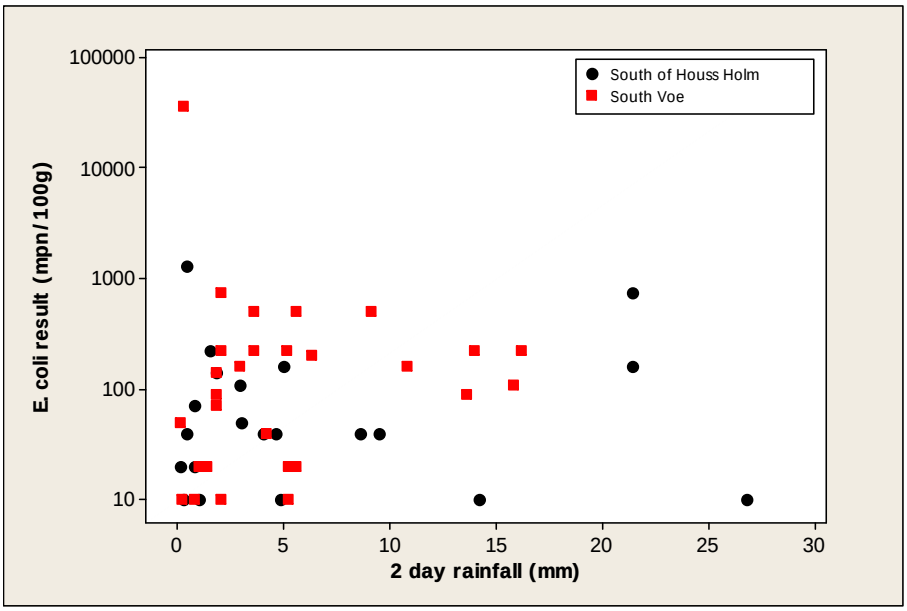

Figure 11.12 Scatterplot of result against rainfall in previous 2 days (oysters)

No correlation was found between the *E. coli* result and the rainfall in the previous two days either for South Voe oysters (Spearmans Rank correlation=0.306, p=0.113, Appendix 6) or for South of Houss Holm oysters (Spearmans Rank correlation=0.042, p=0.857, Appendix 6).

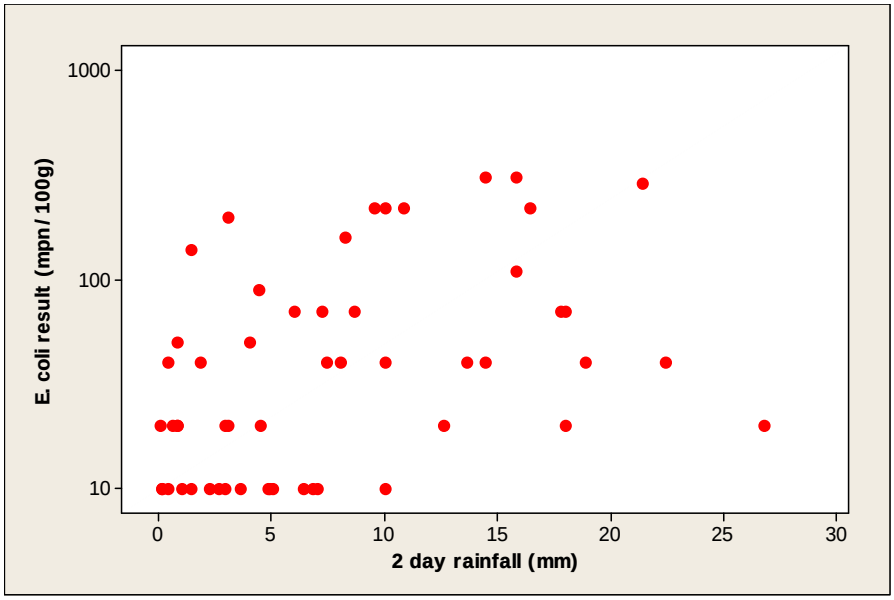

Figure 11.13 Scatterplot of result against rainfall in previous 2 days (South of Houss Holm mussels)

A positive correlation was found between the *E. coli* result and the rainfall in the previous two days for South of Houss Holm mussels (Spearmans Rank correlation=0.478, p=0.000, Appendix 6)

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

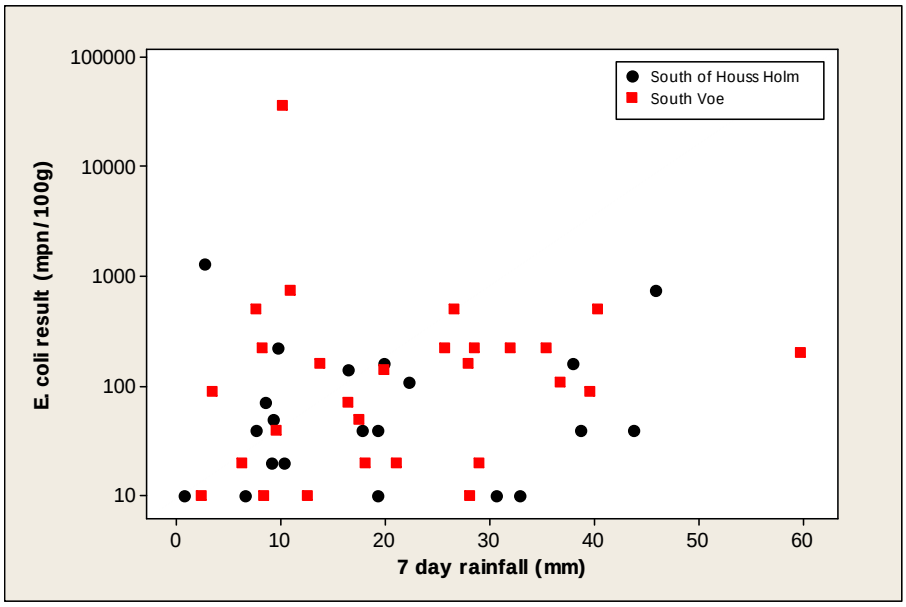

Figure 11.14 Scatterplot of result against rainfall in previous 7 days (oysters)

No correlation was found between the *E. coli* result and the rainfall in the previous seven days either for South Voe oysters (Spearmans Rank correlation=0.217, p=0.267, Appendix 6) or for South of Houss Holm oysters (Spearmans Rank correlation=0.114, p=0.623, Appendix 6).

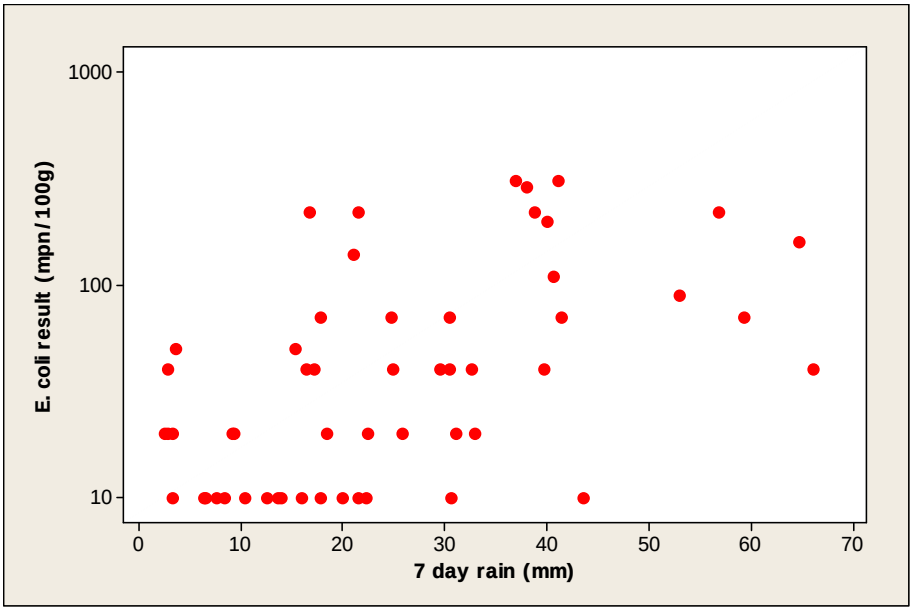

Figure 11.15 Scatterplot of result against rainfall in previous 7 days (South of Houss Holm mussels)

A positive correlation was found between the *E. coli* result and the rainfall in the previous two days for South of Houss Holm mussels (Spearmans Rank correlation=0.533, p=0.000, Appendix 6)

11.6.2 Analysis of results by tide height and state

When the larger (spring) tides occur every two weeks, circulation of water and particle transport distances will increase, and more of the shoreline will be covered

at high water, potentially washing more faecal contamination from livestock into the production area. Figure 11.16 and 11.17 present scatterplots of *E. coli* results by predicted height of the previous high water at Scalloway for oysters and mussels respectively (predictions from TotalTide tidal prediction software). It should be noted that local meteorological conditions such as wind strength and direction can influence the height of tides and this is not taken into account.

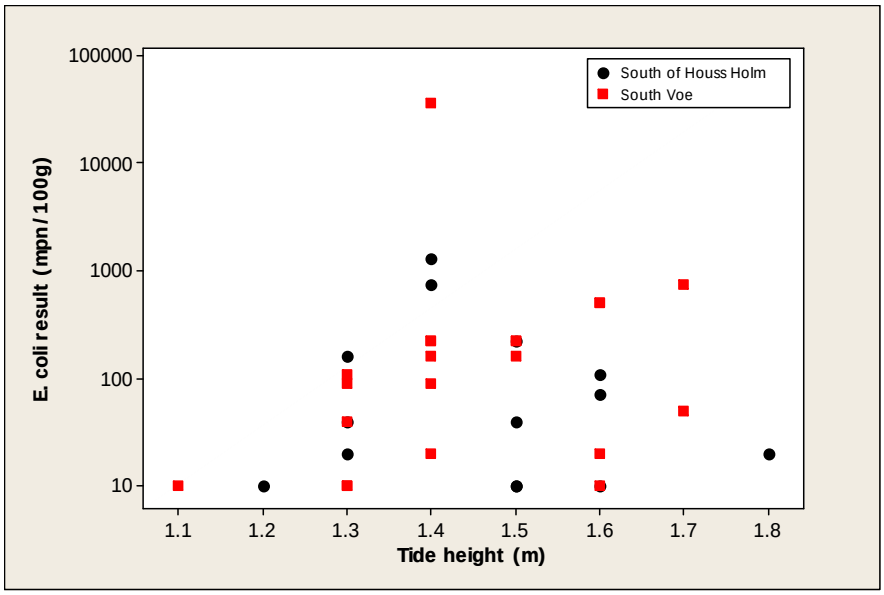

Figure 11.16 Scatterplot of result by tide height (oysters)

The coefficient of determination indicates that there was no relationship between the *E. coli* result and predicted height of the previous tide for oysters at either South Voe (Adjusted R-sq=3.0%, p=0.218, Appendix 6) or South of Houss Holm (Adjusted R-sq=0.0%, p=0.682, Appendix 6).

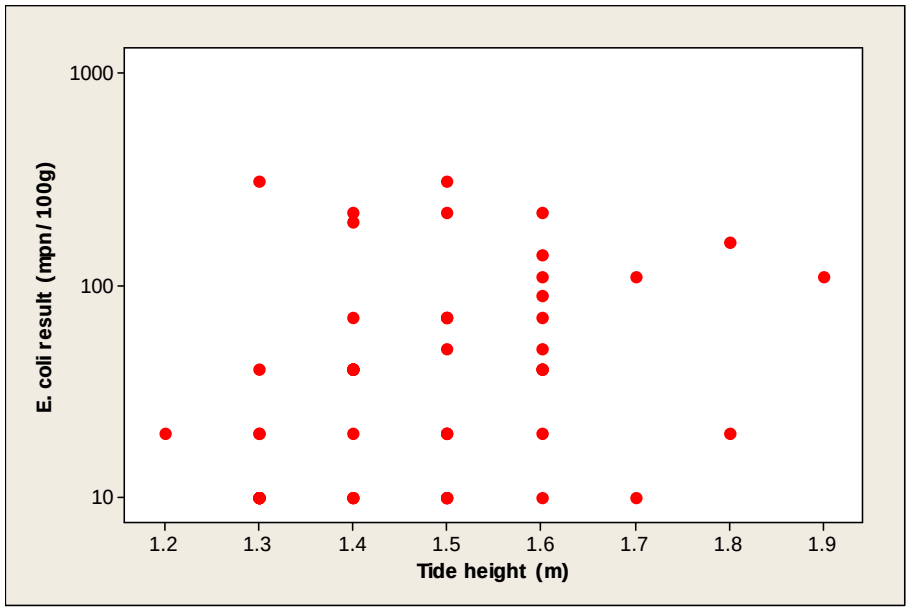

Figure 11.17. Scatterplot of result by tide height (South of Houss Holm mussels)

The coefficient of determination indicates that there was a weak positive relationship between the *E. coli* result and predicted height of the previous tide

(Adjusted R-sq=10.4%, p=0.010, Appendix 6), indicating that faecal contamination levels found in mussels from this site tended to be higher at spring tides than at neap tides.

Direction and strength of flow around the production areas will change according to tidal state on the (twice daily) high/low cycle, and, depending on the location of sources of contamination, this may result in marked changes in water quality in the vicinity of the farms during this cycle. As *E. coli* levels in shellfish can respond within a few hours or less to changes in *E. coli* levels in water, tidal state at time of sampling (hours post high water) was compared with *E. coli* results.

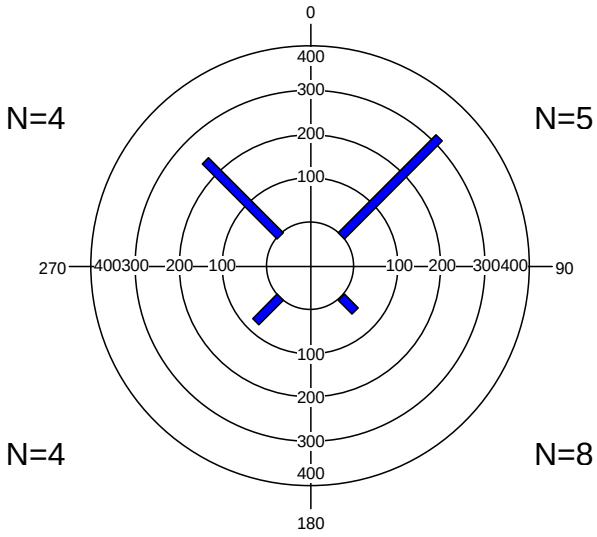

Figure 11.18 Circular histogram of geometric mean *E. coli* result tidal state (South Voe oysters). High water is at 0 degrees, low water is at 180 degrees.

A significant correlation was found between tidal state and *E. coli* result for South Voe oysters (circular-linear correlation, r=0.408, p=0.049, Appendix 6). Results were higher before and after high water.

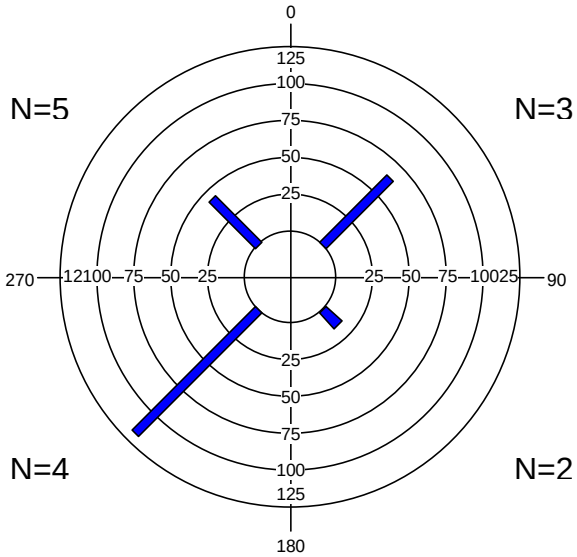

Figure 11.19 Circular histogram of geometric mean *E. coli* result by tidal state (South of Houss Holm oysters) High water is at 0 degrees, low water is at 180 degrees.

No significant correlation was found between tidal state and *E. coli* result for South of Houss Holm oysters (circular-linear correlation, r=0.484, p=0.073, Appendix 6).

