Scottish Sanitary Survey Project

Sanitary Survey Report
Streamsound: Whalsies Ayre (SI 518) and Lang Sound (SI 107)
December 2010

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1. General Description

Lang Sound is located off the south west coast of mainland Shetland and separates the smaller islands of West Burra and East Burra. Stream Sound is located north of Lang Sound, forming a channel between Lang Sound and Clift Sound to the east. Both sounds are relatively sheltered as neither is exposed directly to the open sea and both are protected from surrounding land mass. Populated areas around Lang Sound include the small village of Toogs on the western shore, and Bridge End to the south. There are also dwellings along the unnamed road on the western shore. The town of Scalloway lies approximately 4km to the north of Stream Sound.

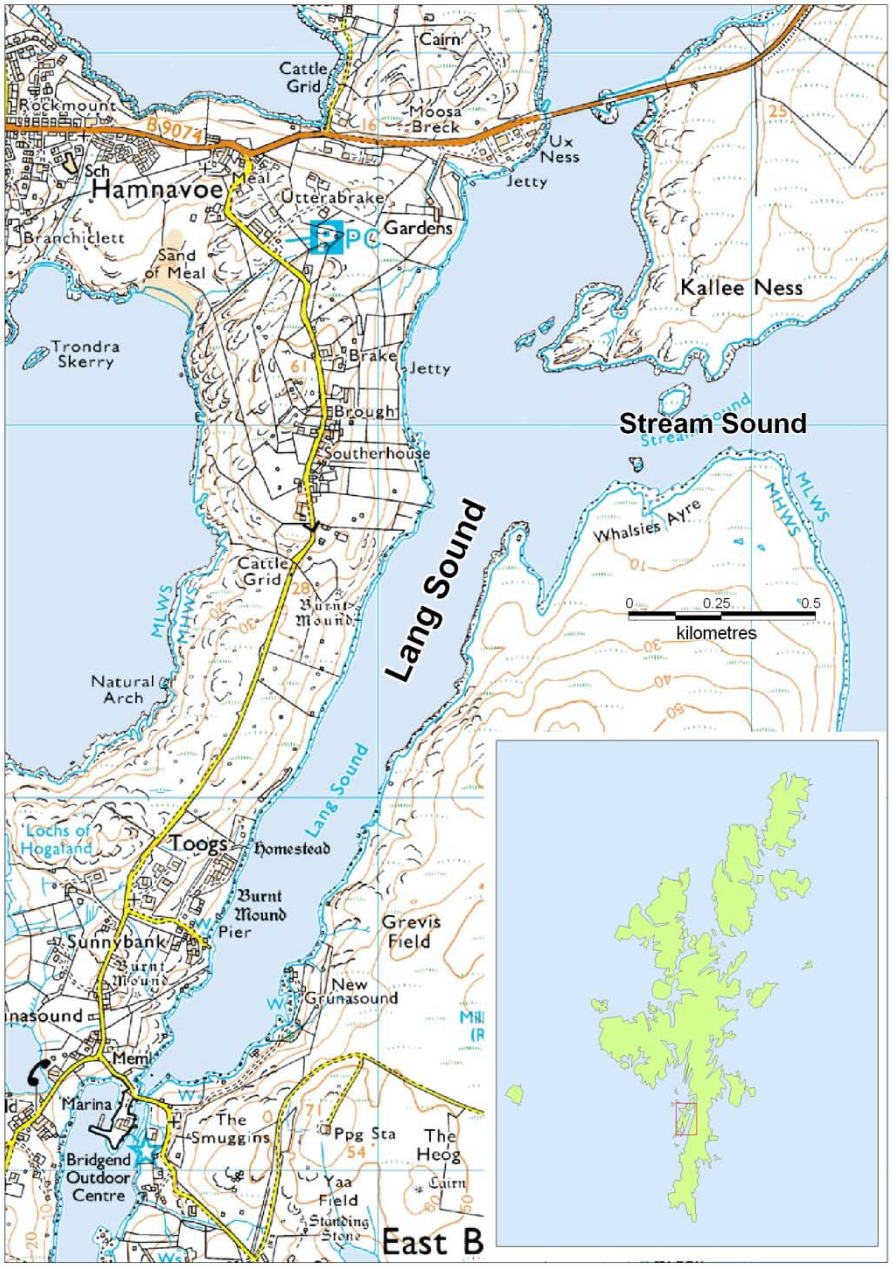

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Figure 1.1 Location of Lang Sound and Stream Sound

2. Fishery

The sanitary survey was prompted by a standard application for classification of a new mussel site in Stream Sound. The site is adjacent to a classified production area, Lang Sound, which has been included in the survey due to its proximity.

Table 2.1 Lang Sound and Stream Sound mussel farms

Production Area	Site	SIN	Species
Stream Sound: Whalsies Ayre	Whalsies Ayre	SI 518 945	Common Mussels
Lang Sound	Lang Sound	SI 107 429	Common Mussels
Not yet specified	New site	Not yet assigned	Common Mussels

The Lang Sound Production area is defined as an area bounded by lines drawn between HU 3813 3480 to HU 3835 3470 extending to mean high water springs (MHWS). The site is classified for mussels as class B from April 2010 to March 2011. The representative monitoring point (RMP) is located at HU 3800 3424.

The new site at Whalsies Ayre (SI 518 945) lies a short distance north of the Lang Sound production area boundary. It is a longline mussel farm, and at the time of survey it consisted of three double-headed long lines with 6 metre droppers at the eastern end and deeper droppers the western end.

The Lang Sound production area was classified at the time of survey for both common mussels and Pacific oysters. At the time of shoreline survey, the long-line mussel farm at Lang Sound (SI 107 429) consisted of nine double-headed long lines with 8 metre deep droppers. The Pacific oyster trestles at Grunnasound (SI 107 756) were no longer present in Lang sound and had reportedly been moved to South Voe. Therefore, the oyster fishery is not considered further in this report.

A further new mussel farm was recently granted planning permission and was due to be installed to the north of the Whalsies Ayre site (location shown in Figure 2.1) at the south end of a lease area that straddles the southern boundary of the Streamsound: Uxness production area. No equipment had been placed on site at the time of shoreline survey, however it is leased by the same harvester as Whalsies Ayre and he requested that both sites be considered in the survey.

To the north of the Lang Sound production area is the Stream Sound: Uxness production area which is classified for common mussels. To the east of the Whalsies Ayre site lies the Clift Sound: Streamsound production area which is also classified for common mussels. These areas were subject to a sanitary survey in 2007, when they were addressed in the sanitary survey for Clift Sound.

Figure 2.1 shows the locations of the shellfish farm locations surveyed in 2010, as well as those noted in 2007 surveys.