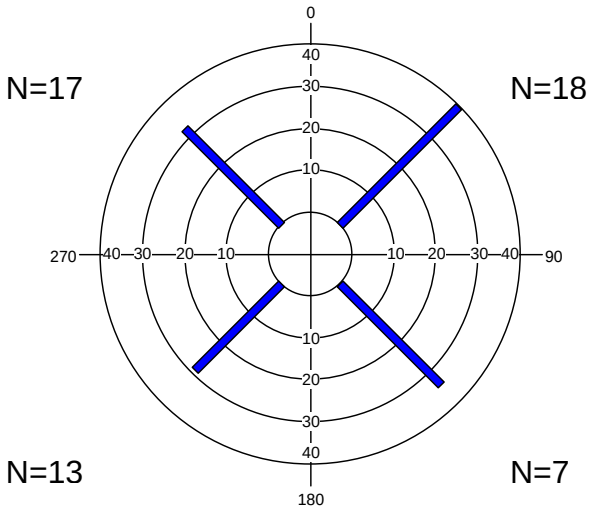

Figure 11.20 Circular histogram of geometric mean *E. coli* result by tidal state (South of Houss Holm mussels) High water is at 0 degrees, low water is at 180 degrees.

No significant correlation was found between tidal state and *E. coli* result for South of Houss Holm mussels (circular-linear correlation, r=0.029, p=0.957, Appendix 6).

Overall, tide height does not appear to have an influence on result for oysters at either site, but a weak positive relationship between results and tide height was found for mussels at South of Houss Holm. This may be a consequence of their location in relation to contamination sources. The mussel farm lies near to a small island where seals were observed by the harvester. Tidal currents in the area are likely to be relatively weak, but spring tides will result in increased particle transport distances so the shellfish would be exposed to contamination originating from sources which are further away during spring tides

A correlation between tidal state (high/low/ebb/flood) at time of sampling was found for South Voe oysters only, with mean results highest around high water. No correlation was found for either species in South of Houss Holm.

11.6.3 Analysis of results by water temperature

Water temperature is likely to affect the survival time of bacteria in seawater (Burkhardt *et al*, 2000) and the feeding and elimination rates of shellfish and therefore may be an important predictor of *E. coli* levels in shellfish flesh. It is of course closely related to season, and so any correlation between temperatures and *E. coli* levels in shellfish flesh may not be directly attributable to temperature, but to other factors such as seasonal differences in livestock grazing patterns. However, water temperature was only recorded for 15 of the 115 samples considered here, so a comparison with the *E. coli* results was not possible.

11.6.4 Analysis of results by wind direction

Wind speed and direction are likely to change water circulation patterns in the production area. Mean wind direction for the 7 days prior to each sample being collected was calculated from wind data recorded at the Lerwick weather station, and geometric mean result by mean wind direction in the previous 7 days is plotted in Figure 11.21 to 11.23 for South Voe oysters, South of Houss Holm oysters and South of Houss Holm mussels respectively.

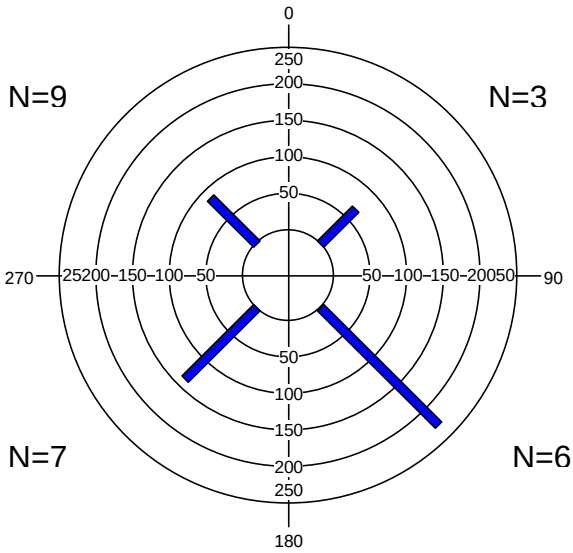

Figure 11.21 Circular histogram of geometric mean *E. coli* result by wind direction (South Voe oysters)

No significant correlation was found between wind direction and *E. coli* result for South Voe oysters (circular-linear correlation, r=0.133, p=0.679, Appendix 6).

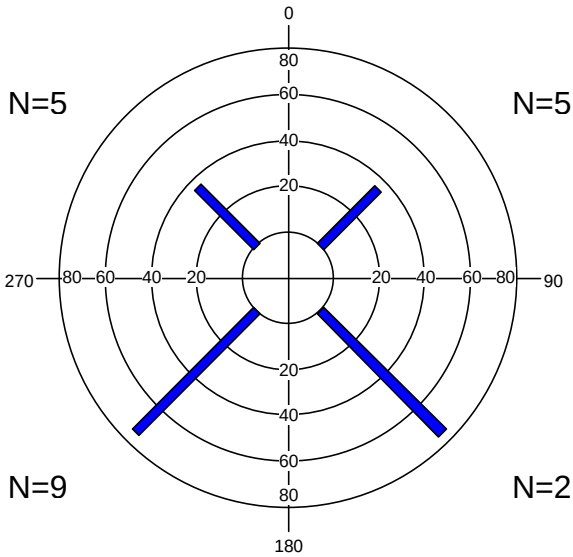

Figure 11.22 Circular histogram of geometric mean *E. coli* result by wind direction (South of Houss Holm oysters)

No significant correlation was found between wind direction and *E. coli* result for South of Houss Holm oysters (circular-linear correlation, r=0.176, p=0.572, Appendix 6).

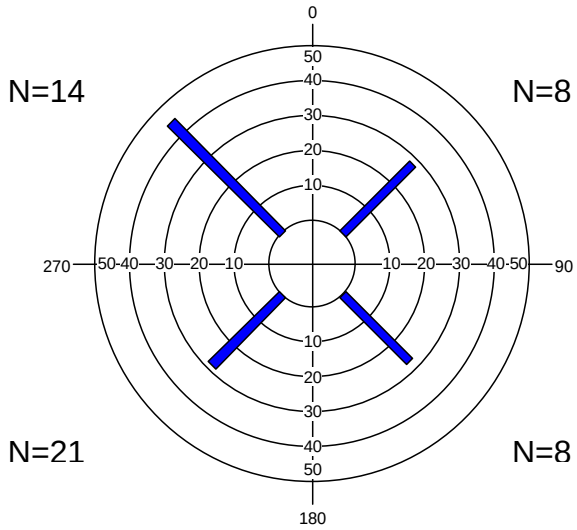

Figure 11.23 Circular histogram of geometric mean *E. coli* result by wind direction (South of Houss Holm mussels)

No significant correlation was found between wind direction and *E. coli* result for South of Houss Holm mussels (circular-linear correlation, r=0.174, p=0.232, Appendix 6).

11.7 Evaluation of peak results

One result of over 4600 *E. coli* MPN/100g was reported for an oyster sample collected in June 2004 from South Voe. Two results of over 1000 *E. coli* MPN/100g were reported, one of which was an oyster samples and the other was a mussel sample, both from South of Houss Holm. The oyster sample was collected in July and the mussel sample in August. They were all taken shortly before or after high water, under varying meteorological conditions.

Table 11.3 Historic *E. coli* sampling results over 1000 MPN/100g

Collection date	*E. coli* result (MPN/100g)	Production area	Location sampled	Species	2 day rain quartile	7 day rain quartile	7 day wind direction	Previous tide height	Time since high water
21/06/04	>18000	South Voe	HU372320	Oysters	Q1	Q1	341º	1.4	11:46
21/08/06	1300	South of Houss Holm	HU375315	Oysters	Q1	Q1	51º	1.4	00:35
17/09/07	1100	South of Houss Holm	HU372320	Mussels	Q4	Q4	280º	1.5	10:45

11.8 Summary and conclusions

The geometric mean result was higher in the South Voe production area than in South of Houss Holm for both shellfish species, but this difference was not found to be statistically significant for either oysters or mussels. The highest individual results for both species came from South Voe. South Voe also had the highest

proportion of results over 230 *E. coli* MPN/100g for both species but sample numbers were too small to permit testing for statistical significance.

No obvious long-term temporal patterns were seen in either species between 2002 and 2007.

A significant difference was found between results by season for South Voe oysters with results for the autumn found to be significantly higher than those in the spring. No significant difference was found between results by season for South of Houss Holm oysters. A significant difference was found between results by season for South of Houss Holm mussels, with results for the winter significantly higher than those in the spring and summer. This correlates well with the higher mean monthly rainfall recorded during the winter months and seems to indicate that faecal contamination may be reaching this area via rainfall runoff.

A weak but statistically significant positive relationship was found between *E. coli* results for South of Houss Holm mussels and rainfall recorded in both the previous 2 days and 7 days prior to sampling. This confirms that rainfall-dependent runoff is correlated with contamination levels observed at the shellfish farm, and suggests that diffuse pollution is the most likely source of contamination here.

No relationship between rainfall in the previous 2 or 7 days and *E. coli* result was found for oysters from either production area.

Analysis of whether monitoring results were correlated with the Spring/Neap tidal cycle uncovered a weak, but statistically significant positive relationship between *E. coli* results for mussels from South of Houss Holm and the height of the previous tide. This suggests that either the higher tide could be washing more faecal contamination into the voe from the shoreline or that the stronger currents associated with spring tides are transporting contaminants from further away to the waters around the mussel farm.

No relationship between the height of previous tide and *E. coli* result was found for oysters from either production area.

A weak correlation between state of tide (high/low/ebb/flood) for South Voe oysters only, with results being higher around the time of high water. The reasons for this are unclear. As this oyster farm was no longer in production at the time of shoreline survey it was not possible to record exactly where the farm was located, which may have given an indication as to why this might be.

No correlation between *E. coli* levels and wind direction was found for any of the site/species combinations.

It should be noted that the relatively small amount of data precluded the assessment of the effect of interactions between environmental factors on the *E. coli* concentrations in shellfish.

11.9 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 either species at the South Voe area as they have both held seasonal classifications in the last three years.

South of Houss Holm is currently classified as an A for both oysters and mussels. For mussels, the geometric mean *E. coli* result for the 3 years to the end of 2007 was 33.8 MPN/100g (31 samples), which is over the maximum threshold geometric mean of 13 MPN/100 g for bimonthly sampling. For oysters, sampling only started in 2006, so it cannot be considered for bimonthly sampling until the end of 2008.

12. Designated Shellfish Growing Waters Data

The South Voe and South of Houss Holm production areas do not fall within any designated Shellfish Growing Waters.

13. River Flow

There are no river gauging stations on rivers or burns along the South Voe coastline. A number of streams would flow into the sea within the production areas, however at the time of shoreline survey the weather had been dry and so few were running sufficiently to measure or sample. In most cases, it was necessary to collect a seawater sample near where the streams would have entered the voe in order to capture any contamination present.

The following streams were measured and sampled during the shoreline survey.

Table 13.1 Stream loadings for South Voe

Date	No	Grid Reference	Description	Width (m)	Depth (m)	Flow (m/s)	Flow (m^3/day)	*E.coli* (cfu/ 100 ml)	Loading (*E.coli* per day)
13/08/08	1a	HU 37462 32857	Stream	0.20	0.04	0.033	23	TNTC	*
28/08/08	1b	HU 37369 32908	Stream	0.22	0.08	0.017	26	350	9.0×10^7
13/08/08	2a	HU 37168 33161	Stream	1.0	0.06	0.08	415	Invalid	-
28/08/08	2b	HU 37166 33160	Stream not flowing	-	-	-	-	-	-

* Not calculated

Due to problems with contaminated media at the laboratory on 13 August, no *E. coli* count was reported for the sample taken from stream 2. As the result for stream 1 was TNTC, the site was revisited for sampling a second time on 28 August 2008. On that date, stream 1 was remeasured and sampled, however stream 2 was found to be dry so a seawater sample was taken instead.

A number of wet areas where water had been seeping onto the shoreline were observed, indicating that during wet periods there may be more land runoff flowing into the voe than was observed at the time of shoreline survey. As sheep and other livestock were present on land around the voe, it is anticipated that any rainfall runoff from land may carry significant concentrations of faecal bacteria from these sources into the voe.

The majority of the drainage ditches and small streams observed were located along the eastern shore of the South Voe production area. These would be expected to have a greater impact on the mussel farm at South Voe and at the oyster raft at Houss than at the South of Houss Holm mussel farm. As so little data was available regarding flow and water quality of streams in the area, the results of those water samples that were collected and analysed as part of the shoreline survey are also presented in Figure 13.1 together with the locations of the measured streams. The only fresh water samples were those associated with the measured streams in Table 13.1, all other samples were of seawater. Further details can be found in Appendix 8, Shoreline Survey Report, Tables 1 and 2.

Highest levels of *E. coli* contamination were observed around the vicinity of Papil, where a number of untreated or sewage discharges were observed. In addition, high levels of contamination were also found in seawater near observed septic tank discharge pipes at the head of the voe and along the eastern shoreline, with a

particularly high result near the oyster farm at Houss, where a septic pipe was observed discharging within 100 m of the oyster raft.

Freshwater flow, and hence the amount of contaminated surface runoff, is anticipated to be higher in winter when more rainfall is recorded though episodes of contamination may occur after a heavy rainfall at any time of year.

Figure 13.1 Streams and seawater samples at South Voe

14. Bathymetry and Hydrodynamics

Figure 14.1 South Voe

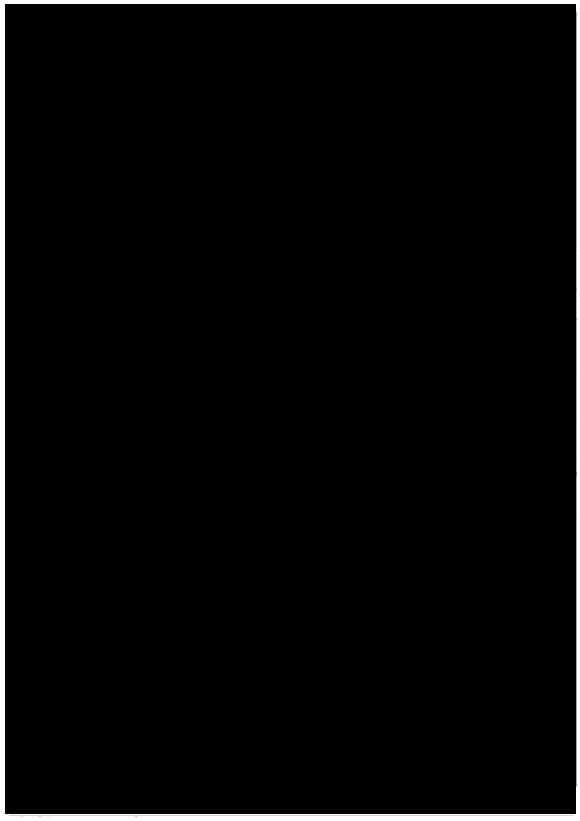

Figure 14.2 Bathymetry of South Voe

The chart above shows that the depth of the water in South Voe and the South of Houss Holm is less than 10 m. The depth of the channel between the two islands begins to increase south of the South of Houss Holm production area.

Tidal Curve and Description

The two tidal curves below are for Scalloway. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 GMT on 11/08/08 and the second is for seven days beginning 00.00 GMT on 19/08/08. This two-week period covers the date of the shoreline survey. Together they show the predicted tidal heights over high/low water for a full neap/spring tidal cycle.

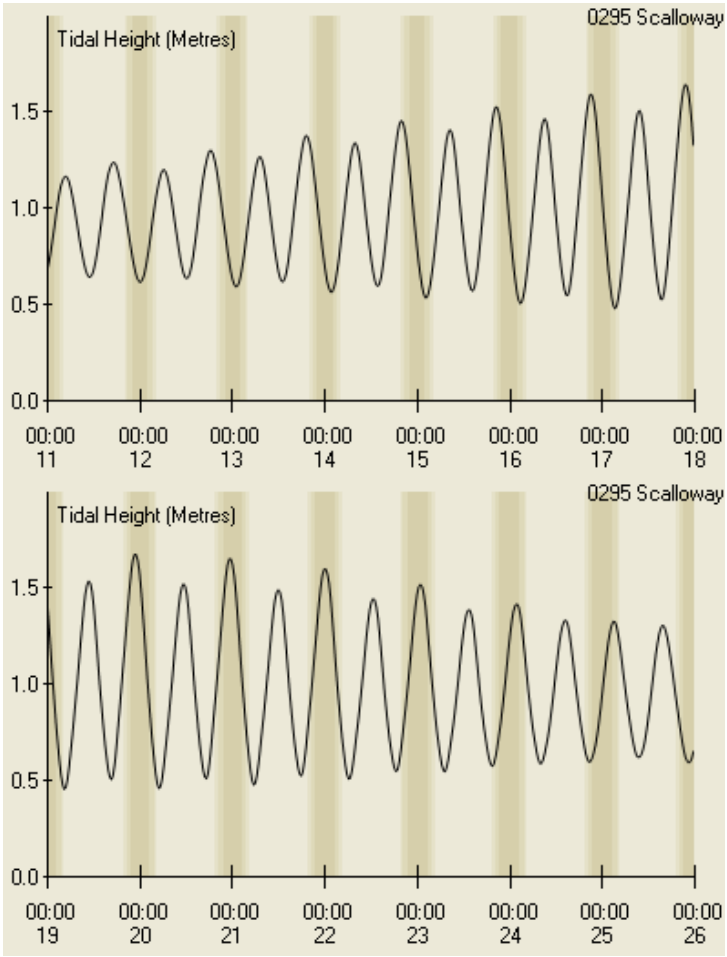

Figure 14.3 Tidal curves for Scalloway

The following is the summary description for Scalloway from TotalTide:

Scalloway is a Secondary Non-Harmonic port. The tide type is Semi-Diurnal. Predicted heights are in metres above Chart Datum.