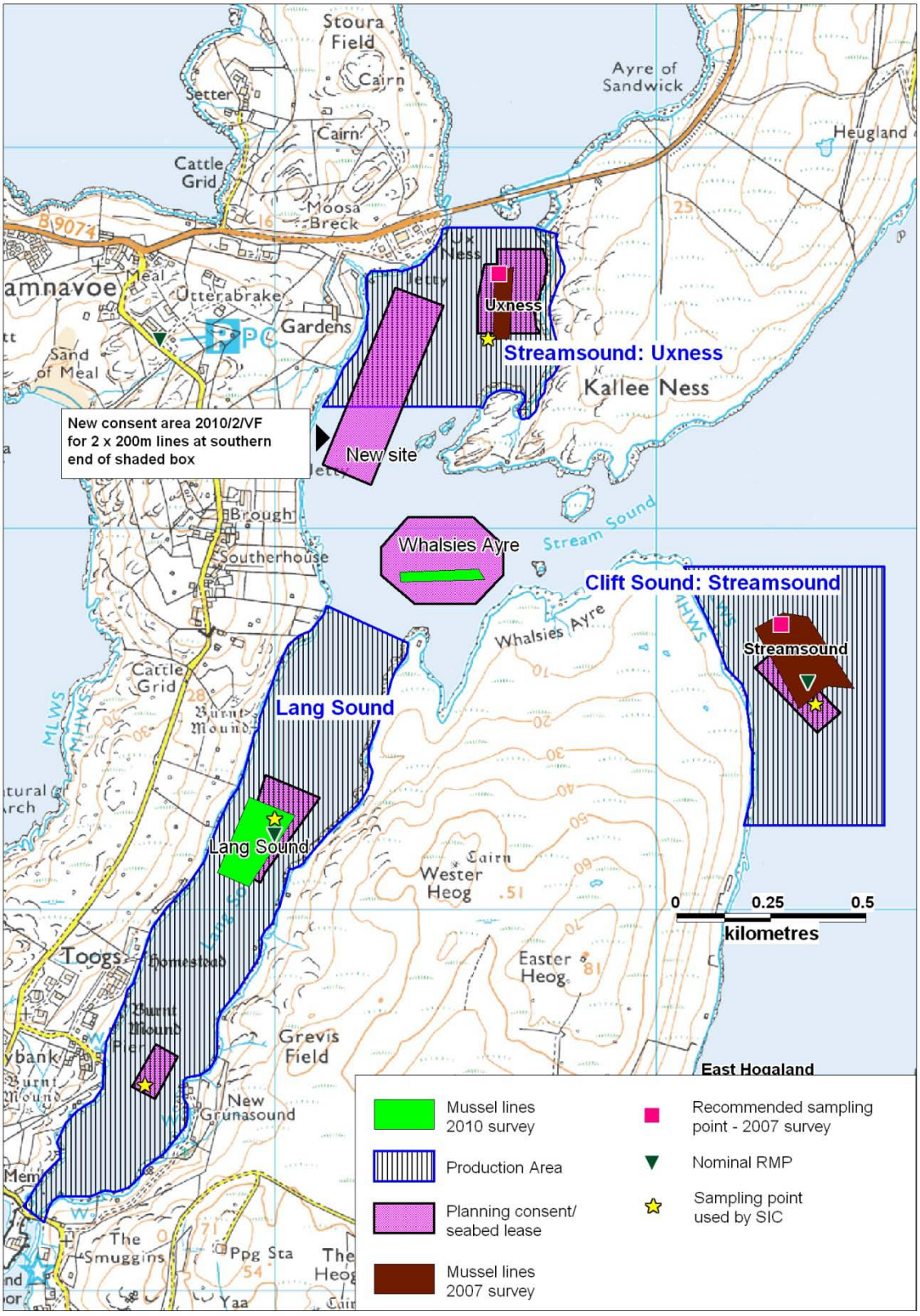

Figure 2.1 Lang Sound and Stream Sound Fisheries

3. Human Population

Figure 3.1 shows information obtained from the General Register Office for Scotland on the population within the census output areas in the vicinity of Stream Sound and Lang Sound. The last census was undertaken in 2001. Census output areas are represented by their reported population, with darker areas indicating areas of higher population.

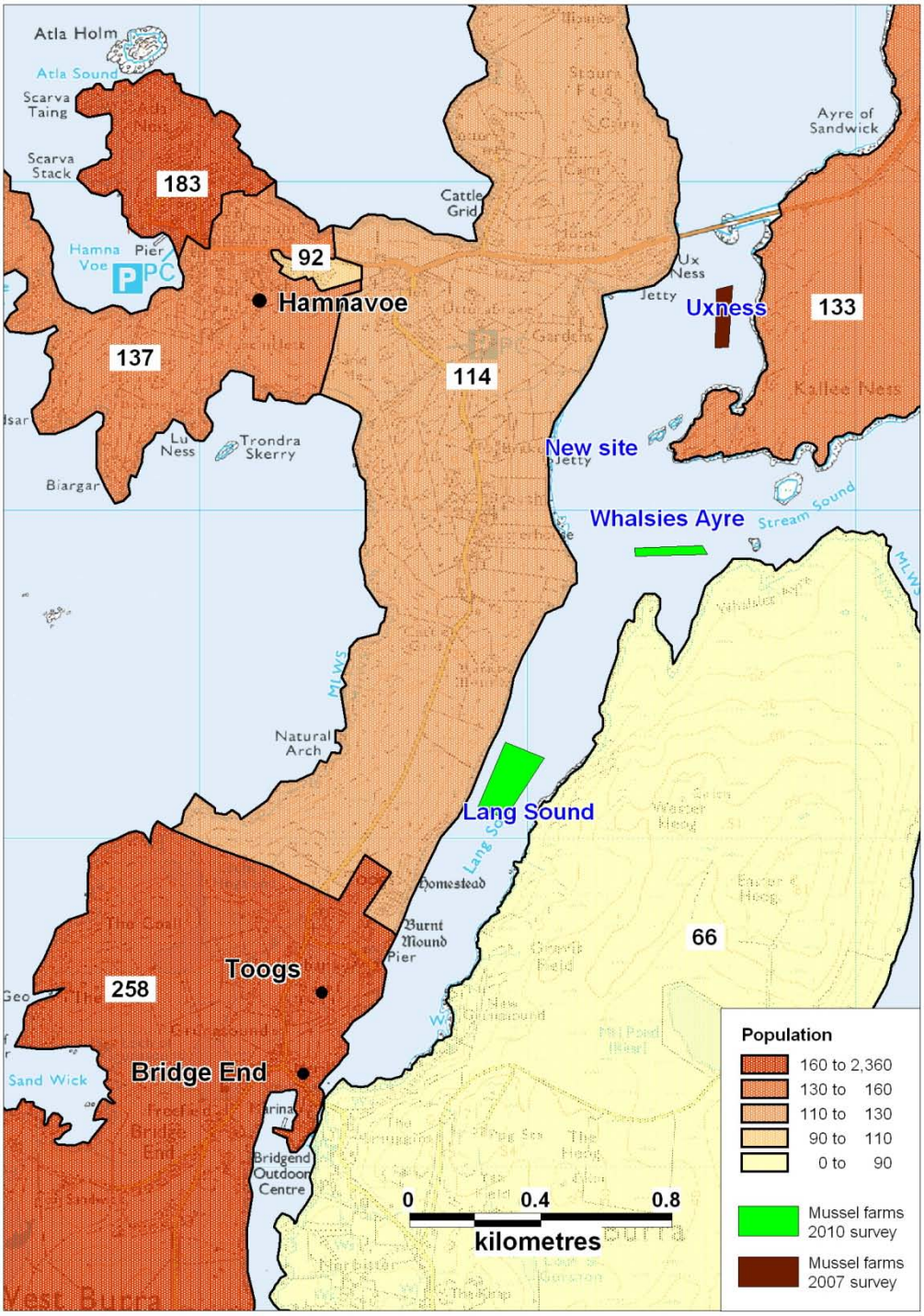

Figure 3.1 Human population adjacent to Lang Sound

Four population census areas immediately border on Lang Sound and Stream Sound. These areas have a total population of 571, however only a small proportion of the population live on or near the shores of the two sounds.

Population adjacent to the fisheries is predominantly confined to the western side of Lang Soundand highest at the southern end, around the settlements of Bridge End and Toogs. Aside from a few homes at the southern end of the sound, there are no homes on the east shore. Homes on small crofts line the northwestern shore up to the Burra bridge north of the Uxness site.

A marina and outdoor activity centre are located at Bridge End, which are located immediately south of the bridge separating Lang Sound from South Voe. Both the marina and the centre are likely to draw additional people to the area during the summer holidays. The outdoor centre has accommodation for up to 26 people and also provides a small area for camping.

Overall, the potential for contamination arising from the human population is highest at the south end of the Sound and intermediate along much of the western shore.

4. Sewage Discharges

Scottish Water identified community septic tanks and sewage discharges for the area surrounding Streamsound and Lang Sound. These are detailed in Table 4.1.

Table 4.1 Discharges identified by Scottish Water

No.	Consent Ref No.	NGR of discharge	Discharge Name	Discharge Type	Level of Treatment	Consented Flow (DWF) m3/d	Consented Design Pop/PE
1	WPC/N/488882	HU 375 336	North Toogs ST, Burra	Continuous	Septic Tank	NA	250
2	CAR/L/1005013	HU 3730 3580	Hulsidale, Burra	Continuous	Septic Tank	18.26	83
3	CAR/L/1002299	HU 3710 3619	Hamnavoe, Burra	Continuous	Septic Tank	80	500
4	WPC/N/48963	HU 3870 3930	Scalloway Maa Ness WWTW	Continuous	Septic Tank	1250	2020
5	CAR/L/1004025	HU 3870 3930	Maa Ness CSO	Intermittent	6mm screen	625	NA
6	CAR/L/1002296	not stated	Bridge End PS	Continuous	Septic Tank	not stated	380

No sanitary or microbiological data were available for these discharges. Of the discharges listed above, only the North Toogs septic tank and the Bridge End Pumping Station emergency overflow discharge to either of the two sounds. The others discharge 4-5 km away (by sea) from the Whalsies Ayre fishery.