MHWS	1.6 m
MHWN	1.3 m
MLWN	0.6 m
MLWS	0.5 m

The tidal range at spring tide is therefore approximately 1.1 m and at neap tide 0.7 m.

There was no information available on this water body in the Scottish Sea Loch Catalog (Edwards & Sharples, 1991).

Currents

No tidal diamond information was available for this water body. Currents in coastal waters are driven by a combination of tide, wind and freshwater inputs. The following constitutes a simple assessment of water movements around the area.

Tidal flows in the area are expected to be relatively weak as the tidal range is limited. Water flows between South Voe and Lang Sound at Bridge End and so contaminants from the septic tank at Toogs may at least part of the time be transported south into the head of South Voe. It is not known what percentage of the time this flows in either direction.

Wind-driven flows are likely to affect circulation and mixing within the voe. The upper end of the voe is relatively sheltered from all directions: the Holm of Papil and the Holm of Houss would provide some protection from the south and all other sides of the voe are protected by land. It is likely that winds will tend to be funnelled north and south along the voe due to the local topography. Water circulation patterns are likely to be significantly affected by the islands and headlands found at Papil and Houss. During the shoreline survey, water close to shore was observed flowing opposite to the predominant tidal flow indicating that near shore flows may lag behind the main tidal flow and may be complicated by other morphological features.

Water depths are very shallow, with depths over the majority of the area less than 5 metres. As a result, there is limited opportunity for dilution to take place. The water body is very narrow, particularly in the few kilometres at the head of the voe so it is likely that even small discharges here could impact the entire width of the voe.

Further south, the voe opens up and there is more opportunity for both wind driven mixing and dilution of contaminants.

15. Shoreline Survey Overview

The sanitary survey at South Voe and South Houss of Holm was carried out in response to an application to change production in South Voe from Pacific oysters to common mussels.

The shoreline survey was conducted on the 12-14th August, with a revisit for additional sample collections occurring on 28th August 2008.

The South Voe production area now consists of one mussel farm of three long-lines. The harvester has now discontinued oyster production at South Voe. The Houss Holm production area consists of one oyster raft at Houss. A long line mussel farm is located to the south of the oyster raft at South of Houss Holm. Stock is harvested at any time of year there is demand and sufficient stock to warrant harvest. The mussels are harvested in rotation within each farm. The oysters have been on site for approximately 5 years and have not yet been harvested.

One sewage discharge was identified by SW to the north at Toogs. A number of private discharges were observed along the shoreline of South Voe. The majority were located along the western shoreline, with a number of discharges observed at or near Papil and Bridge End. At Bridge End, a toilet block associated with the outdoor centre discharges directly to the voe on the eastern side of the centre. Toilets are used by campers, student groups and other visitors at the centre. A series of 8 probable discharge pipes were observed along the shore west of the marina. It is not known whether all are septic discharges and/or currently in use. At Papil, active discharges were observed on either side of a wooden pier. There was a notable odour of sewage. Two of these were observed actively discharging at the time of survey. A further three discharges were observed along the beach south of Papil and a strong sewage odour was noted. At one of these, solid waste was observed. There were also few septic tank discharge pipes observed along the eastern shoreline. One of these discharge pipes discharged to within approximately 50 metres of the oyster raft at Houss.

There are several significant settlements in the vicinity of both production areas. The land surrounding these settlements is grassland and improved pasture used for grazing livestock. A pony stud was located on the shores of the fresh water loch that discharges into the western side of South Voe, at the south end of the beach near Papil. A variety of livestock including cattle, a large number of sheep, goats, horses, ponies and domestic fowl were observed during the shoreline walk. In some areas, such as near Houlls, animals were kept at the shoreline.

Approximately 12 seals were seen basking and in the water around an island to the south of the production area. Rabbits were seen in most fields and rabbit droppings were readily apparent where the grass was short. There were small (<20 individuals) congregations of shorebirds were observed moving about the area, but no large congregations were found. The cliffs near the mouth of the voe are used by nesting Northern Fulmars in the summer season.

The voe is shallow, restricting access to only small boats with shallow draft. Seven small work boats were observed on moorings on the west side of the voe and a marina for boats of less than approximately 10 metres in length was located at the head of the voe near the Outdoor Centre. On the day of survey there were 25 boats present, with 3 slips empty.

Seawater samples varied from 1 to TNTC *E. coli* (cfu/100ml). There were twelve seawater samples with results higher than 200 *E. coli* (cfu/100ml). The majority of these were located around the Papil headland with the remaining on the eastern coastline of East Burra adjacent to the South Voe production area.

An oyster sample was taken from the Houss trestle, giving a result of <20 E. coli (MPN/100g). Six common mussel samples were taken from the South Houss of Holm long lines and presented results between <20 and 220 *E. coli* (MPN/100g). Three mussel samples were taken from the South Voe long lines and provided results of 20, 80 and 80 E. coli (MPN/100g).

Few streams were actively flowing during the time of survey. Two streams were flowing sufficiently to measure. One was located on the northwest shore of the voe near Bridge End, though on the revisit it was not flowing sufficiently to sample directly so a seawater sample was taken at the point of its discharge. The second stream was along the eastern shoreline, a bit over 0.2 km south of the Bridge End outdoor centre. This was flowing on both days, as the first sample did not provide a quantitative result had to be resampled and remeasured on the second visit.

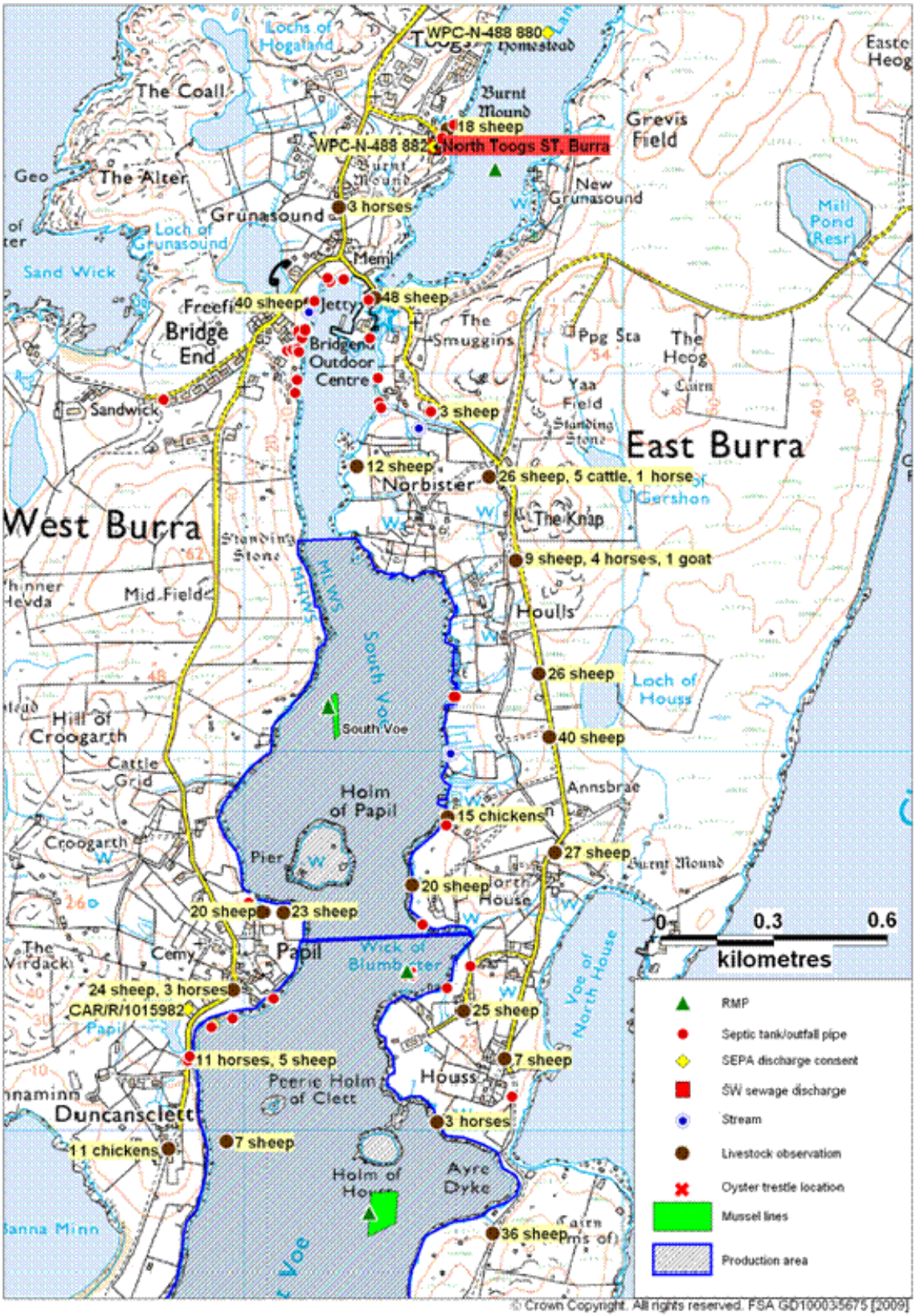

Figure 15.1 Summary of shoreline observations

16. Overall Assessment

Human sewage impacts

Significant impact from human sewage was found around the voe. The marina, Bridge End outdoor centre and other homes all discharge to the top end of South Voe. While the septic tank at North Toogs discharges to Lang Sound, Lang Sound is connected to South Voe via a narrow opening at Bridge End and so could also affect water quality at the top of the voe depending upon the state of tide.

As there is no community septic system south of Bridge End, the homes located along the remainder of the voe have either septic tanks or raw discharges to the voe. A number of these were observed at Papil during the shoreline survey and water samples confirmed high concentrations of faecal bacteria in the vicinity. Further private septic tank outfall was observed on the eastern shore of the voe, with one discharging within 100 m of the oyster raft at Houss. Norovirus testing confirmed the impact of human faecal contamination on the oyster farm here.

The South Voe mussel farm and the Houss oyster raft appeared to be the more significantly impacted by these than the mussel farm at South of Houss Holm.

Agricultural impacts

Agricultural census data for 2008 identified that sheep are predominantly kept within the two parishes bordering on the production areas. The shoreline survey confirmed that there was extensive sheep grazing in the area. Animals were mainly seen along the eastern shore of the Voe and in the vicinity of Papil, on the western shore of the voe. Livestock observations at these locations relate only to the date of shoreline survey, and it is probable that the sheep graze throughout this area. Contamination of livestock origin will mostly be carried to the production areas either via direct runoff from land immediately bordering the voe or via the streams draining the surrounding land.

Small streams were found predominantly along the eastern shore of the voe, and the Loch of Papil would also collect runoff from surrounding pasture which would then be discharged into the voe to the northwest of the mussel farm at South of Houss Holm. Overall numbers of livestock will increase in late spring following the birth of lambs, and decrease from the autumn as animals are sent to market leading to a seasonal increase in deposition of faecal matter during the summer and potentially higher levels of contamination when rainfall increases in early autumn and begins to wash these deposits into streams and watercourses. Due to the small size of the voe, these impacts are likely to affect all of the shellfish farms relatively equally.

Wildlife impacts

Seals are present in relatively large numbers (up to 30 or more) near the South of Houss Holm mussel farm. It is likely that some amount of seal faeces may impact the farm depending on how much time they spend in or near the mussel lines. Seals will forage widely for food so it is likely they will feed near all the shellfish

farms at some point in time. As they are highly mobile, it is likely that any impact will be limited and unpredictable.

Seasonal variation

An outdoor education centre is located at the head of the voe, and this is likely to be used more heavily during the summer months. As a toilet block associated with this centre discharges directly to the voe it can be expected that when this is in use it will negatively impact water quality at the head of the voe. Livestock numbers in the area will be higher in the summer, so contamination from livestock sources may also be expected to be higher during the summer and early autumn, though this may be partially dependent upon rainfall for deposition into watercourses.

The marina at the head of the voe is likely to receive heavier use during the summer, though many of the boats may not be large enough to have marine toilets on board and so may not significantly impact water quality in the upper voe.

Rivers and streams

The catchment area for these production areas is very small, so overall direct freshwater inputs are low. The only stream successfully measured and sampled did contain significant concentrations of faecal bacteria (350 *E. coli* / 100 ml). It could be expected that given the numbers of livestock in the area, when streams are running they may carry a similar or possibly higher loading. The impact from these would be most acute along the eastern shore of South Voe, which would likely affect the Houss oyster farm and South Voe mussel farm the most, as they are nearer than the mussel farm at South of Houss Holm.

Meteorology, hydrology, and movement of contaminants

In Shetland generally, the weather is both wetter and windier in autumn and winter. Prevailing winds are from the south west.

Investigation of the interrelation between historical monitoring results and environmental factors indicated that for the mussel farm at South of Houss Holm, higher E. coli monitoring results were significantly correlated with the winter season, higher rainfall, and spring tides. This seems to indicate that diffuse sources of faecal contamination may be more significant than point sources in this area.

Temporal and geographical patterns of sampling results

Sampling results indicate that contamination levels are higher in South Voe than in West Voe.

17. Recommendations

South Voe

Based on the location of human sewage discharges at the head of the voe and around the settlement of Papil, it is recommended that the production area for South Voe mussels be curtailed to exclude as much as possible of the voe to the north and south of the mussel farm. Contamination to this site is likely from discharges to the north and south of the identified shellfish farm and contamination is likely to be higher outside the recommended production area boundaries. For this reason, the boundaries have been restated to tightly bracket the current lease and farm. The recommended revised boundaries for the South Voe production area are as listed in Table 17.1.

Table 17.1 Recommended boundary and RMP for South Voe mussels, SI 421 825 08

Existing Boundary	Existing RMP	Recommended Boundary	Recommended RMP
Area within lines drawn between HU 3715 3150 to HU 3760 3152 and HU 3715 3260 to HU 3724 3260	HU 372 320	Area bounded by lines drawn between HU 3718 3244 to HU 3735 3248 to HU 3734 3200 to HU 3706 3200 extending to MHWS	HU 3724 3205

It is recommended that the RMP be moved to HU 3724 3205, on the southern boundary of the existing mussel farm. This lies nearest the closest source of significant faecal contamination, the untreated sewage discharges near the pier at Papil. A sampling tolerance of 20 meters is recommended to allow for movement of the mussel lines.

The recommended sampling depth is 3 m, as pollutants are likely to be well mixed and there may be higher die-off of bacteria near the surface due to UV light penetration.

Currently, results for South Voe are reported under SI 264 445 08, though the classification application was filed under SI 421 825 08. The SIN applied to the application for mussels is used for this recommended area.

South of Houss Holm

The South of Houss Holm production area has far more sewage input at the northern end than at the southern end. The western side of the production area between Papil and Duncansclett should be declassified as there are untreated sewage discharges and an unofficial report of illness related to consumption on razor clams from this area. It is further recommended that the area be split into two separate production areas: Houss and South of Houss Holm.

Houss

The oyster raft at Houss, and the associated seabed lease, lie within 100 m of two private sewage discharges and the positive norovirus tests on Pacific oysters from this site confirm the presence of faecal contamination from human sources. The oyster farm and lease are covered in one production area, as described in Table 17.2 and represented in Figure 17.1. The boundaries were drawn to exclude those areas that lie closest to the sewage discharges. As the oyster raft here is small, it is recommended that the RMP be retained as that currently used by the local authority for sampling, HU 3743 3142. A sampling tolerance of 10 m is recommended as the raft is small and this will include most of it.

Table 17.2 Recommended boundary and RMP for Houss oysters, SI TBD

Existing Boundary	Existing RMP	Recommended Boundary	Recommended RMP
Area bounded by lines drawn between HU 3635 2980 and HU 3706 2980 and between HU 3715 3150 and HU 3760 3152	HU 375 315	Area bounded by lines drawn between HU 3716 3156 to HU 3750 5153 to HU 3751 3136 and between HU 3739 3134 and HU 3714 3144 extending to MHWS	HU 3743 3142

The recommended sampling depth is 3 m as this is the depth to which the oyster bags are hung and takes into consideration the comment for South Voe above.

South of Houss Holm

The South of Houss Holm mussel farm and associated seabed lease do not have any direct discharges of human sewage waste within 100 m. It is recommended that the northern extent of this production area be moved to exclude area between Duncansclett and Papil as well as the Peerie Holm of Clett, where seals are known to haulout. The southern extent of the production area is likely to have significantly lower levels of contamination from faecal bacteria than the northern end where the shellfish farm lies and so monitoring at the northern end of the production area will represent the most significant sources of contamination to the entire area. The southern boundary is therefore retained as originally described in the classification document.

Table 17.3 Recommended boundary and RMP for South of Houss Holm mussels, SI 261 739 08

Existing Boundary	Existing RMP	Recommended Boundary	Recommended RMP
Area bounded by lines drawn between HU 3635 2980 and HU 3706 2980 and between HU 3715 3150 and HU 3760 3152	HU 373 307	Area bounded by lines drawn between HU 3689 3100 to HU 3752 3100 and between HU 3708 2982 to HU 3635 2980 extending to MHWS	HU 3734 3083

It is recommended that the RMP be moved to HU 3734 3083, which lies within the north western corner of the shellfish farm, as this end of the farm is most likely to be impacted by any contamination coming from sewage discharges to the north. A

sampling tolerance of 20 m is recommended to allow for movement of the mussel lines. Recommendations are summarised in Table 17.3 below.

The recommended sampling depth is 3m for the same reasons given for the previous two production areas.

A map showing the relative locations of the revised production areas and RMPs can be found in Figure 17.1 below.

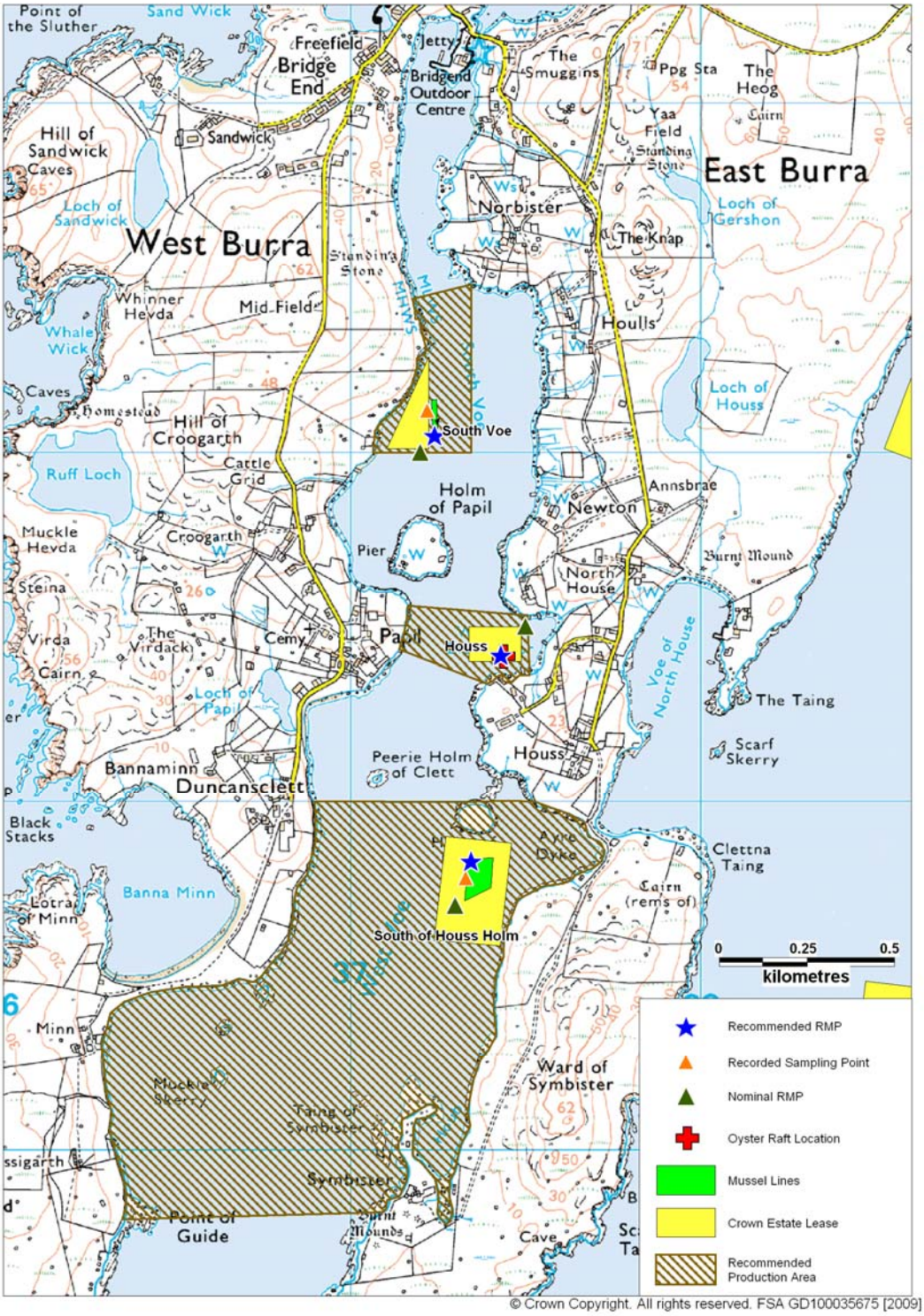

Figure 17.1 Recommended production areas and RMPs

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19. List of Tables and Figures

Tables

Figures

Appendices

1. **Sampling Plan**
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**
9. **Norovirus Testing Summary**

Sampling Plan for South Voe

PRODUC-TION AREA	SITE NAME	SIN	SP.	TYPE OF FISH-ERY	NGR OF RMP	EAST	NORTH	TOLER-ANCE (M)	DEPTH (M)	METHOD OF SAMPLING	FREQ OF SAMPLING	LOCAL AUTHORITY	AUTHORISED SAMPLER(S)	LOCAL AUTHORITY LIAISON OFFICER
South Voe	South Voe	SI 264 445 08	Common mussels	Long lines	HU 3724 3205	43724	113205	20 m	3 m	Hand	Monthly	Shetland Islands	Sean Williamson George Williamson Kathryn Winter Marion Slater	Dawn Manson
South of Houss Holm: Houss	Houss	SI 261 739 13	Pacific oyster	Raft	HU 3743 3142	43743	113142	10 m	3 m	Hand	Monthly	Shetland Islands	Sean Williamson George Williamson Kathryn Winter Marion Slater	Dawn Manson
South of Houss Holm	South of Houss Holm	SI 261 044 08	Common mussels	Long lines	HU 3734 3083	43734	113083	20 m	3 m	Hand	Monthly	Shetland Islands	Sean Williamson George Williamson Kathryn Winter Marion Slater	Dawn Manson

Table of Recommended Boundaries and RMPs –South Voe

Production Area	Species	SIN	Existing Boundary	Existing RMP	New Boundary	New RMP	Comments
South Voe	Mussels	SI 264 445 08	Area within lines drawn between HU 3715 3150 to HU 3760 3152 and HU 3715 3260 to HU 3724 3260	HU 372 320	Area bounded by lines drawn between HU 3718 3244 to HU 3735 3248 to HU 3734 3200 to HU 3706 3200 extending to MHWS	HU 3724 3205	Area curtailed to exclude more contaminated areas to the north, east and south.
South of Houss Holm: Houss	Pacific oysters	SI 261 739 13	Area bounded by lines drawn between HU 3635 2980 and HU 3706 2980 and between HU 3715 3150 and HU 3760 3152	HU 375 315	Area bounded by lines drawn between HU 3716 3156 to HU 3750 5153 to HU 3751 3136 and between HU 3739 3134 and HU 3714 3144 extending to MHWS	HU 3743 3142	New production area for oysters. Curtail to exclude pollution sources north and east of raft.
South of Houss Holm	Mussels	SI 261 044 08	Area bounded by lines drawn between HU 3635 2980 and HU 3706 2980 and between HU 3715 3150 and HU 3760 3152	HU 373 307	Area bounded by lines drawn between HU 3689 3100 to HU 3752 3100 and between HU 3708 2982 to HU 3635 2980 extending to MHWS	HU 3734 3083	Curtail northern boundary to exclude areas of higher contamination.

Geology and Soils Information

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

Seals

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*). Shetland hosts significant populations of both species.

Common seal surveys are conducted every 5 years and an estimate of minimum numbers is available through Scottish Natural Heritage. The Shetland-wide count in 2006 was 3021 harbour seals, though this was anticipated to be an underestimation of the total population (Sea Mammal Research Unit 2007).

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, although there are some breeding colonies in other areas including Shetland. Minimum pup production in Shetland was estimated as 943 in 2004. Adult numbers are estimated to be 3.5 times the pup population (Callan Duck, Sea Mammal Research Unit, personal communication).

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).

Whales and Dolphins

A variety of cetacean species are routinely observed near Shetland. During 2001-2002, there were confirmed sightings of the following species (Shetland Sea Mammal Group 2003):

Table 8.1 Cetacean sightings near Shetland by species.

Common name	**Scientific name**	**No. sighted***
Minke whale	*Balaenoptera acutorostrata*	28
Humpback whale	*Megaptera novaeangliae*	1
Sperm whale	*Physeter macrocephalus*	3
Killer whale	*Orcinus orca*	183
Long finned pilot whale	*Globicephala melas*	14
White-beaked dolphin	*Lagenorhynchus albirostris*	399
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	136
Striped dolphin	*Stenella coeruleoalba*	1
Risso's dolphin	*Grampus griseus*	145
Common dolphin	*Delphinus delphis*	6
Harbour porpoise	*Phocoena phocoena*	>500

*Numbers sighted are based on rough estimates based on reports received from various observers and whale watch groups.

Little is known about the volume or bacterial composition of cetacean faeces. As mammals, it can be safely assumed that their guts will contain an unknown concentration of normal commensal bacteria, including *Escherichia coli*. It is highly likely that cetaceans will be found from time to time in the area, although the larger species may not visit this area as it is fairly shallow. The impact of their presence is, as with pinnipeds, likely to be fleeting and unpredictable.

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 5km 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 x 10^5 faecal coliforms per faecal deposit and ring-billedgulls (*Larus delawarensis*) approximately 1.77 x 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 observed to 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 and birds are known to carry *Salmonella*.

Deer

No deer are found 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). 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 is subject to run into the water either due to rainfall or on the incoming tide. No information was found at the time of this report on the bacteriological content of otter faeces. However, given the total numbers present in Shetland and the foraging habits described above it is highly unlikely that otter faeces will be a significant source of contamination to the fishery.

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Tables of Typical Faecal Bacteria Concentrations

Summary of faecal coliform concentrations (cfu 100ml-1) for different treatment levels and individual types of sewage-related effluents under different flow conditions: geometric means (GMs), 95% confidence intervals (Cis), and results of t-tests comparing base- and high-flow GMs for each group and type.
Source: Kay, D. et al (2008) Faecal indicator organism concentrations in sewage and treated effluents. *Water Research* 42, 442-454.

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}		

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 *E. coli* results were log transformed prior to analysis.

Section 11.3 T-test comparison of oyster results by production area

```
Two-sample T for Logresult

ProductionArea        N   Mean  StDev  SE Mean
South of Houss Holm  21  1.718  0.610     0.13
South Voe            28  2.014  0.764     0.14

Difference = mu (South of Houss Holm) - mu (South Voe)
Estimate for difference:  -0.296
95% CI for difference:  (-0.691, 0.100)
T-Test of difference = 0 (vs not =): T-Value = -1.51  P-Value = 0.139  DF = 46
```

Section 11.3 T-test comparison of mussel E. coli results by production area

```
Two-sample T for Logresult

ProductionArea        N   Mean  StDev  SE Mean
South of Houss Holm  59  1.546  0.490    0.064
South Voe             7  1.835  0.824     0.31

Difference = mu (South of Houss Holm) - mu (South Voe)
Estimate for difference:  -0.290
95% CI for difference:  (-1.067, 0.488)
T-Test of difference = 0 (vs not =): T-Value = -0.91  P-Value = 0.397  DF = 6
```

Section 11.5 One-Way ANOVA comparison of *E. coli* result by season (South Voe oysters)

```
Source  DF      SS     MS     F      P
SEASON   3   4.569  1.523  3.26  0.039
Error   24  11.206  0.467
Total   27  15.775

S = 0.6833   R-Sq = 28.96%   R-Sq(adj) = 20.08%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level  N    Mean   StDev  ------+---------+---------+---------+---
1      7  1.3579  0.2298  (--------*--------)
2      7  2.3063  1.2002                  (-------*--------)
3      7  2.3838  0.3760                   (--------*--------)
4      7  2.0086  0.4828            (-------*--------)
                          ------+---------+---------+---------+---
                              1.20      1.80      2.40      3.00
Pooled StDev = 0.6833

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of SEASON

Individual confidence level = 98.90%

SEASON = 1 subtracted from:

SEASON    Lower  Center   Upper  ----+---------+---------+---------+-----
2       -0.0588  0.9484  1.9557               (---------*----------)
3        0.0187  1.0259  2.0332                (---------*---------)
4       -0.3566  0.6507  1.6579            (----------*---------)
                                 ----+---------+---------+---------+-----
                                  -1.0       0.0       1.0       2.0
```

```
SEASON = 2 subtracted from:

SEASON    Lower   Center   Upper  ----+---------+---------+---------+-----
3       -0.9298   0.0775  1.0847       (---------*---------)
4       -1.3050  -0.2978  0.7095   (---------*---------)
                                  ----+---------+---------+---------+-----
                                   -1.0       0.0       1.0       2.0
SEASON = 3 subtracted from:

SEASON    Lower   Center   Upper  ----+---------+---------+---------+-----
4       -1.3825  -0.3752  0.6320  (---------*---------)
                                  ----+---------+---------+---------+-----
                                   -1.0       0.0       1.0       2.0
```

Section 11.5 One-Way ANOVA comparison of *E. coli* result by season (South of Houss Holm oysters)

```
Source  DF     SS     MS     F      P
SEASON   3  0.039  0.013  0.03  0.993
Error   17  7.408  0.436
Total   20  7.447

S = 0.6601   R-Sq = 0.52%   R-Sq(adj) = 0.00%

                         Individual 95% CIs For Mean Based on
                         Pooled StDev
Level  N    Mean   StDev  ----+---------+---------+---------+-----
1      5  1.6491  0.6391  (--------------*---------------)
2      6  1.7652  0.9833      (-------------*-------------)
3      4  1.7381  0.3822  (-----------------*-----------------)
4      6  1.7158  0.3169     (-------------*-------------)
                         ----+---------+---------+---------+-----
                           1.20      1.60      2.00      2.40
Pooled StDev = 0.6601
```

Section 11.5 One-Way ANOVA comparison of *E. coli* result by season (South of Houss Holm mussels)

```
Source  DF      SS     MS     F      P
SEASON   3   3.040  1.013  5.12  0.003
Error   55  10.883  0.198
Total   58  13.922

S = 0.4448   R-Sq = 21.83%   R-Sq(adj) = 17.57%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N    Mean   StDev  -----+---------+---------+---------+----
1      13  1.3767  0.4433     (-------*-------)
2      16  1.2836  0.3606  (-------*------)
3      16  1.6812  0.4266                (------*------)
4      14  1.8475  0.5438                    (-------*-------)
                          -----+---------+---------+---------+----
                             1.20      1.50      1.80      2.10
Pooled StDev = 0.4448

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of SEASON

Individual confidence level = 98.96%
```

```
SEASON = 1 subtracted from:

SEASON    Lower   Center   Upper     +---------+---------+---------+---------
2       -0.5335  -0.0931  0.3474               (--------*--------)
3       -0.1359   0.3045  0.7449                       (--------*--------)
4        0.0165   0.4709  0.9252                          (--------*---------)
                                    +---------+---------+---------+---------
                                  -1.00     -0.50      0.00      0.50
SEASON = 2 subtracted from:

SEASON    Lower  Center   Upper     +---------+---------+---------+---------
3       -0.0195  0.3976  0.8146                        (-------*-------)
4        0.1323  0.5639  0.9956                           (-------*--------)
                                    +---------+---------+---------+---------
                                 -1.00     -0.50      0.00      0.50
SEASON = 3 subtracted from:

SEASON    Lower  Center   Upper     +---------+---------+---------+---------
4       -0.2653  0.1663  0.5980                    (-------*--------)
                                    +---------+---------+---------+---------
                                 -1.00     -0.50      0.00      0.50
```