A large number of discharge consents have been issued by the Scottish Environment Protection Agency (SEPA) for the area around Stream Sound and Lang Sound. Consents for those discharges to water or land nearest the fisheries are listed in Table 4.2. Scottish Water identified that the names North Toogs and Bridge End both referred to the same septic tank.

Table 4.2 Discharge consents identified by SEPA

No.	Ref No.	NGR of discharge	Discharge Type	Level of Treatment	Consented flow (DWF) m^3/d	Consented/ design PE	Discharges to
1	CAR/L/1002298	HU 3759 3368	Continuous	untreated	1	-	Lang Sound
2	CAR/L/1002296	HU 3780 3390	Continuous	primary	-	380	Lang Sound
3	CAR/R/1061259	HU 3810 3474	Continuous	septic tank	-	5	Lang Sound
4	CAR/R/1069341	HU 3789 3488	Continuous	septic tank	-	-	soakaway
5	CAR/R/1039604	HU 3807 3523	Continuous	septic tank	-	5	Lang Sound
6	CAR/R/1039608	HU 3807 3523	Continuous	septic tank	-	5	Lang Sound
7	CAR/R/1039614	HU 3807 3523	Continuous	septic tank	-	7	Stream Sound
8	CAR/R/1038753	HU 3775 3550	Continuous	septic tank	-	13	soakaway
9	CAR/R/1036662	HU 3756 3567	Continuous	septic tank	-	5	soakaway
10	CAR/R/1036623	HU 3756 3569	Continuous	septic tank	-	5	soakaway
11	CAR/R/1039724	HU 3772 3574	Continuous	septic tank	-	12	soakaway
12	CAR/R/1005013	HU 3736 3585	Continuous	septic tank	-	-	Atlantic ocean
13	CAR/R/1002299	HU 3710 3619	Continuous	septic tank	-	-	Atla Ness
14	CAR/L/1004025	HU 3870 3921	Continuous	septic tank	-	2850	Bur Wick

There is some disagreement between records for the North Toogs septic tank discharge (Item 1 in Tables 4.1 and 4.2). The Scottish Water records give a consent reference WPC/N/488882. These consents are being converted to CAR/L designated consents by SEPA, who have given a current consent reference of CAR/L/1002298 for this discharge. SEPA have recorded the discharge as untreated whilst Scottish Water records show that it is treated by septic tank. This

would make a difference to the final effluent quality, as septic tank treatment significantly reduces the concentration of faecal bacteria present in the final effluent under base flow conditions (Kay *et al*, 2008). A further septic tank discharge to Lang Sound is reported by SEPA to be located north of the Toogs discharge, at the centre of the sound 200 m south of the Lang Sound mussel farm.

Sewage infrastructure recorded during the shoreline survey is listed in Table 4.3. During the 2008 survey at South Voe, a number of discharges were observed at the north end of the voe nearer to Lang Sound. As South Voe and Lang Sound are connected via a channel at Bridge End, contamination may move between the two. As no discharge consents were received from SEPA for discharges to the northern end of South Voe, it was deemed relevant to include the 2008 observations in Table 4.3. It is presumed that the observed discharges are still in place.

Table 4.3 Discharges and septic tanks observed during shoreline surveys

No.	Discharge consent	Date	NGR	Description
1	CAR/R/1039614, CAR/R/1039604, CAR/R/1039608	11/05/2010	HU 3807 3522	Two discharge pipes, 1 flowing but too slowly to record. Evidence of sewage fungus, odour.
2	CAR/L/1002296	11/05/2010	HU 3766 3393	Sewage pipe, signposted outfall, manhole, pumping station
3	CAR/L/1002298	11/05/2010	HU 3755 3365	Pipe, 13cm outer diameter.
4	WPC/N/488 882 (possible)	11/05/2010	HU 3753 3357	Septic tanks. Broken pipe with small trickle, to low flow to measure
5	-	12/05/2010	HU 3776 3339	Possible septic tank discharge 9.5cm diameter. However no houses above pipe.
6	-	12/05/2010	HU 3776 3354	Also septic tank outlet pipe
7	-	12/08/2008	HU 3733 3310	Outfall pipe, flowing
8	-	12/08/2008	HU 3749 3290	Septic tank
9	-	13/08/2008	HU 3735 3299	Septic tank
10	-	13/08/2008	HU 3736 3293	Septic tank inspection pipe, flowing
11	-	13/08/2008	HU 3736 3291	Inspection cover, no apparent pipes
12	-	14/08/2008	HU 3723 3324	Outfall pipe, foul odour
13	-	14/08/2008	HU 3722 3325	Vacuum sewer marker, septic tank and outfall pipe, flowing
14	-	14/08/2008	HU 3718 3319	Septic tank and dry outfall pipe
15	-	14/08/2008	HU 3716 3312	Two outfall pipes, one underwater extending 3 m out from cliff face the other above water and dry
16	-	14/08/2008	HU 3715 3310	Septic discharge
17	-	14/08/2008	HU 3726 3325	Inspection cover
18	-	14/08/2008	HU 3711 3306	Air vent and inspection cover for septic tank
19	-	14/08/2008	HU 3714 3307	Plastic outfall pipe
20	-	14/08/2008	HU 3714 3306	Iron outfall pipe
21	-	28/08/2008	HU 3714 3311	Tank covers
22		17/05/2007	HU 3873 3579	Fish shed, 3 boats
23		17/05/2007	HU 3836 3568	Pipe from Scottish Seafarms shorebase, not flowing at time.

Not all of the observations pertain to active discharges. In some cases, only a septic tank or cover was observed. These may discharge to soakaway or may be

related to other sewage infrastructure noted nearby. Two fishery shore bases located at Uxness were considered likely to have staff toilets and septic tanks, even though no registrations were on file with SEPA. The majority of observed septic tanks and discharges were located along the western and southern shores of Lang Sound. The area around Hamnavoe was not included in the shoreline survey, however the two community discharges at Hamnavoe discharge to the Atlantic ocean and are sufficiently distant that they are not considered likely to be a significant source of direct contamination to the fishery.

Clarification was sought from both Scottish Water and SEPA regarding the locations of sewerage assets in the area. SEPA identified that a vacuum system with no associated EO was installed under CAR/L/1002296 and that this incorporated CAR/L/1002298, though the license was not surrendered. A grid reference was provided for the pumping station, HU 3765 3387, which plots approximately 60 m south of the shoreline survey observation and lies approximately 150 m WSW of the reported outfall location. Scottish Water confirmed that pumping station and outfall were active and lay approximately 30 meters from the septic tank.

Based on this information, and satellite imagery of the area, the location reported by Scottish Water for the North Toogs ST may actually be redundant. This tank may have been disconnected when the vacuum sewerage system was installed. There appeared to be a septic tank a short distance from the pumping station north of Toogs in a satellite image of the area. The discharge pipe at this location (Table 4.2, Number 2) is presumed to be the final effluent discharge. The consented final effluent discharge location (CAR/L/102296) lies 200 m south of the Lang Sound mussel farm. With primary treatment, the maximum combined daily loading expected for this discharge would be approximately 6.1 x 10^{12} faecal coliforms per day, calculated based on average loading at base flow levels (Kay *et al*. 2008) and average water use of 160 litres/person^{-day}. This would be expected to have a deleterious impact on water quality at the southern end of the Lang Sound mussel farm and would be expected to contribute to background levels of faecal contamination in the sound as a whole.

Three private septic tanks with a combined PE of 17 discharge to a single pipe located along the northern shore of the sound immediately to the west of where the new site is likely to be situated. This discharge would be expected to have a localised impact on water quality that may affect the new mussel farm site, depending on where it is installed. Further discharges to the northwest are to soakaway, and these are considered unlikely to impact water quality at the fisheries unless malfunctioning.