Section 11,6.1 Spearmans' Rank correlation of *E. coli* results and 2 day rainfall (South Voe oysters)

```
Pearson correlation of result ranked and 2 day rain ranked = 0.306
P-Value = 0.113
```

Section 11,6.1 Spearmans' Rank correlation of *E. coli* results and 2 day rainfall (South of Houss Holm oysters)

```
Pearson correlation of result ranked and 2 day rain ranked = 0.042
P-Value = 0.857
```

Section 11,6.1 Spearmans' Rank correlation of *E. coli* results and 2 day rainfall (South of Houss Holm mussels)

```
Pearson correlation of rain result ranked and 2 day rain ranked = 0.478
P-Value = 0.000
```

Section 11,6.1 Spearmans' Rank correlation of *E. coli* results and 7 day rainfall (South Voe oysters)

```
Pearson correlation of result ranked and 7 day rain ranked = 0.217
P-Value = 0.267
```

Section 11,6.1 Spearmans' Rank correlation of *E. coli* results and 7 day rainfall (South of Houss Holm oysters)

```
Pearson correlation of result ranked and 7 day rain ranked = 0.114
P-Value = 0.623
```

Section 11,6.1 Spearmans' Rank correlation of *E. coli* results and 7 day rainfall (South of Houss Holm mussels)

```
Pearson correlation of rain result ranked and 7 day rain ranked = 0.533
P-Value = 0.000
```

11.6.2 Regression analysis for tide height vs *E. coli* result (South Voe oysters)

```
The regression equation is
Logresult tide = - 0.19 + 1.53 Tide Height

Predictor      Coef  SE Coef      T      P
Constant     -0.186    1.744  -0.11  0.916
Tide Height   1.530    1.202   1.27  0.218

S = 0.825509   R-Sq = 7.9%   R-Sq(adj) = 3.0%

Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   1.1039  1.1039  1.62  0.218
Residual Error  19  12.9478  0.6815
Total           20  14.0518

Unusual Observations

       Tide  Logresult
Obs  Height       tide    Fit  SE Fit  Residual  St Resid
  8    1.40      4.556  1.956   0.187     2.600      3.23R
 18    1.10      1.000  1.497   0.450    -0.497     -0.72 X

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

11.6.2 Regression analysis for tide height vs *E. coli* result (South of Houss Holm oysters)

```
The regression equation is
Logresult for tide = 2.51 - 0.53 Tide Height

Predictor      Coef  SE Coef      T      P
Constant      2.507    1.862   1.35  0.203
Tide Height  -0.530    1.265  -0.42  0.682

S = 0.728900   R-Sq = 1.4%   R-Sq(adj) = 0.0%

Analysis of Variance

Source          DF      SS      MS     F      P
Regression       1  0.0934  0.0934  0.18  0.682
Residual Error  12  6.3755  0.5313
Total           13  6.4689
```

11.6.2 Regression analysis for tide height vs *E. coli* result (South of Houss Holm mussels)

```
The regression equation is
logresult for tide = - 0.098 + 1.10 Tide Height

Predictor       Coef  SE Coef      T      P
Constant     -0.0982   0.6076  -0.16  0.872
Tide Height   1.1049   0.4106   2.69  0.010

S = 0.447691   R-Sq = 12.0%   R-Sq(adj) = 10.4%

Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   1.4515  1.4515  7.24  0.010
Residual Error  53  10.6226  0.2004
Total           54  12.0742
```

```
Unusual Observations

       Tide  logresult
Obs  Height   for tide     Fit  SE Fit  Residual  St Resid
  3    1.90     2.0414  2.0010  0.1855    0.0404      0.10 X
 19    1.50     2.4914  1.5591  0.0614    0.9323      2.10R
 29    1.30     2.4914  1.3381  0.0931    1.1532      2.63R
 50    1.40     2.3424  1.4486  0.0673    0.8938      2.02R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

11.6.2 Circular linear correlation for tidal state (on the high low cycle) vs *E. coli* result (South Voe oysters)

CIRCULAR-LINEAR CORRELATION
Analysis begun: 27 October 2008 12:01:45

Variables (& observations)	r	p
Angles & Linear (21)	0.408	0.049

11.6.2 Circular linear correlation for tidal state (on the high low cycle) vs *E. coli* result (South of Houss Holm oysters)

CIRCULAR-LINEAR CORRELATION
Analysis begun: 27 October 2008 12:04:59

Variables (& observations)	r	p
Angles & Linear (14)	0.484	0.073

11.6.2 Circular linear correlation for tidal state (on the high low cycle) vs *E. coli* result (South of Houss Holm mussels)

CIRCULAR-LINEAR CORRELATION
Analysis begun: 27 October 2008 11:57:09

Variables (& observations)	r	p
Angles & Linear (55)	0.029	0.957

11.6.4 Circular linear correlation for wind direction vs *E. coli* result (South Voe oysters)

CIRCULAR-LINEAR CORRELATION
Analysis begun: 28 October 2008 11:49:00

Variables (& observations)	r	p
Angles & Linear (25)	0.133	0.679

11.6.4 Circular linear correlation for wind direction vs *E. coli* result (South of Houss Holm oysters)

CIRCULAR-LINEAR CORRELATION
Analysis begun: 28 October 2008 11:48:16

Variables (& observations)	r	p
Angles & Linear (21)	0.176	0.572

11.6.4 Circular linear correlation for wind direction vs *E. coli* result (South of Houss Holm mussels)

CIRCULAR-LINEAR CORRELATION
Analysis begun: 28 October 2008 11:47:28

Variables (& observations)	r	p
Angles & Linear (51)	0.174	0.232

Hydrographic Methods

Introduction

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. This document collects together information common to all hydrographic assessments avoiding the repetition of information in each individual report.

The hydrography at most sites will be assessed on the basis of bathymetry and tidal flow software only and is not discussed in any detail in this document. 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 focus on this more detailed hydrographic assessment and describes the common methodology applied to all sites.

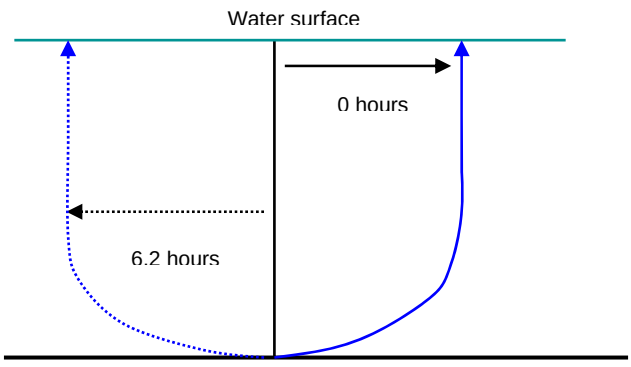
The regulations require an appreciation of the hydrography and currents within a region classified for shellfish production.

Background processes

This section gives an overview of the hydrographic processes relevant to sanitary surveys.

Movement in the estuarine and coastal waters is generally driven by one of three mechanisms: 1) Tides, 2) Winds, 3) Density differences. Unless tidal flows are weak they usually dominate over the short term (~12 hours) and move material over the length of the tidal excursion. The tidal residual flow acts over longer time scales to give a net direction of transport. 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.

a)



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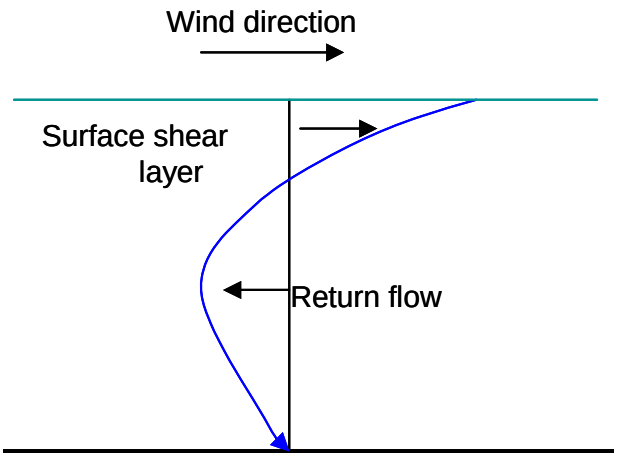

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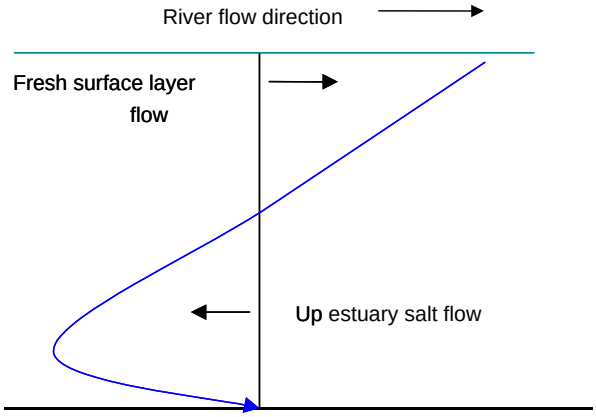


Figure 1. Typical vertical profiles for water currents. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction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

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.

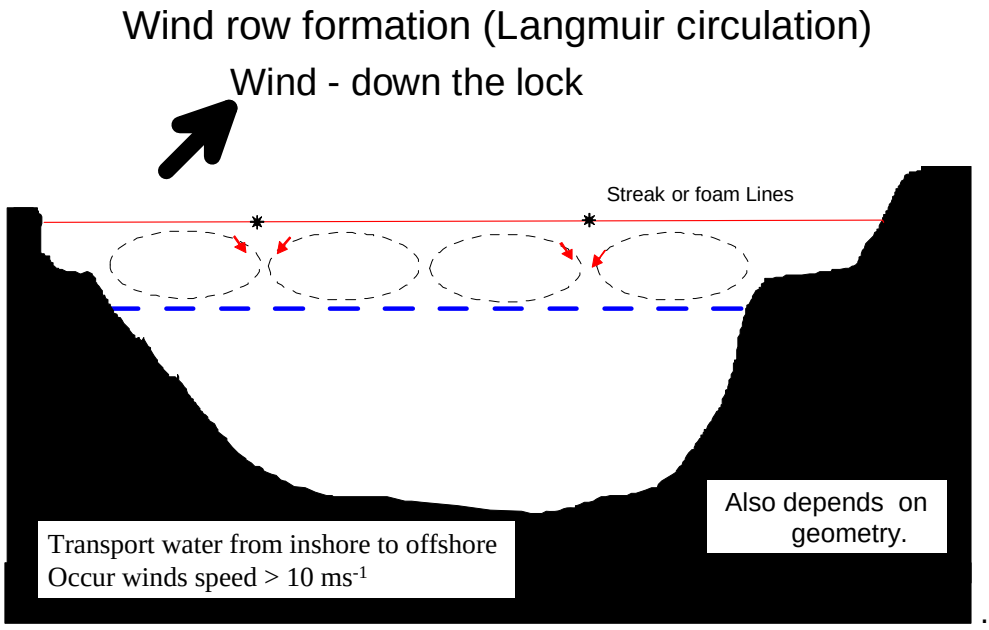


Figure 2: Schematic of wind driven 'wind row' currents. The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

Shoreline Survey Report

South Voe SI 421
and
South of Houss Holm SI 261

Scottish Sanitary Survey Project

Cefas

Shoreline Survey Report

Prod. area:	South Voe and South of Houss Holm
Site name:	South Voe Mussels, South of Houss Holm, Houss
Species:	Common Mussels, Pacific Oysters
Harvester:	George Duncan, George Williamson, Keith Robertson
Local Authority:	Shetland Islands Council
Status:	New production at South Voe, S. of Houss Holm existing
Date Surveyed:	12-14 August 2008, revisit 28 August
Surveyed by:	Michelle Price-Hayward, Sean Williamson
Existing RMP:	HU373307, HU 375315
Area Surveyed:	See Map in Figure 1

Weather observations

12 August: Winds easterly, force 1-2. Mostly sunny, temperature 18C.
13 August. Winds northerly, force 5. Partly cloudy to overcast, temperature 14C.
14 August. Winds northerly, force 4. Partly cloudy, patchy showers late in day. Temperature 14C.
28 August. Winds westerly, force 2. Overcast, scattered light showers.

Fishery

The South Voe production area now consists of one mussel farm of three long-lines. The harvester has discontinued oyster production. Droppers are 5 metres in length as the water is less than 10 m deep here.

The Houss Holm production area consists of one oyster raft at Houss. Oysters are suspended in pouches at a depth of 3-4 metres beneath the raft.

A long line mussel farm is located to the south of the oyster raft at South of Houss Holm. It consists of 5 long lines with 5 metre droppers.

Stock is harvested at any time of year there is demand and sufficient stock to warrant harvest. The mussels are harvested in rotation within each farm. The oysters have been on site for approximately 5 years and have not yet been harvested.

The fishery as observed on the day of survey is illustrated in Figure 1.

Sewage/Faecal Sources

The only septic tank reported by Scottish Water is located to the north at Toogs. This discharges to Lang Sound, which is connected to South Voe via a narrow neck of water spanned by a bridge. The septic tank discharges approximately 0.5 km north of the bridge. Seawater samples taken in the vicinity contained 30-50 *E.coli*/100 ml.

A number of private discharges were observed along the shoreline of South Voe. The majority were located along the western shoreline, with a number of discharges observed at or near Papil and Bridge End.

At Bridge End, a toilet block associated with the outdoor centre discharges directly to the voe on the eastern side of the centre. The centre was unoccupied at the time and there was no observable flow from the pipe. A seawater sample taken from adjacent the discharge pipe contained 21 *E. coli*/100ml. Toilets here are used by campers, student groups and other visitors at the centre.

A series of 8 probable discharge pipes was observed along the shore west of the marina. It is not known whether all are septic discharges and/or currently in use. Water samples 40-44 were taken from this area and contained between 1 to 280 *E. coli*/100 ml, with the highest concentration observed at the northernmost sampling point.

At Papil, active discharges were observed on either side of a wooden pier. There was a notable odour of sewage. Two of these were observed actively discharging at the time of survey. Sea water samples collected from near the outfalls contained the highest levels of faecal indicator bacteria observed during the survey: 14000 and 18000 *E.coli*/100 ml.

Three discharges were observed along the beach south of Papil and a strong sewage odour was noted. At one of these, (Waypoint 99) solid waste was observed. A water sample taken from seawater adjacent to the discharge contained 5000 *E. coli*/100 ml. Two other water samples taken from along this beach contained 90 and 8800 *E. coli*/100 ml, respectively (Waypoints 144 and 147).

A local resident recalled a neighbour who became ill after consumption of razor fish from this beach within the past 2-3 years, though this was not directly confirmed.

There were few septic tank discharge pipes observed along the eastern shoreline. However, one of these discharged to within approximately 50 metres of the oyster raft at Houss (Waypoint 72). It was not possible to determine whether the discharge was flowing at the time. A seawater sample (South Voe 19) collected from adjacent to the pipe contained 1200 *E. coli*/100 ml.

Seasonal Population

No hotels or B&Bs were observed in the area, however there is accommodation at the outdoor education centre for visiting students and others on activities at the centre. Kayak tours are operated from this location during the summer months.

Boats/Shipping

The voe is shallow, restricting access to only small boats with shallow draft. Seven small work boats were observed on moorings on the west side of the

voe and a marina for boats of less than approximately 10 metres length was located at the head of the voe near the Bridge End Outdoor Centre. On the day of survey there were 25 boats present, with 3 slips empty.

Streams

There were few streams actively flowing during the time of survey. Two streams were flowing sufficiently to measure. One was located on the northwest shore of the voe near Bridge End (Waypoint 114), though on the revisit it was not flowing sufficiently to sample directly so a seawater sample was taken at the point of its discharge.

The second was along the eastern shoreline, a bit over 0.2 km south of the Bridge End outdoor centre. This was flowing on both days, as the first sample did not provide a quantitative result had to be resampled and remeasured on the second visit (Waypoints 41, 71, and 152).

Land Use

There are several significant settlements in the vicinity of the production areas. The land around these areas is grassland and improved pasture used for grazing. A pony stud is located on the shores of the fresh water loch that discharges into the western side of South Voe, at the south end of the beach near Papil.

A variety of livestock were observed during the shoreline walk. In all, 5 cattle, 468 sheep and goats, 30 horses and ponies, and 41 domestic fowl were observed. In some areas, such as near Houlls, animals were kept at the shoreline. Sheep were observed all around the voe and numbers counted were not likely to be fully representative of the number present.

Wildlife/Birds

One seal and one otter were seen during the shoreline walk. Approximately 12 seals were seen basking and in the water around an island to the south of the production area. One of the harvesters reported having seen up to 30 seals in the vicinity of South of Houss Holm, though this number has diminished in the past two years.

Rabbits were seen in most fields and rabbit droppings were readily apparent where the grass was short.

Small (<20 individuals) congregations of shorebirds were observed moving about the area, but no large congregations were found.

The cliffs near the mouth of the voe are used by nesting Northern Fulmars in the summer season, and chicks were observed on nests on 15 August.

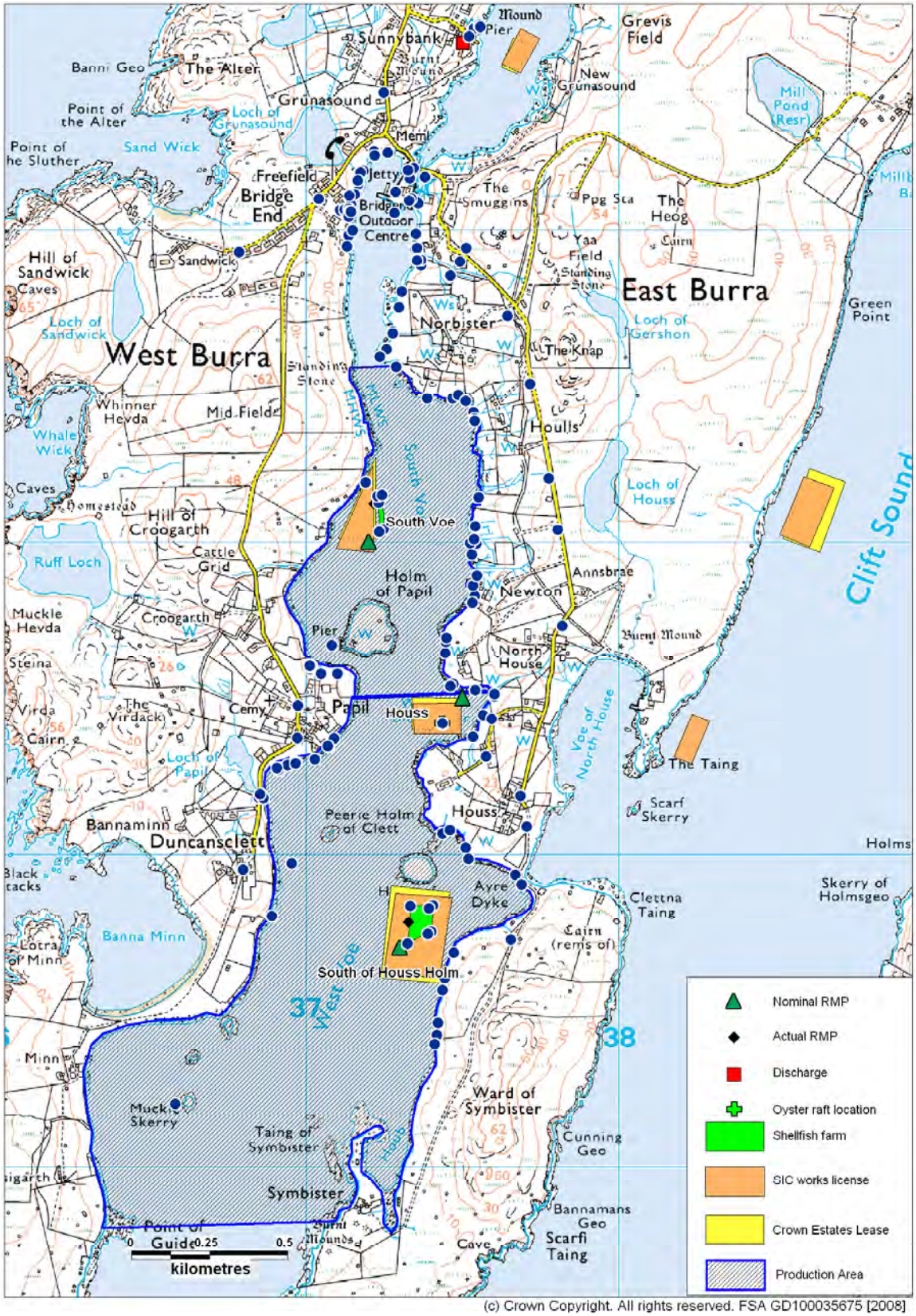


Figure 1. Overview map of fishery and survey observations.

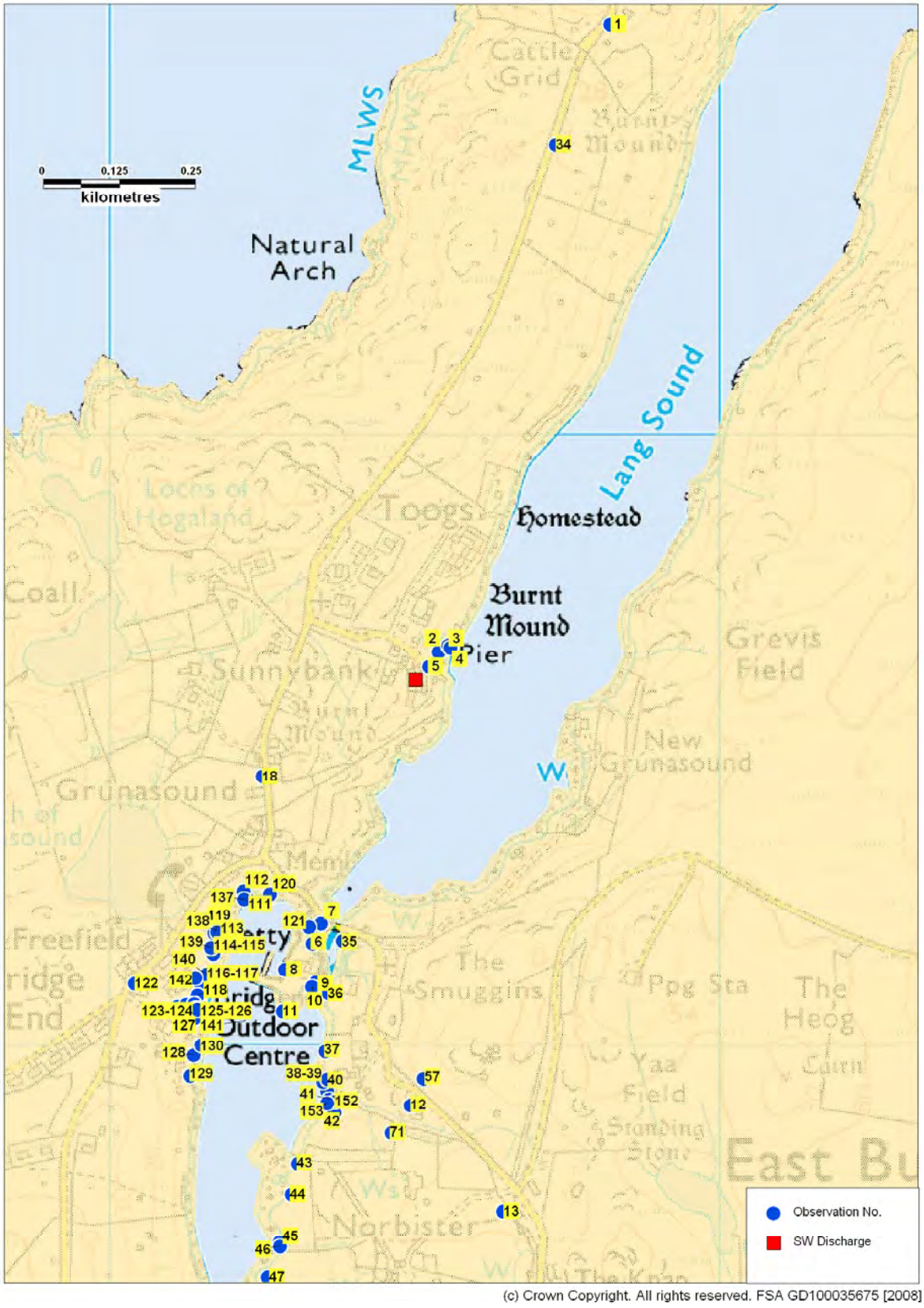


Figure 2. Map of shoreline observations for Northern part of survey area.

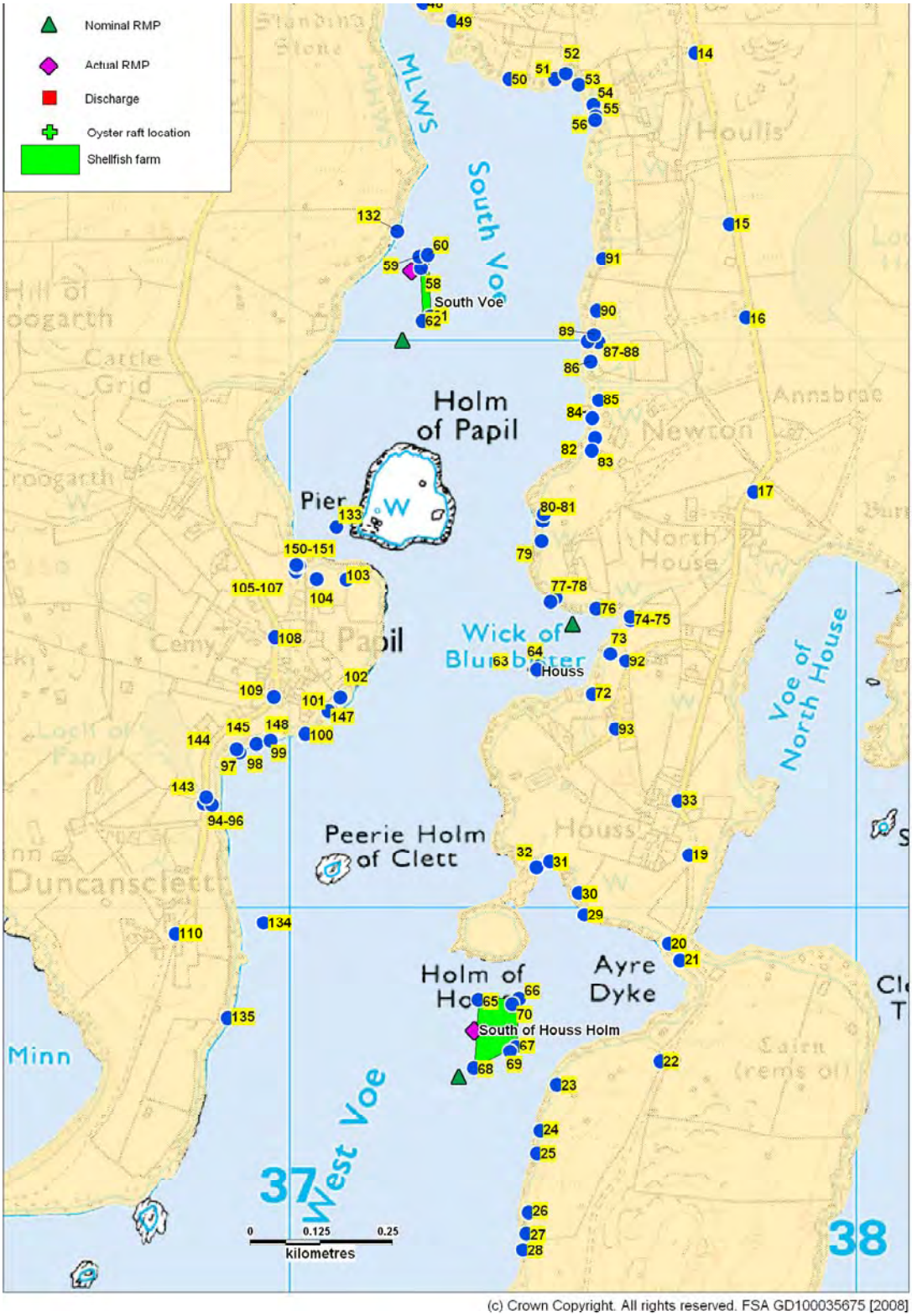


Figure 3. Map of shoreline observations for Southern part of survey area.

Table 1. Shoreline Observations

Wp no.	Date	Time	Grid Ref	East	North	Photo graph	Description
1	12/08/08	10:21	HU 37820 74673	437820	1134674		Area overlooking Lang Sound mussel farm. 1 house + 2 sheds, fence corner. Septic tank approximately100 meters beyond fence. 60 sheep in three fields.
2	12/08/08	10:39	HU 37539 33646	437539	1133646		18 sheep in field.
3	12/08/08	10:40	HU 37555 33657	437555	1133657	Figure 6	Toogs septic tank. Outfall just below tank. Rowboat tied near bank.
4	12/08/08	10:57	HU 37558 33653	437558	1133653		Water sample 1, Salinity 35 ppt.
5	12/08/08	11:04	HU 37523 33622	437523	1133622	Figure 7	Post marked vacuum sewer.
6	12/08/08	11:12	HU 37332 33167	437332	1133167		Bridge between south voe and lang sound, water flowing S-N. Estimated width of channel 4 metres.
7	12/08/08	11:16	HU 37346 33200	437346	1133200	Figure 8, 9	Photograph taken from northwest of bridge. House and shed here. Three more photographs panning w to s from this position. 48 sheep viewed to west.
8	12/08/08	11:23	HU 37287 33124	437287	1133124	Figure 10	Jetty and marina at Bridge End, space for 28 boats under 10m length, 3 slips unoccupied. Small open boat at jetty, Water sample 2, salinity 36 ppt.
9	12/08/08	11:44	HU 37338 33103	437338	1133103		Out building, appears to be shower or toilet block associated with outdoor centre.
10	12/08/08	11:48	HU 37331 33096	437331	1133096	Figure 11	Discharge pipe at S end of building, photograph, Water sample 3, salinity not recorded.
11	12/08/08	11:57	HU 37283 33056	437283	1133056		To west of this point, 19 homes + 1 church. To east, 8 homes + 1 church.
12	12/08/08	12:07	HU 37493 32902	437493	1132902	Figure 12	House, septic tank, 3 sheep, 5 buoys possibly moorings. Photograph looking west.
13	12/08/08	12:11	HU 37645 32728	437645	1132728	Figure 13	View toward mussel lines, looking south are 26 sheep, 1 horse, 9 houses, 5 cattle on ridge in distance.. Looking E, 1 home,3 sheep, 1 horse
14	12/08/08	12:18	HU 37717 32509	437717	1132509		4 horses, 9 sheep, 1 goat, 2 dogs, 4 houses, 6 kayakers passing mussel farm.
15	12/08/08	12:22	HU 37778 32207	437778	1132207		26 sheep, small field drain.
16	12/08/08	12:23	HU 37807 32043	437807	1132043		>36 sheep.
17	12/08/08	12:24	HU 37821 31735	437821	1131735		27 sheep, 2 houses.
18	12/08/08	12:44	HU 37250 33442	437250	1133442	Figure 14	Marshy area, 6 homes, 3 horses. Mussel farm at S of House Holm visible from here.
19	12/08/08	15:17	HU 37706 31093	437706	1131093		Septic tank.
20	12/08/08	15:21	HU 37671 30937	437671	1130937		Beach, washed up plastic rubbish, plastics mostly, algal mat, Water sample 4, salinity 36 ppt.
21	12/08/08	15:27	HU 37690 30907	437690	1130907		Wind funneling through here from east.
22	12/08/08	15:32	HU 37656 30729	437656	1130729		36 sheep.
23	12/08/08	15:36	HU 37473 30688	437473	1130688	Figure 15	Lobster pots along shore, Photograph of southeast corner of mussel farm. 2 great black backed gulls sitting on floats.
24	12/08/08	15:40	HU 37444 30607	437444	1130607		2 rabbits.