The majority of the observed and/or consented discharges to Lang Sound, as well as those to the north end of South Voe, lie south of the Lang Sound mussel farm. The discharges to South Voe can be carried into Lang Sound when water flows northward through the channel under the bridge. These are all likely to impact overall water quality in Lang Sound, but would be expected to have the greatest impact locally to the discharges.

Overall, the number of discharges to Lang Sound is anticipated to cause a general increase in background levels of faecal contamination present in the sound.

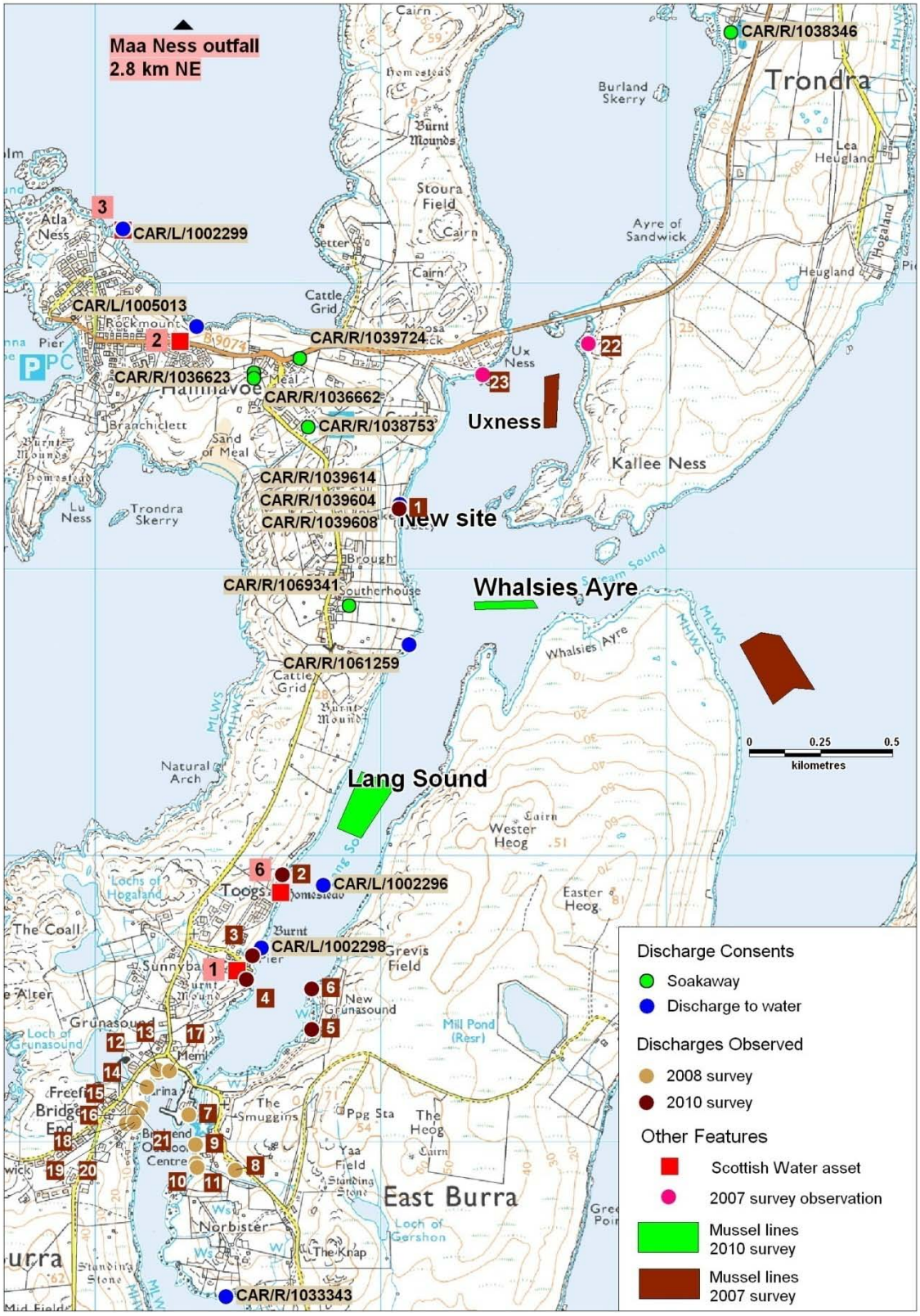

Figure 4.1 Map of discharges for Lang Sound

5. Geology and Soils

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

Figure 5.1 Component soils and drainage classes for Lang Sound/Stream Sound

The island of West Burra, which borders the western side of the Lang Sound mussel fishery, is covered predominantly by poorly draining soils with the exception of an area of well-drained calcareous soils at Hamnavoe. The islands of East Burra and Trondra, which border the eastern side of Lang Sound, contain freely-draining soils in the area adjacent to the fishery. Therefore, the potential for rainfall runoff contaminated with *E. coli* from human and/or animal waste is higher along the western side of the fishery, where the poorly-draining soils will lead to greater runoff. The impact to the fisheries will be highest where they approach streams or other sites of land-runoff along the western side of the sound.

6. Land Cover

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

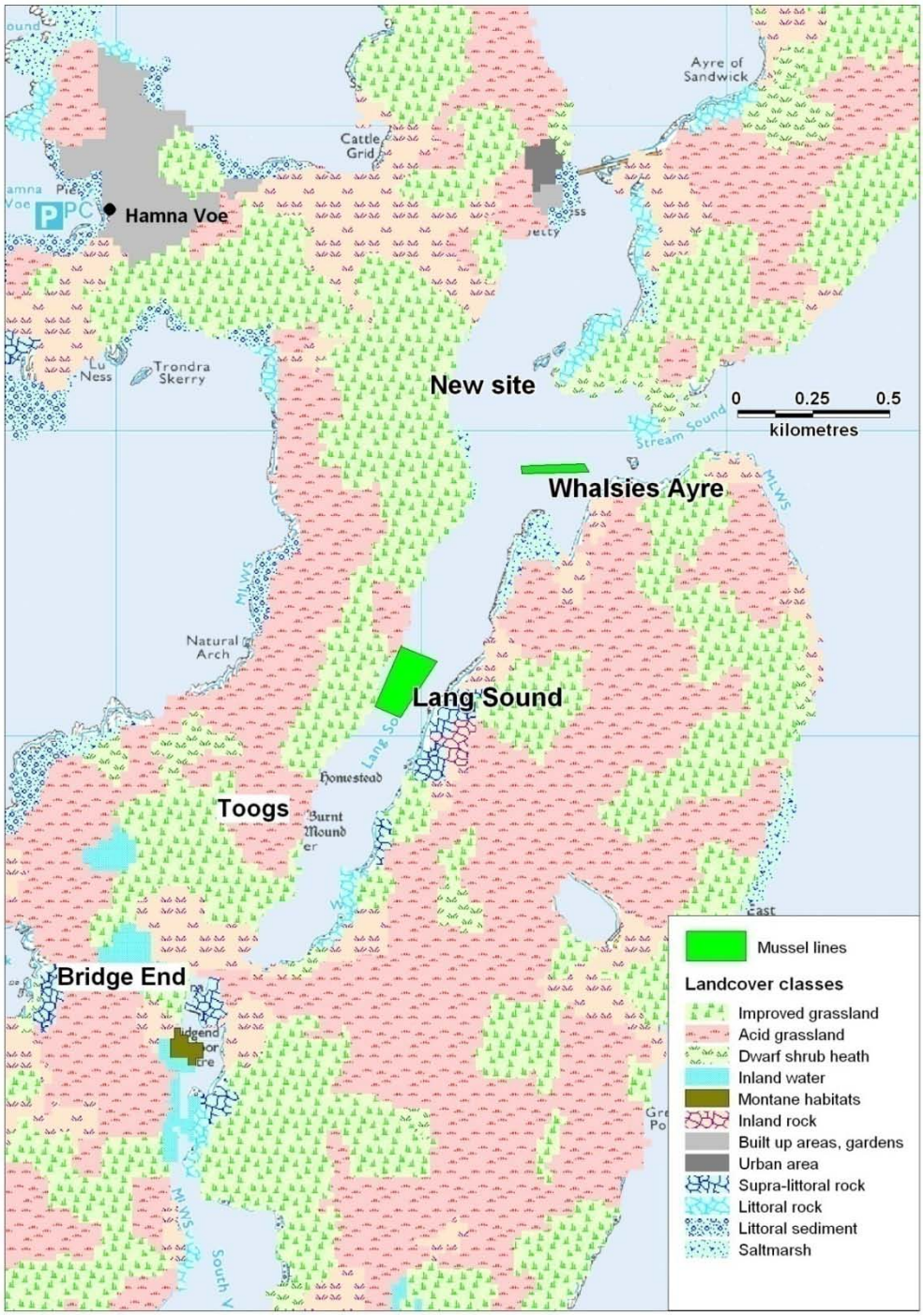

Figure 6.1 LCM2000 class land cover data for Lang Sound

The land on the west side of the fishery is predominantly improved grassland along the shore of Lang Sound with acid grassland further west. On the eastern side of the fishery landcover is predominantly acid and improved grassland with smaller

areas of heath and salt marsh. A fairly large area of littoral and supra-littoral rock is shown opposite the Lang Sound mussel farm.