Wp no.	Date	Time	Grid Ref	East	North	Photo graph	Description
25	12/08/08	15:41	HU 37438 30567	437438	1130567		Damp area where water drains from hillside.
26	12/08/08	15:43	HU 37423 30463	437423	1130463		Damp area where water drains from hillside.
27	12/08/08	15:44	HU 37419 30426	437419	1130426		Damp ground from drainage.
28	12/08/08	15:49	HU 37413 30397	437413	1130397		Sample 5, 10m out from this point. No salinity taken..Looking south toward bight of land at Symbister, complex of abandoned buildings.
29	12/08/08	16:08	HU 37521 30988	437521	1130988		3 houses, 1 ruin.
30	12/08/08	16:09	HU 37511 31026	437511	1131026		3 horses on top of hill.
31	12/08/08	16:11	HU 37461 31081	437461	1131081		Mussel floats ashore, harvesters house, stream draining land, flag iris, water too shallow to measure, slow flow.
32	12/08/08	16:15	HU 37437 31071	437437	1131071		Water sample 6, salinity 29 ppt, jetty.
33	12/08/08	16:47	HU 37687 31190	437687	1131190		7 sheep.
34	13/08/08	09:27	HU 37382 33171	437731	1134477		Photographs looking E and NE from this point.
35	13/08/08	09:44	HU 37382 33171	437382	1133171		Water at bridge flowing strongly N to S.
36	13/08/08	09:52	HU 37359 33087	437359	1133086		Water sample 7, salinity 34 ppt.
37	13/08/08	10:10	HU 37353 32991	437353	1132991	Figure 16	Septic pipe from house, photograph. 3 linked bouys just offshore, water sample 8, salinity 34 ppt. 1 rabbit.
38	13/08/08	10:15	HU 37350 32941	437350	1132941	Figure 17	Jetty, photograph looking west, house and barn.
39	13/08/08	10:17	HU 37357 32945	437357	1132945		Utilities covers.
40	13/08/08	10:19	HU 37356 32926	437356	1132926	Figure 18	Septic tank inspection pipe. Water sample 9, Sal 5ppt. Took 2nd sample for salinity test.
41	13/08/08	10:27	HU 37360 32912	437360	1132912		Stream and inspection cover. No apparent pipes. Water sample 10. Returned to measure, see Wp 71.
42	13/08/08	10:35	HU 37368 32890	437368	1132890		Field with diverse vegetation - lots of scabious, sphagnum moss, ground spongy and wet. Bog cotton, heather.
43	13/08/08	10:41	HU 37308 32806	437308	1132806		Fenced field.
44	13/08/08	10:43	HU 37298 32756	437298	1132756		Grassland, very short. Little other vegetation other than thistles. Rocky outcrops. 12 sheep uphill.
45	13/08/08	10:48	HU 37278 32678	437278	1132678		Small open boat moored offshore approximately 50 metres.
46	13/08/08	10:50	HU 37279 32671	437279	1132671		Wet area of runoff, 1 rabbit. Water sample 11, salinity 34 ppt.
47	13/08/08	10:57	HU 37259 32621	437259	1132621		Trickle of water running under grass, too shallow to sample so seawater sample taken. Water sample 12, salinity 30 ppt.
48	13/08/08	11:04	HU 37237 32597	437237	1132597		Tall grass, little other vegetation, 4 homes up hill, old slipway, 3 rabbits.
49	13/08/08	11:07	HU 37291 32565	437290	1132565		Plastic debris at tideline.
50	13/08/08	11:12	HU 37389 32464	437389	1132463		2 rabbits, 1 grey seal.
51	13/08/08	11:15	HU 37470 32463	437470	1132463		Black rabbit.

Wp no.	Date	Time	Grid Ref	East	North	Photo graph	Description
52	13/08/08	11:15	HU 37489 32473	437489	1132473		Plastic debris at tideline.
53	13/08/08	11:22	HU 37511 32453	437511	1132453		Thick layer of plastic debris on shore, water sample 13, salinity 34 ppt. According to landowner, otters here, used to be up to 30 or so seals. Keeps 2 horses on field at shore. 6 ducks, 8 hens, 6 goats.
54	13/08/08	11:29	HU 37537 32418	437537	1132418		Damp drainage area.
55	13/08/08	11:30	HU 37541 32399	437541	1132398		Bigger ditch, low flow too shallow to sample. Landowner building culvert over for horses.
56	13/08/08	11:33	HU 37540 32391	437540	1132391		Water sample 14, salinity 33 ppt.
58	13/08/08	15:20	HU 37233 32130	437233	1132130		South Voe mussels, Water sample 15, mussel samples 1-3. 4 metre droppers, 3 lines. Two easternmost are together, one will be moved appr 10m eastward. Salinity profile: Bottom at 5m sal 34.9 t 13.3C. 3m, sal 35.0 t 13.8C. 1m sal 34.9 t 14.1C.
59	13/08/08	15:34	HU 37230 32151	437230	1132150		NW corner of South Voe mussel lines.
60	13/08/08	15:35	HU 37245 32153	437245	1132153		NE corner of South Voe mussel lines.
61	13/08/08	15:36	HU 37250 32045	437250	1132045		SE corner of South Voe mussel lines.
62	13/08/08	15:36	HU 37236 32037	437236	1132037		SW corner of South Voe mussel lines.
63	13/08/08	15:40	HU 37437 31418	437437	1131418	Figure 19	Oyster raft, oyster sample from here, bags at 3m depth. Water sample 16. Sal profile 5m sal 34.8, t 14.0c. 3m sal 34.9, t 14.1C. 1m sal 34.9, t 14.1C.
64	13/08/08	16:04	HU 37438 31421	437438	1131421		Centre of raft.
65	13/08/08	16:07	HU 37334 30837	437334	1130837		Corner of mussel lines at South of Houss Holm.
66	13/08/08	16:08	HU 37406 30839	437406	1130839		Corner of mussel lines at South of Houss Holm.
67	13/08/08	16:09	HU 37401 30755	437401	1130755		Corner of mussel lines at South of Houss Holm.
68	13/08/08	16:10	HU 37326 30717	437326	1130717		Corner of mussel lines at South of Houss Holm.
69	13/08/08	16:14	HU 37390 30747	437390	1130747		Water sample 17. Mussel samples S. of Houss Holm 1-3. Max depth 9m. Sal profile 9m sal 34.9, t 13.7, 6m sal 34.9 t 13.7, 3m sal 34.9 t 13.8, 1m sal 34.9 t 13.8.
70	13/08/08	16:20	HU 37394 30830	437394	1130830		Water sample 18. South of Houss samples 4-6 mussels. Salinity profile 8m sal 34.9 t 13.5, 6m sal 34.9 t 13.6, 3m sal 34.9 t 13.7, 1m sal 34.9, t 13.7.
71	14/08/08	10:54	HU 37462 32857	437462	1132857		Stream, 4cm x 20cm, flow 0.033 m/s.
72	14/08/08	11:17	HU 37536 31379	437536	1131379	Figure 20	Discharge pipe, photograph. Water sample 19, salinity 34 ppt. 4 houses. Oyster barge just offshore.
73	14/08/08	11:21	HU 37567 31449	437567	1131449		Cliff. Tall grass.
74	14/08/08	11:24	HU 37603 31509	437603	1131509		Plastic debris at tideline.
75	14/08/08	11:25	HU 37603 31515	437603	1131515		Trickle of water in drainage ditch.
76	14/08/08	11:29	HU 37542 31529	437542	1131529		Water sample 20, salinity 34 ppt.
77	14/08/08	11:35	HU 37471 31548	437471	1131548		Septic tank at shoreline, no pipe apparent. Little scum on water, upwind from no.76, so no addtl sample taken. Horse hoof prints.
78	14/08/08	11:39	HU 37462 31541	437462	1131541		Water sample 21, salinity 35 ppt.
79	14/08/08	11:44	HU 37446 31648	437446	1131648		Cut ditch running from large barn. Wet but no flow. 20 sheep.

Wp no.	Date	Time	Grid Ref	East	North	Photo graph	Description
80	14/08/08	11:46	HU 37448 31684	437448	1131684		Second cut ditch from same farm. Wet but no flow.
81	14/08/08	11:47	HU 37450 31696	437450	1131696		Third cut ditch from same farm. Wet but no flow.
82	14/08/08	11:50	HU 37534 31808	437534	1131808		Septic tank below house, no discharge pipe observed.
83	14/08/08	11:52	HU 37540 31830	437540	1131830		Ruin and 15 chickens.
84	14/08/08	11:52	HU 37535 31865	437535	1131865		Jetty.
85	14/08/08	11:54	HU 37547 31897	437547	1131897		Ditch with standing water.
86	14/08/08	11:56	HU 37532 31964	437532	1131964		From this point north, houses are set back 500m or so from shoreline.
87	14/08/08	11:58	HU 37546 31999	437546	1131999		Trickling stream under and through grass, audible but barely visible.
88	14/08/08	12:00	HU 37527 32000	437527	1132000		Water sample 22. Salinity 25 ppt. Bright green algae on shore, water percolating through rocks.
89	14/08/08	12:03	HU 37538 32012	437538	1132012		Ditch, barely flowing. Too shallow to sample.
90	14/08/08	12:04	HU 37543 32055	437543	1132055		Patch of rushes, wet underfoot.
91	14/08/08	12:09	HU 37554 32146	437554	1132146		Septic pipe, pvc to iron with adjacent natural ditch. Otter seen under pipe. Water sample 23, salinity 20 ppt.
92	14/08/08	12:33	HU 37595 31437	437595	1131437		Septic tank, odorous. Green plastic cover. No apparent pipes.
93	14/08/08	12:35	HU 37577 31317	437577	1131317		25 sheep.
94	14/08/08	12:49	HU 36850 31185	436850	1131185	Figure 21	5 sheep, 11 ponies, septic pipe and discharge from small freshwater loch. Large amount of green scum. Photograph on phone.
95	14/08/08	12:51	HU 36864 31183	436864	1131183		Water sample 24, salinity 30 ppt.
96	14/08/08	12:53	HU 36854 31196	436854	1131196		Out from loch. Beach sand under cobble. Razor shells around, 2 gulls, 15 shorebirds.
97	14/08/08	12:56	HU 36913 31275	436913	1131275	Figure 22	Discharge pipe with foul odour. Appears to be leaking next to pipe, small trickle across sand. Water sample 25, salinity 35 ppt.
98	14/08/08	13:00	HU 36942 31290	436942	1131290	Figure 23	Green scum along shoreline. Photograph.
99	14/08/08	13:01	HU 36970 31297	436970	1131297	Figure 24	Outfall, wood and concrete encased plastic pipe. Green aglae. Solid waste evident at opening of pipe. Pipe discharges to side instead of end. 12 houses visible on shore, may be more behind. Water sample 26, salinity 35 ppt. 2 gulls.
100	14/08/08	13:06	HU 37029 31308	437029	1131308		Buried broken pipe - does not appear to be in use.
101	14/08/08	13:08	HU 37074 31350	437074	1131350	Figure 25	Outfall, similar construction to No. 99. Appears to be flowing. Water sample 27, salinity 36 ppt. Green scum evident.
102	14/08/08	13:16	HU 37091 31373	437091	1131373		Decomposed part of sea mammal, dead gull.
103	14/08/08	13:22	HU 37102 31580	437102	1131580	Figure 26	7 small workboats in bay. 23 sheep.
104	14/08/08	13:24	HU 37049 31581	437049	1131581		Slipway. 20 sheep.
105	14/08/08	13:25	HU 37018 31604	437018	1131604	Figure 27	3 pipes under pier. End of one underwater. 1 barely flowing onto gravel. 1 dribbling, solid waste evident in pipe. All 10cm inner diameter. Water sample 28 salinity 35 ppt.

Wp no.	Date	Time	Grid Ref	East	North	Photo graph	Description
106	14/08/08	13:36	HU 37012 31609	437012	1131609		Water sample 29 taken from dribbling pipe. Flow 100 ml in 40 sec.
107	14/08/08	13:37	HU 37012 31595	437012	1131595		Cabbage patch.
108	14/08/08	13:41	HU 36975 31479	436975	1131479		10 houses.
109	14/08/08	13:43	HU 36973 31374	436973	1131374		2 small houses, 24 sheep and 3 ponies.
110	14/08/08	18:40	HU 36800 30954	436800	1130954		15 geese, 11 chickens, 1 house.
111	14/08/08	18:56	HU 37225 33242	437225	1133242	y	Pipe and concrete. Smelly.
112	14/08/08	18:57	HU 37219 33253	437219	1133253		Vacuum sewer marker, septic tank. Photographs. Water sample 30, septic discharge from pipe 30ml in 15 sec from side flow approx 1/4 main flow.
113	14/08/08	19:08	HU 37184 33192	437184	1133192		Photographs of concrete structure and pipe. Septic tank with dry pipe. Seawater sample 31,
114	14/08/08	19:11	HU 37168 33161	437168	1133161		Stream, empty oyster bags. 1m x 6cm flow 0.08 m/s. Water sample 32.
115	14/08/08	19:20	HU 37169 33150	437169	1133150		Algal growth.
116	14/08/08	19:22	HU 37162 33118	437162	1133118		Two septic pipes, one underwater extending at least 3m out from cliff face the other above water and dry. Water sample 33, seawater.
117	14/08/08	19:28	HU 37150 33096	437150	1133096		Septic discharge.
118	14/08/08	19:30	HU 37144 33082	437144	1133082	y	Wall, approx 25m to iron pipe, 20 to plastic pipe,
119	14/08/08	19:33	HU 37171 33184	437171	1133184		40 sheep.
120	14/08/08	19:36	HU 37262 33249	437262	1133249		Iron inspection cover.
121	14/08/08	19:39	HU 37327 33194	437327	1133194		Vacuum sewer marker in front of Bridge End sign.
122	14/08/08	19:47	HU 37041 33101	437041	1133101		12 houses.
123	14/08/08	19:48	HU 37111 33064	437111	1133064		Air vent and inspection cover for septic tank.
124	14/08/08	19:49	HU 37125 33067	437125	1133067		Vacuum sewer marker.
125	14/08/08	19:49	HU 37138 33068	437138	1133068		Plastic pipe.
126	14/08/08	19:50	HU 37142 33061	437142	1133061		Iron pipe.
127	14/08/08	19:50	HU 37138 33045	437138	1133045		Slipway.
128	14/08/08	19:52	HU 37137 32985	437137	1132985		Two ceramic pipes with no apparent flow, though dried debris evident..
129	14/08/08	19:54	HU 37132 32951	437132	1132951		Broken pipe, not flowing.
130	14/08/08	19:59	HU 37150 33001	437150	1133001		Jetty, water sample 34, salinity 35 ppt.
131	14/08/08	20:05	HU 36786 32933	436786	1132933		Septic tank.
132	15/08/08	10:30	HU 37191 32194	437191	1132194		Whipweed flowing toward shore
133	15/08/08	10:38	HU 37084 31673	437084	1131673		Whipweed flowing west, wind SE force 2-3.
134	15/08/08	10:49	HU 36955 30974	436955	1130974		Fulmar nesting, west cliff face, 7 sheep
135	15/08/08	10:53	HU 36892 30806	436892	1130806		2 fulmar chicks, crofts south of Bannamin abandoned.
136	15/08/08	11:03	HU 36583 30205	436583	1130205		Approximately 12 seals
137	28/08/08	09:29	HU 37220 33240	437220	1133240		Water sample 40.

Wp no.	Date	Time	Grid Ref	East	North	Photo graph	Description
138	28/08/08	09:34	HU 37176 33186	437176	1133186		Water sample 41.
139	28/08/08	09:39	HU 37166 33160	437166	1133160	y	Water sample 42 (seawater) Insufficient flow for freshwater sample.
140	28/08/08	09:43	HU 37158 33116	437158	1133116		Water sample 43 (seawater) No apparent flow from pipes.
141	28/08/08	09:49	HU 37144 33059	437144	1133059		Water sample 44, site of septic tank with iron discharge pipe.
142	28/08/08	09:52	HU 37140 33111	437140	1133111		Tank covers.
143	28/08/08	10:08	HU 36855 31196	436855	1131196		Water sample 45.
144	28/08/08	10:12	HU 36908 31281	436908	1131281		Water sample 46.
145	28/08/08	10:15	HU 36964 31298	436964	1131298	y	Sanitary debris.
147	28/08/08	10:23	HU 37070 31349	437070	1131349		Water sample 48.
148	28/08/08	10:29	HU 36967 31296	436967	1131296		Water sample 47.
150	28/08/08	10:47	HU 37014 31603	437014	1131603		Pipe underwater, discharge apparent as grey 'cloud', Water sample 50.
151	28/08/08	10:48	HU 37013 31606	437013	1131606	y	Other side of pier from 150, pipe just above water dribbling. Water sample 49 (seawater) from near dribble.
152	28/08/08	11:12	HU 37369 32908	437369	1132908		Stream, flow 0.017, w 22.0 cm d 8.0 cm, Water sample 51.
153	28/08/08	11:17	HU 37356 32906	437356	1132906		Water sample 52.

Photographs referenced in the table can be found attached as Figures 5-11.

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 voe or loch.

Sampling

Water and shellfish samples were collected at sites marked on the map. Samples were transferred to cool boxes for transport to the laboratory. All samples were analysed for *E. coli* content. Water sampled at the site was tested for salinity using a hand held refractometer. These readings are recorded in Table 1 as salinity in parts per thousand (ppt).

Seawater samples were also tested for salinity by the laboratory using a salinity meter under more controlled conditions. These results are reported in table 2.

Water samples 25 through 34 had to be repeated as the laboratory had discovered a contaminated batch of media had been used to test these samples. Conditions under which they were resampled differed from those during the original sampling date. The tide was high on the resample day and many of the discharges were either underwater or not flowing.

In addition, as a TNTC result was obtained for water sample 10 (a fresh water sample) we elected to collect another sample in order to get a more precise result.

Bacteriology results follow in Tables 2 and 3.

Table 2. Water Sample Results

Date	Sample Number	Type	Grid Ref	East	North	*E. coli* (cfu/100ml)	Salinity lab	Salinity field
12/08/2008	South Voe 1	Seawater	HU37558 33653	437558	1133653	30	-	35
12/08/2008	South Voe 2	Seawater	HU37287 33124	437287	1133124	50	-	36
12/08/2005	South Voe 3	Seawater	HU37331 33096	437331	1133096	21	-	35
13/08/2008	South Voe 4	Seawater	HU37671 30937	437671	1130937	1	32.41	36
13/08/2008	South Voe 5	Seawater	HU37413 30397	437413	1130397	31	33.85	-
13/08/2008	South Voe 6	Seawater	HU37437 31071	437437	1131071	560	26	29
13/08/2008	South Voe 7	Seawater	HU37359 33086	437359	1133086	15	-	34
13/08/2008	South Voe 8	Seawater	HU37353 32991	437353	1132991	10	-	34
13/08/2008	South Voe 9	Seawater	HU37356 32926	437356	1132926	65	31.39	-
13/08/2008	South Voe 10	Seawater	HU37360 32912	437360	1132912	TNTC	-	-
13/08/2008	South Voe 11	Seawater	HU 37279 32671	437279	1132671	155	-	34

Date	Sample Number	Type	Grid Ref	East	North	*E. coli* (cfu/100ml)	Salinity lab	Salinity field
13/08/2008	South Voe 12	Seawater	HU37259 32621	437259	1132621	TNTC	-	30
13/08/2008	South Voe 13	Seawater	HU37511 32453	437511	1132453	5	-	34
14/08/2008	South Voe 14	Seawater	HU37540 32391	437540	1132391	440	-	33
13/08/2008	South Voe 15	Seawater	HU37233 32130	437233	1132130	<1	34.36	34.9
13/08/2008	South Voe 16	Seawater	HU37437 31418	437437	1131418	30	34.6	34.9
14/08/2008	South Voe 17	Seawater	HU37390 30747	437390	1130747	30	34.6	34.9
14/08/2008	South Voe 18	Seawater	HU37394 30830	437394	1130830	<1	-	34.9
14/08/2008	South Voe 19	Seawater	HU37536 31379	437536	1131379	1200	-	34
14/08/2008	South Voe 20	Seawater	HU37542 31529	437542	1131529	<1	-	34
14/08/2008	South Voe 21	Seawater	HU37462 31541	437462	1131541	40	-	35
14/08/2008	South Voe 22	Seawater	HU37527 32000	437527	1132000	390	-	25
14/08/2008	South Voe 23	Seawater	HU37554 32146	437554	1132146	300	-	20
14/08/2008	South Voe 24	Seawater	HU36864 31183	436864	1131183	200	-	30
14/08/2008	South Voe 25	Seawater	HU36913 31275	436913	1131275	Contam	-	35
14/08/2008	South Voe 26	Seawater	HU36970 31297	436970	1131297	Contam	-	35
14/08/2008	South Voe 27	Seawater	HU37074 31350	437074	1131350	Contam	-	36
14/08/2008	South Voe 28	Seawater	HU37018 31604	437018	1131604	Contam	-	35
14/08/2008	South Voe 29	Foul water	HU37012 31609	437012	1131609	Contam	-	-
14/08/2008	South Voe 30	Foul water	HU37219 33253	437219	1133253	Contam	-	-
14/08/2008	South Voe 31	Seawater	HU37184 33192	437184	1133192	Contam	-	-
14/08/2008	South Voe 32	Freshwater	HU37168 33161	437168	1133161	Contam	-	-
14/08/2008	South Voe 33	Seawater	HU37162 33118	437162	1133118	Contam	-	-
14/08/2008	South Voe 34	Seawater	HU37150 33001	437150	1133001	Contam	-	35
28/08/2008	South Voe 40	Seawater	HU37220 33240	437220	1133240	280	33.55	-
28/08/2008	South Voe 41	Seawater	HU37176 33186	437176	1133186	70	32.8	-
28/08/2008	South Voe 42	Seawater	HU37166 33160	437166	1133160	33	29.66	-
28/08/2008	South Voe 43	Seawater	HU37158 33116	437158	1133116	1	34.71	-
28/08/2008	South Voe 44	Seawater	HU37144 33059	437144	1133059	4	32.83	-
28/08/2008	South Voe 45	Seawater	HU36855 31196	436855	1131196	27	30.31	-
28/08/2008	South Voe 46	Seawater	HU36908 31281	436908	1131281	90	34.51	-
28/08/2008	South Voe 47	Seawater	HU37070 31349	437070	1131349	5000	34.37	-
28/08/2008	South Voe 48	Seawater	HU36967 31296	436967	1131296	8800	34.5	-
28/08/2008	South Voe 49	Seawater	HU37014 31603	437014	1131603	18000	33.88	-
28/08/2008	South Voe 50	Seawater	HU37013 31606	437013	1131606	14000	33.31	-
28/08/2008	South Voe 51	Freshwater	HU37369 32908	437369	1132908	350	-	-
28/08/2008	South Voe 52	Seawater	HU37356 32906	437356	1132906	40	31.42	-

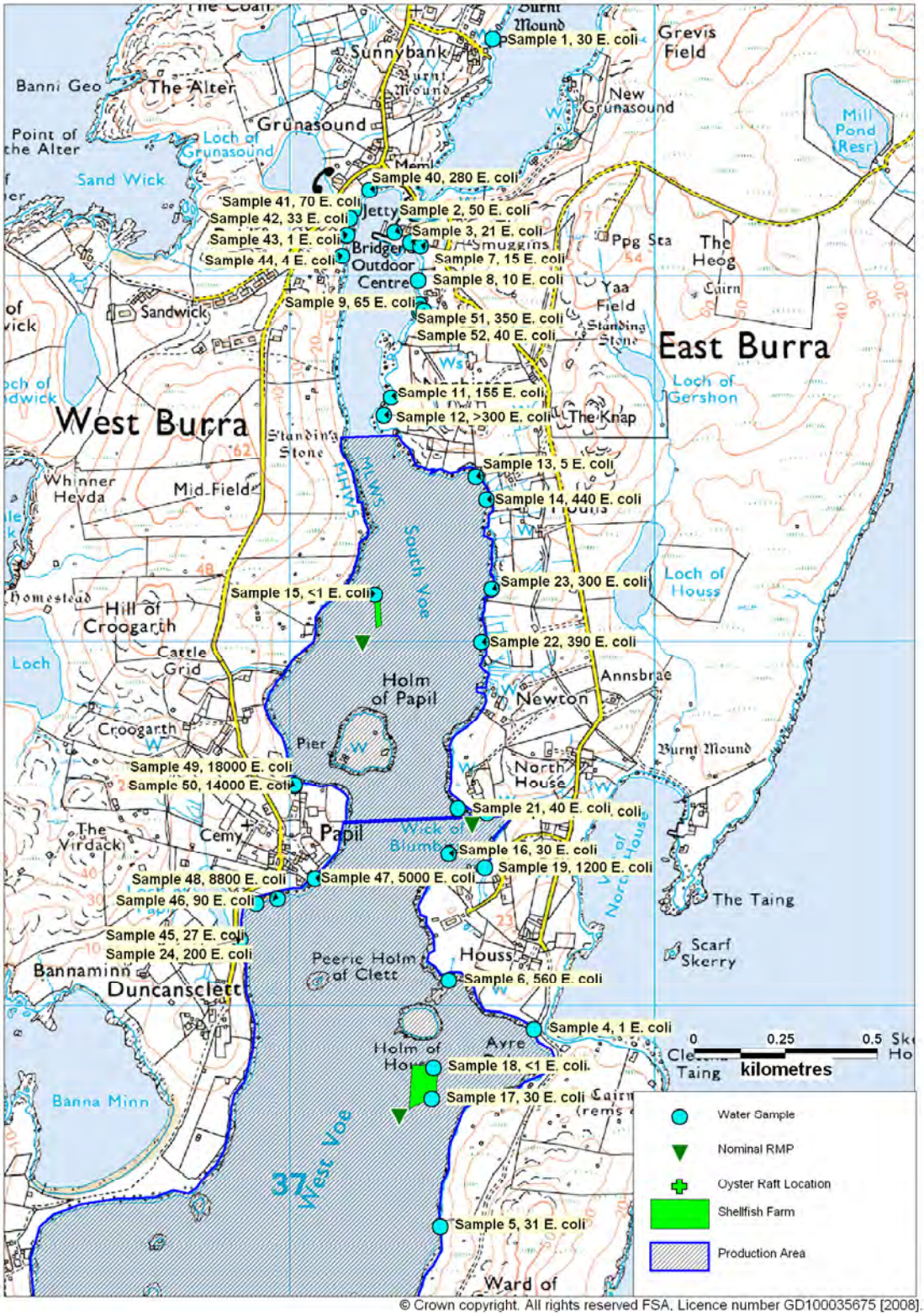
Table 3. Shellfish Sample Results

Date	Sample	Grid Ref	East	North	Type	E. coli (cfu/ 100g)	Depth (m)
08/13/08	Houss 1	HU 37437 31418	437437	1131418	Pac oyster	<20	4
08/13/08	S.Houss Holm 1	HU 37390 30747	437390	1130747	Mussel	<20	1
08/13/08	S.Houss Holm 2	HU 37390 30747	437390	1130747	Mussel	<20	3
08/13/08	S.Houss Holm 3	HU 37390 30747	437390	1130747	Mussel	20	6
08/13/08	S.Houss Holm 4	HU 37394 30830	437394	1130830	Mussel	220	1
08/13/08	S.Houss Holm 5	HU 37394 30830	437394	1130830	Mussel	80	3
08/13/08	S.Houss Holm 6	HU 37394 30830	437394	1130830	Mussel	170	6
08/13/08	South Voe 1	HU 37233 32130	437233	1132130	Mussel	20	1
08/13/08	South Voe 2	HU 37233 32130	437233	1132130	Mussel	80	3
08/13/08	South Voe 3	HU 37233 32130	437233	1132130	Mussel	80	5

Table 4. Salinity and Temperature Profile Results

	HU 37233 32130 (Wp 58)	HU 37437 31418 (Wp 63)	HU 37390 30747 (Wp 69)	HU 37394 30830 (Wp 70)
Sal				
1 m	34.9	34.9	34.9	34.9
3 m	35	34.9	34.9	34.9
5 m	34.9	34.8		
6 m			34.9	34.9
8 m				34.9
9 m			34.9	
Temp				
1m	14.1	14.1	13.8	13.7
3 m	13.8	14.1	13.8	13.7
5 m	13.3	14.0		
6 m			13.7	13.6
8 m				13.5
9 m			13.7	

Figure 4. Water sample results map.



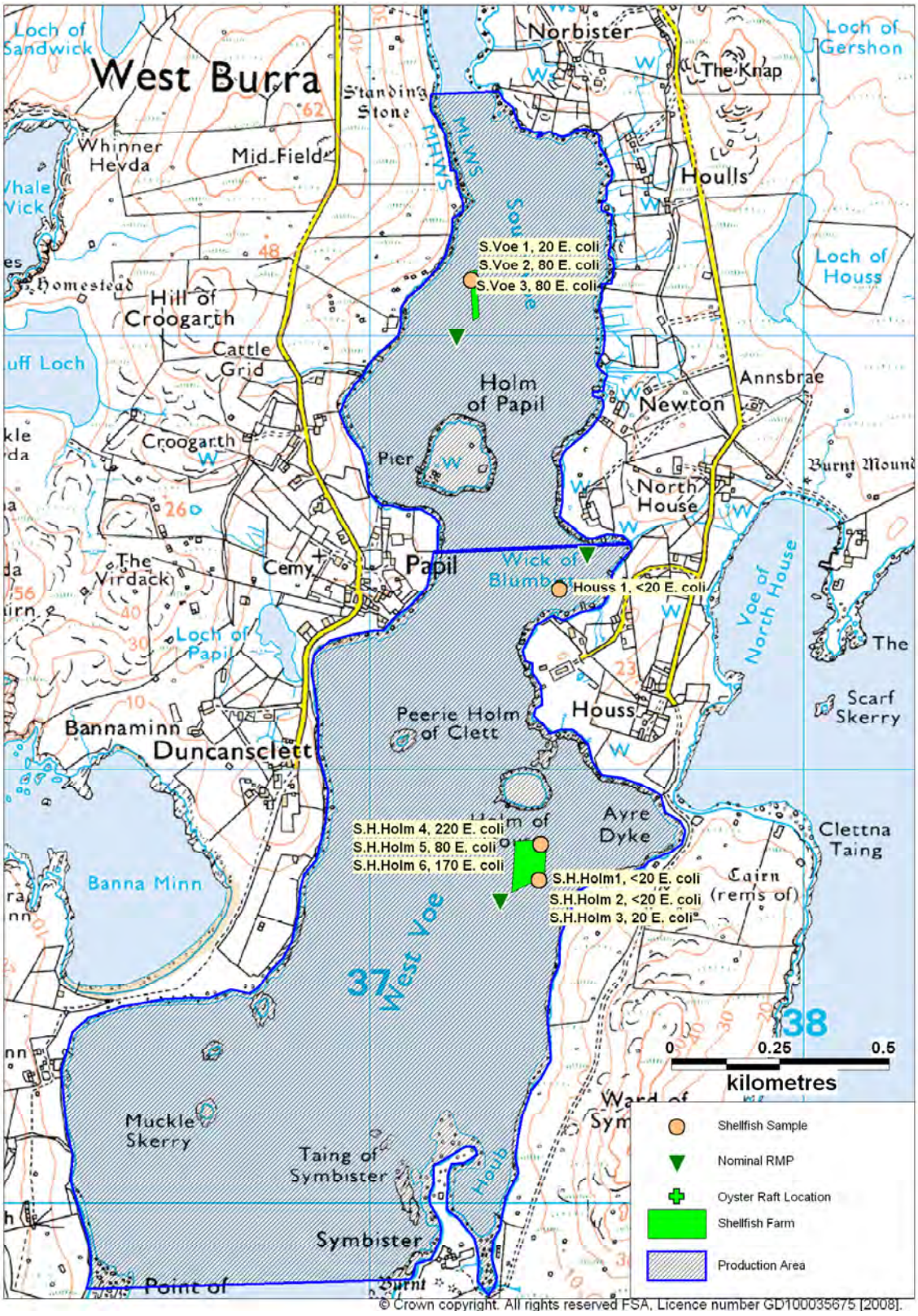


Figure 5. Shellfish sample results map

Photographs

Figure 6. Septic tank, Toogs

Figure 7. Vacuum Sewer, Toogs

Figure 8. Bridge at Bridge End, viewed from north west bank.

Figure 9. View south across road from same vantage point as Figure 8.

Figure 10. Marina at Bridge End looking toward west.

Figure 11. Discharge pipe behind toilet block.

Figure 12. Homes, mooring buoys looking west across South Voe.

Figure 13. South Voe mussel lines.

Figure 14. View of mussel lines at South of Houss Holms, looking south from waypoint 18.

Figure 15. View of SE corner of South of Houss Holm mussel farm.

Figure 16. Septic pipe from house, waypoint 37.

Figure 17. Jetty, photo looking west from waypoint 38.

Figure 18. Seotic tank inspection pipe.

Figure 19. Oyster raft.

Figure 20. Discharge pipe from home on shore near oyster raft.

Figure 21. Outfall from freshwater loch, green scum on shoreline.

Figure 22. Discharge pipe, waypoint 97.

Figure 23. Green scum along shoreline.

Figure 24. Outfall with solid waste evident, waypoint 99.

Figure 25. Outfall with grey discharge plume.

Figure 26. Small workboats in bay, waypoint 103.

Figure 27. Discharge pipe adjacent pier, dribbling from end.

Norovirus Testing Summary

South of Houss Holm - Houss
SI 261 739 13

Pacific oyster samples taken from the raft at Houss were submitted for Norovirus analysis quarterly commencing August 2008.

Results are tabulated below. No native oyster samples were submitted for norovirus analysis as there were none on site at the time of sampling.

Ref No.	Date	NGR	GI	GII
08-162	13 Aug 08	HU 37437 31418	Not detected	Not detected
08-196	25 Oct 08	HU 3743 3142	Not detected	Not detected
09-016	21 Feb 09	HU 3743 3142	Positive at limit of detection	Positive
09-107	18 May 09	HU 3743 3142	Not detected	Not detected