The LCM2000 built up area at the north end of Lang Sound roughly corresponds with a small industrial area associated with an aquaculture shore base. The area identified as urban just to the north of the built up area in Figure 6.1 corresponds with an area of rocky ground that could have been mistaken for urban in satellite imagery. A small area of montane habitat and larger areas of inland water bordering the shores of the voe to the south of Lang Sound are also erroneously identified.

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.

The built up area at the north end of the sound would contribute the highest faecal coliform loading, and this would impact predominantly the north end of the sound. Although not identified as built up on the Landcover map, areas of hardstanding around the combined settlements of Toogs and Bridge End would be considered developed area in the context of faecal coliform contribution from runoff. These developed areas would impact most predominantly at the south end of Lang Sound, to the south of the fishery. Contributions from improved grassland along the west shore is likely to affect both the Lang Sound and the new site as they lie closest to this type of shoreline and will be most immediately impacted by contaminated runoff from it. Therefore, the overall predicted contribution of contaminated runoff from these land cover types would be intermediate, and would be expected to increase significantly following rainfall events.

7. Farm Animals

Agricultural census data was requested for the parishes Burra Isles and Tingwall from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD). The two parishes encompass land area of 14.10 km^2 and 65.46 km^2 respectively. Reported livestock populations for the parishes in 2008 and 2009 are listed in Table 7.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data. Any entries which relate to less than five holdings, or where two or fewer holdings account for 85% or more of the information, are replaced with an asterisk.

Table 7.1Livestock numbers in Burra Isles and Tingwall parishes 2008 - 2009

	Burra Isles				Tingwall			
	2008		2009		2008		2009	
	Holdings	Numbers	Holdings	Numbers	Holdings	Numbers	Holdings	Numbers
Pigs	0	0	0	0	*	*	*	*
Poultry	15	185	18	244	11	220	11	221
Cattle	*	*	*	*	8	336	8	298
Sheep	50	3845	51	3901	38	13174	40	13803
Horses and ponies	5	17	5	17	13	129	13	97

* Data withheld for reasons of confidentiality

Cattle are noted to be present in Burra Isles, and though data have been withheld it is highly likely that those numbers present will be significantly lower than in Tingwall parish. In both parishes, sheep are by far the most numerous animals with the number of holdings and total animals increasing in Burra Isles between 2008 and 2009. In Tingwall, small decreases in cattle and ponies were offset by a larger increase in the number of sheep.

Tingwall parish stretches 20km north to south and over 6.5 km east to west at its widest point and encompasses an area of 65.5 km^2. Only the extreme southern end of the parish borders Lang Sound. The parish of Burra Isles encompasses the islands of East Burra and West Burra and a number of smaller islands, the largest of which are Papa, Oxna, and South Havra. It covers a total land area of 14.1 km^2. The majority of the land surrounding Lang Sound falls within the Burra Isles parish, however this still only represents a small proportion of the total parish area. Therefore, the livestock population data provided for these parishes is not an accurate reflection of the number of animals likely to be contributing to diffuse faecal pollution occurring with Lang Sound. Consequently, the shoreline survey observations provide more relevant data with regard to livestock presence in the area around the mussel fisheries in the sound. These observations pertain to the date of survey only and are dependent upon the point of view of the observer at the time, however.

Sheep were the most common animal observed, with a total of 163 noted the majority of which were located around the southern end of the sound. Sheep dung

was observed on the shoreline west of the Whalsies Ayre and new sites, though the number of animals along this shore was just over one quarter of the total.

Ponies and their droppings were observed at Kallee Ness, north of the Whalsies Ayre site and east of the new site as well as at the southern end of the sound. Pony manure was found dumped on the shoreline near the farm on the southeast shore.

The only other livestock observed in the area were a small number of domestic geese seen near the farm southeast of the Lang Sound mussel site. The distribution of animals observed during the shoreline survey is shown in Figure 7.1.

Sheep are likely to be present over much of the area during the course of the year as they are moved to take advantage of rough grazing areas. Numbers are likely to be significantly higher in summer, when lambs are present, than during winter. Sheep and pony faeces are likely to be a significant source of faecal bacteria to rainfall runoff from land adjacent to the fishery.

Overall, the impact of livestock droppings on water quality in the sound is likely to be highest at the southern end of the sound particularly along the eastern shore. Impacts to the new fisheries near Whalsies Ayre are likely to come from sheep on crofts to the west and ponies on Kallee Ness to the north. Impacts to the new site are likely to come from the sheep on the west shore and as it is situated close to that shore.it is likely to be more impacted from this source than the Whalsies Ayre site.

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

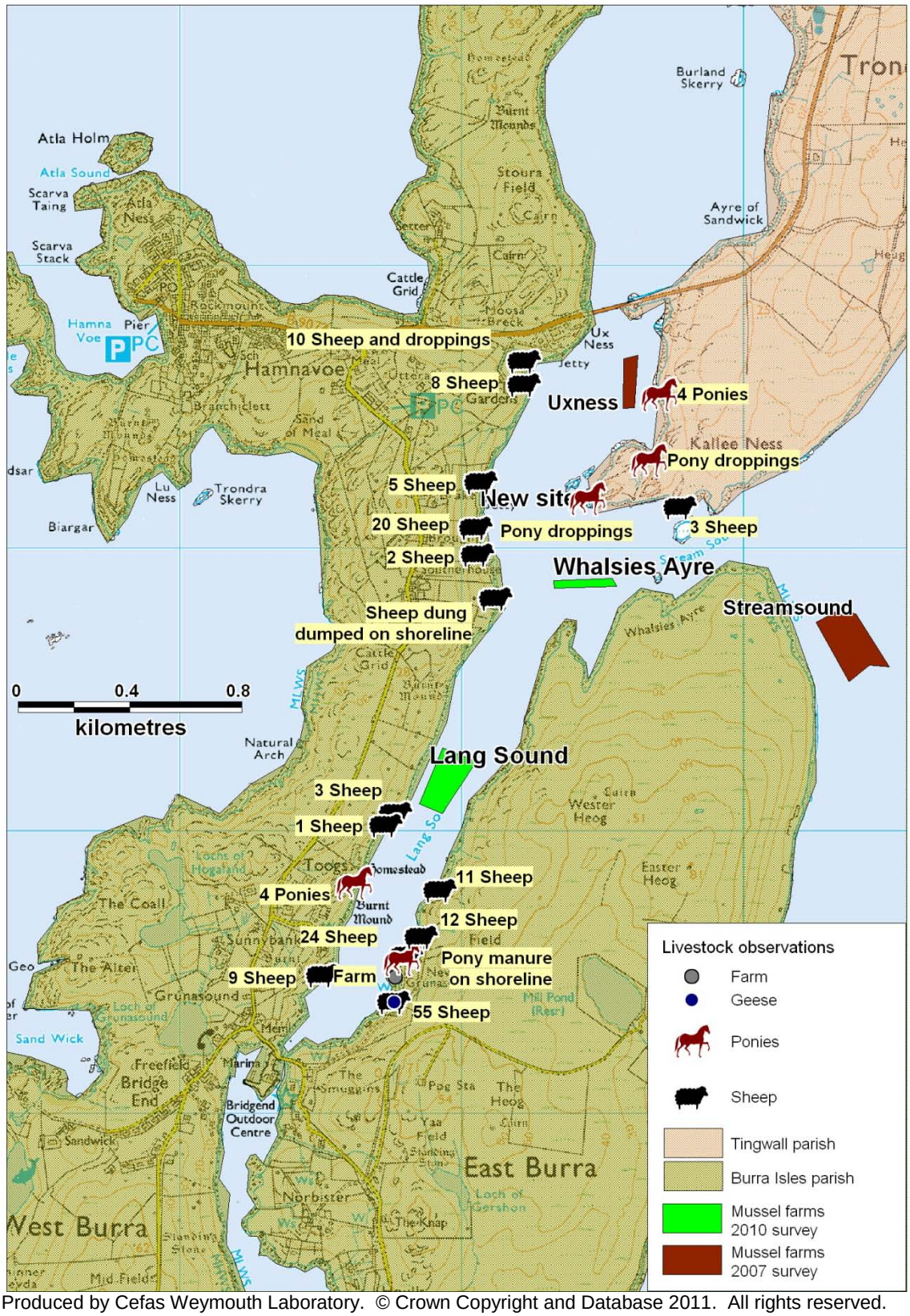

Figure 7.1 Livestock observations at Lang Sound

8. Wildlife

There are no designated conservation areas near Lang Sound and Stream Sound.

General information related to potential risks to water quality by wildlife can be found in Appendix 4. A number of wildlife species present or likely to be present at Aith Voe and East Burra Firth could potentially affect water quality around the fisheries.

Seals

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

There are no identified breeding colonies of seals located within or near Lang Sound. The nearest identified haulout site is south of the Lang Sound, at the south end of South Voe, though this is over 10 km away by sea. However, these animals are likely to be found foraging in or around the sound. Five seals were observed near the north end East Burra during the shoreline survey, indicating that the animals are present in the vicinity of the fishery. One seal was observed hauled out on a float at the Whalsies Ayre mussel farm.

The bacteriological impact from these animals is difficult to estimate both in terms of magnitude and timing. However, if seals are routinely present in the area then they would be expected to contribute in some way to background levels of contamination present in the sound. Seals defecating directly onto the mussel lines from the floats could potentially cause a highly localised increase in contamination in the vicinity of the float. If a particular float or location within the mussel farm were to be a favoured haulout area by one or more animals, this could result in a potentially significant impact to the lines nearest the float.

Whales/Dolphins

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

Otters

No otters were seen during the shoreline survey at Lang Sound, although otters are known to be present around much of Shetland. The typical population densities of coastal otters are low and so if present in the area, their impacts on the shellfishery would be expected to be very minor.

Birds

A number of seabird species breed in Shetland. These were the subject of a detailed census carried out between 1998 and 2002. Total counts of all species recorded within 5 km of the mussel lines are presented in Table 8.1. Where counts are of pairs of birds, the actual number of breeding adults will be double. This data is thematically mapped in Figure 8.1.

Table 8.1 Seabird counts within 5km of the Langsound/Streamsound mussel sites.

Common name	Species	Count	Method
Black Guillemot **(r)**	*Cepphus grylle*	95	Individuals on land
Northern Fulmar **(r)**	*Fulmarus glacialis*	1056	Occupied sites
Herring Gull **(r)**	*Larus argentatus*	329	Occupied nests/Occupied territory
Common Gull	*Larus canus*	57	Occupied nests/Occupied territory
Lesser Black-backed Gull	*Larus fuscus*	31	Occupied territory
Great Black-backed Gull **(r)**	*Larus marinus*	74	Occupied nests/Occupied territory
Black-headed Gull	*Larus ridibundus*	1	Occupied territory
European Shag **(r)**	*Phalacrocorax aristotelis*	6	Occupied nests/Occupied sites
Kittiwake **(r)**	*Rissa tridactyla*	173	Occupied nests
Arctic skua	*Stercorarius parasiticus*	13	Occupied territory
Great Skua	*Stercorarius skua*	73	Occupied territory
Arctic Tern	*Sterna paradisaea*	746	Occupied nests/Occupied territory

(r) – resident population

A significant number of seabird nesting sites are present in the area around Lang Sound. However, there are relatively few bordering on the sound itself. These sites are typically occupied during the summer months when eggs and/or chicks are present. Once the chicks have fledged, most species disperse. Therefore impacts from faeces deposited around the nesting sites are likely to be highest during the summer months and after rainfall. In addition to faeces deposited at the nesting site, direct deposition to water is likely to occur as adult birds venture away from the nest to feed. Seabirds, particularly gulls, shags, and terns, are use the floats used on mussel farms as resting sites and so are likely to deposit faeces on or near the floats.

In addition to seabirds, domestic geese (and goose droppings) were observed at the farm on the southeast shore of Lang Sound. However, both resident and migrating wild geese can be regularly found grazing on fields around the Shetland Islands and therefore may be present at some times along both sounds. There is little suitable shoreline for wading birds in the sound, so they are unlikely to be present in large numbers. As this area is not surveyed as part of the Wetland Bird Survey (WeBS), no records were available on the presence or numbers of either wading birds or wildfowl at Lang Sound.

Conclusions

Wildlife species most likely to contribute faecal matter to the waters around the fishery are seabirds and seals. Both birds and seals were observed at or near the fishery during the shoreline survey and significant populations of both are present in the wider area around Lang Sound. Although there are breeding sites in the area, seabirds may be present on the mussel floats year-round and so may pose a risk from direct deposition to the water around the mussel farms. Seals are likewise present in the area year-round and may also rest on mussel floats, thereby posing a risk of contamination to the lines in the vicinity of the floats. However, these impacts are likely to be limited in duration. The numbers of seabirds present in the area will be higher in summer and faecal material from the nest sites can be washed into the surrounding waters by rainfall runoff.

Figure 8.1 Map of seabird distributions and wildlife observations

9. Meteorological data

The nearest weather station is located at Lerwick, approximately 8 km to the north east of the production area, for which uninterrupted rainfall data was available for 2003-2009. Wind data was also available from this station. It is likely that overall wind and rainfall patterns are similar at Lerwick and Stream Sound/Lang Sound. However, differences in local topography may skew wind patterns in different ways, and conditions at any given time may differ somewhat due to the distance between them. This section aims to describe the local rain and wind patterns and how they may affect the bacterial quality of shellfish at Stream Sound/Lang Sound.

9.1 Rainfall

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

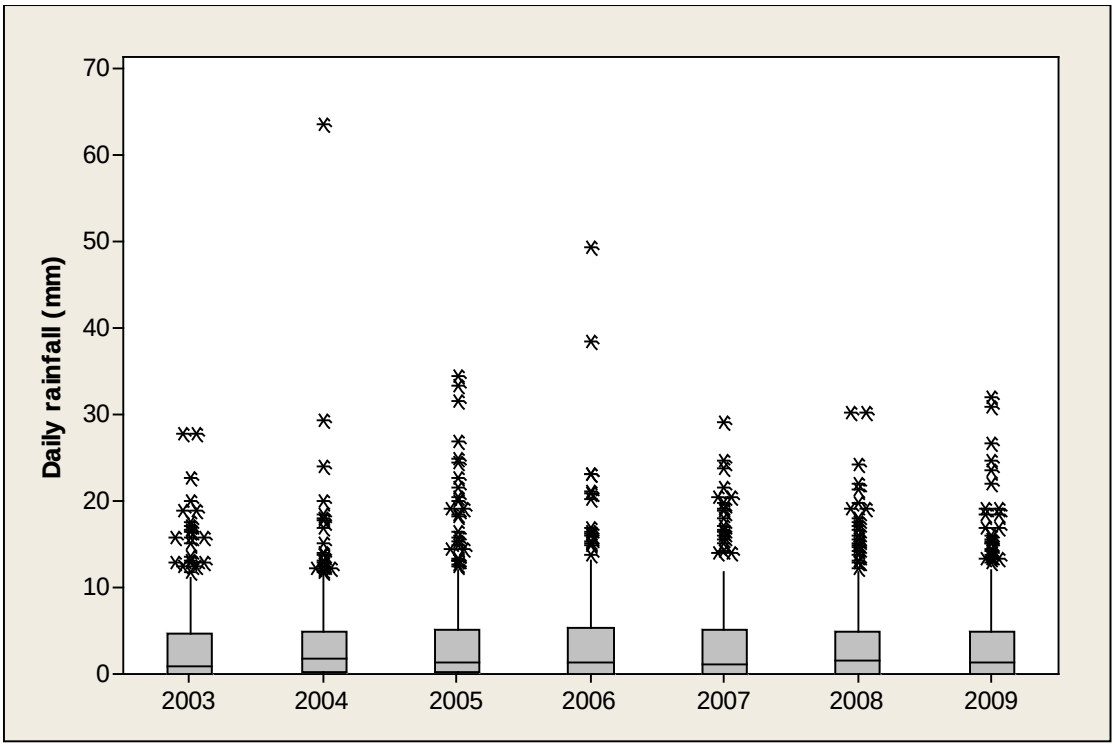

Figure 9.1 Box plot of daily rainfall values by year at Lerwick, 2003-2009

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

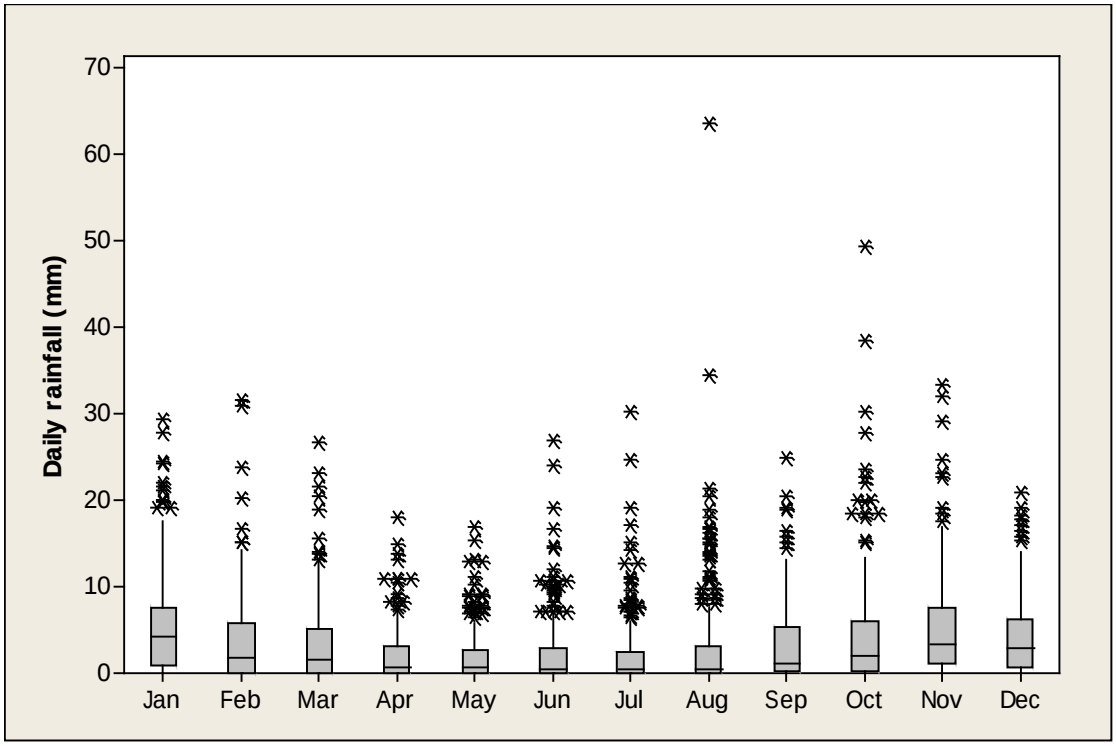

Figure 9.2 Box plot of daily rainfall values by month at Lerwick, 2003-2009

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

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

9.2 Wind

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

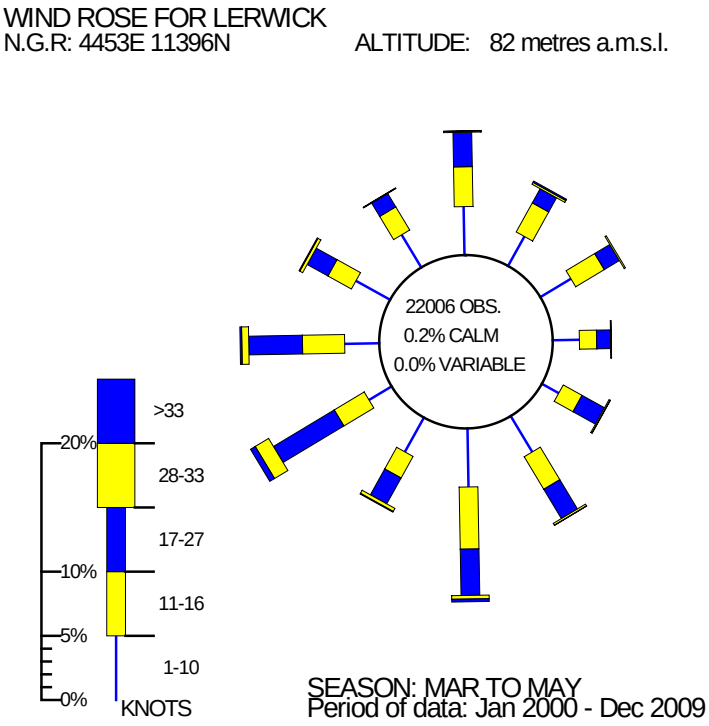

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Figure 9.3 Wind rose for Lerwick (March to May)

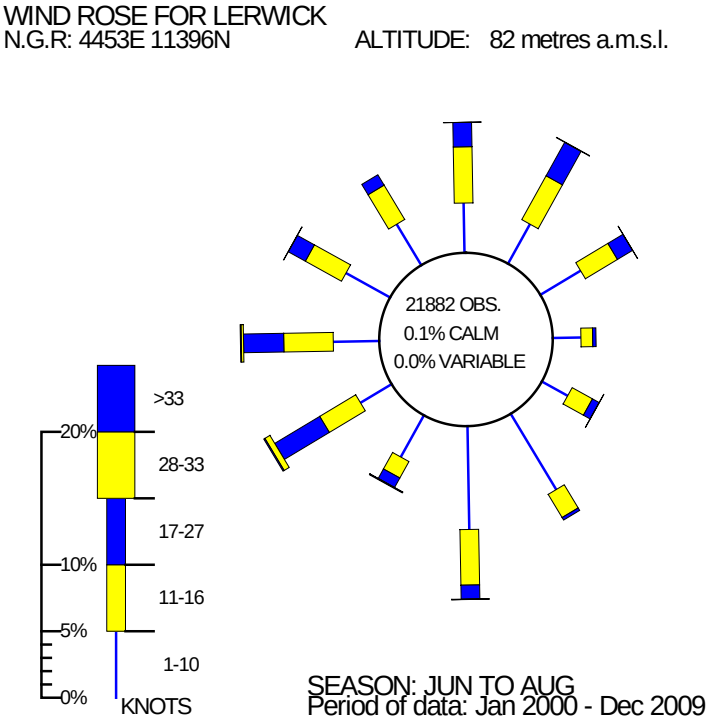

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Figure 9.4 Wind rose for Lerwick (June to August)

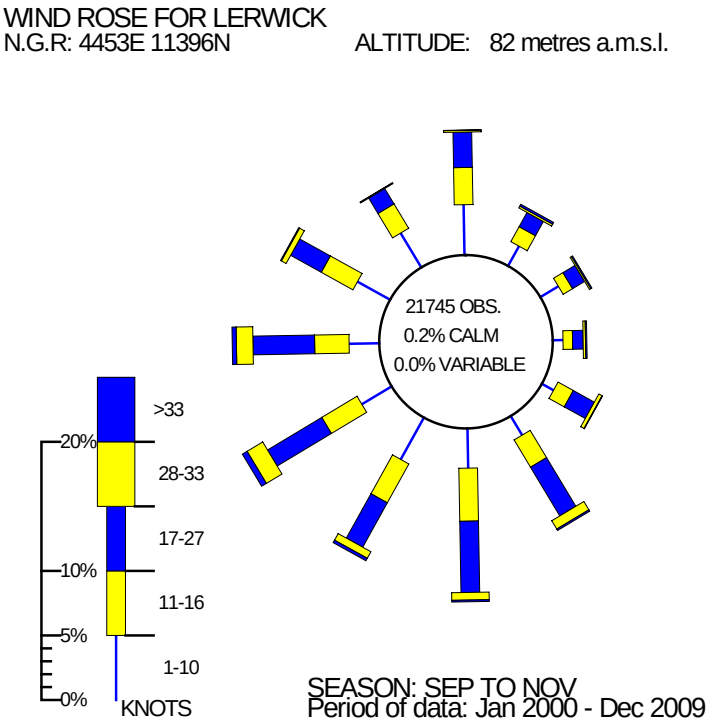

Figure 9.5 Wind rose for Lerwick (September to November)

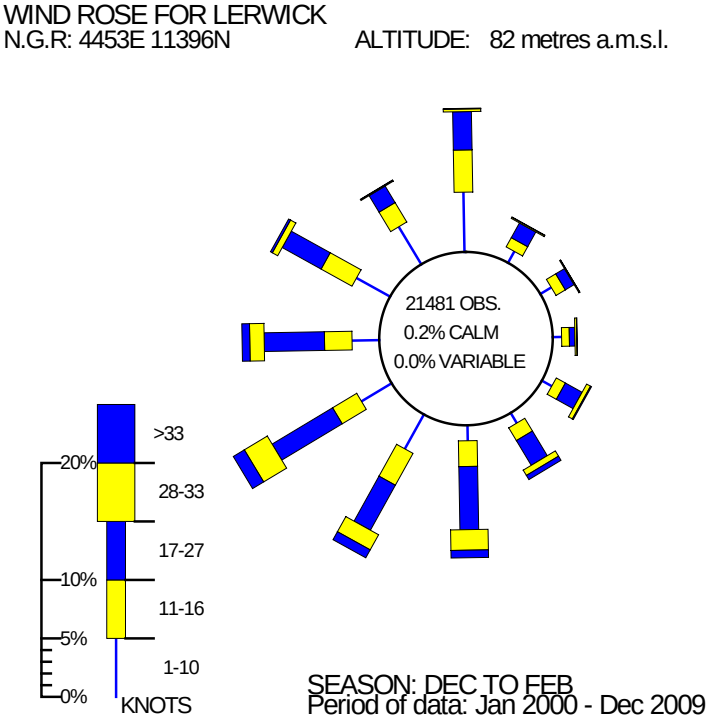

Figure 9.6 Wind rose for Lerwick (December to February)

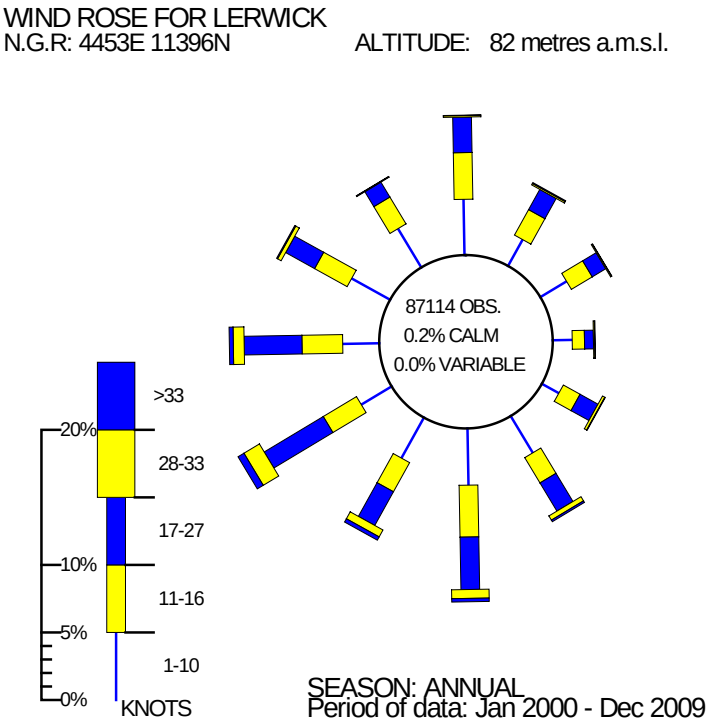

Figure 9.7 Wind rose for Lerwick (All year)

The prevailing wind direction at Lerwick is from the south and west, but wind direction often changes markedly from day to day with the passage of weather systems. There is a higher occurrence of north easterly winds during the summer. Winds are generally lightest in the summer and strongest in the winter. Lang Sound has a north-south orientation and so would be most exposed to winds from either of these directions. Stream Sound has an east-west orientation and would be most exposed to winds from the east. Wind patterns in the area would be expected to be affected by the surrounding land and may differ between the Whalsies Ayre site, which is more exposed to the east and the Lang Sound site, which is far more sheltered.

Winds typically drive surface water at about 3% of the wind speed (Brown, 1991) so a gale force wind (34 knots or 17.2 m/s) would drive a surface water current of about 1 knot or 0.5 m/s. Therefore strong winds, particularly those from the directions to which it is most exposed will significantly alter the pattern of surface currents at within Stream Sound/Lang Sound.

Strong winds may affect tide height depending on wind direction and local hydrodynamics. A strong wind combined with a spring tide may result in higher than usual tides, which will carry accumulated faecal matter from livestock, at and above the normal high water mark, into the production area.

10. Current and historical classification status

Classification records for common mussels at Lang Sound were available back to 2005 and are presented in Table 10.1

Table 10.1 Classification history, Lang Sound Common Mussels

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2005	B	B	B	B	B	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	B	B	B	B	B	B	B	B	B
2010	B	B	B	B	B	B	B	B	B	B	B	B
2011	B	B	B									

The area was classified year-round A for mussels from 2006 to 2008, and then in 2009 the classification was downgraded to B year-round.

The area was classified for Pacific oysters in 2007 and the classification history is presented in Table 10.2.

Table 10.2 Classification history, Lang Sound Pacific oysters

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2007				B	B	B	B	B	B	B	B	B
2008	B	B	B	B	B	B	B	B	B	B	B	B
2009	B	B	B	B	B	B	B	B	B	B	B	B
2010	B	B	B	B	B	B	B	B	B	B	B	B
2011	B	B	B									

Streamsound: Whalsies Ayre has not previously been classified.

11. Historical *E. coli* data

11.1 Validation of historical data

All shellfish samples taken from the Lang Sound production area from the beginning of 2002 up to the 20th May 2010 were extracted from the database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. Only 5 samples were recorded as taken from Streamsound: Whalsies Ayre.

All samples were received by the testing laboratory within two days of collection. A total of 4 samples had an invalid result recorded and so could not be used in the analysis. A total of 19 samples had the result reported as <20, and were assigned a nominal value of 10 for statistical assessment and graphical presentation.

All *E. coli* results are reported in most probable number per 100g of shellfish flesh and intravalvular fluid.

11.2 Summary of microbiological results

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

Table 11.1 Summary of historical sampling and results

Sampling Summary		
Production area	Lang Sound	Stream Sound: Whalsies Ayre
Site	Lang Sound	Whalsies Ayre
Species	Common mussels	Common mussels
SIN	SI 107 429 08	SI 518 945 08
Location	HU 380 342	HU 385 348
Total no of samples	84	5
No. 2002	3	0
No. 2003	12	0
No. 2004	11	0
No. 2005	11	0
No. 2006	10	0
No. 2007	8	0
No. 2008	9	0
No. 2009	9	1
No. 2010	10	4
Results Summary		
Minimum	<20	20
Maximum	1700	490
Median	70	50
Geometric mean	73	69
90 percentile	500	-
95 percentile	700	-
No. exceeding 230/100g	18 (21%)	1 (20%)
No. exceeding 1000/100g	2 (2%)	0
No. exceeding 4600/100g	0 (0%)	0
No. exceeding 18000/100g	0 (0%)	0

11.3 Overall geographical pattern of results

Mussel samples were reported against two locations, though only 5 sample results were reported for the Whalsies Ayre location. The sample locations and geographic mean results are displayed on a map in Figure 11.1 to provide a spatial frame of reference. The geometric mean results and proportion of results exceeding 230 for the two mussel sites were very similar, although there was a large difference in the number of samples submitted. As the samples submitted from Whalsies Ayre only covered a period of 5 months, these results cannot be considered as representative of what might be found over the course of a full year and are insufficient for further geographic or temporal analysis.

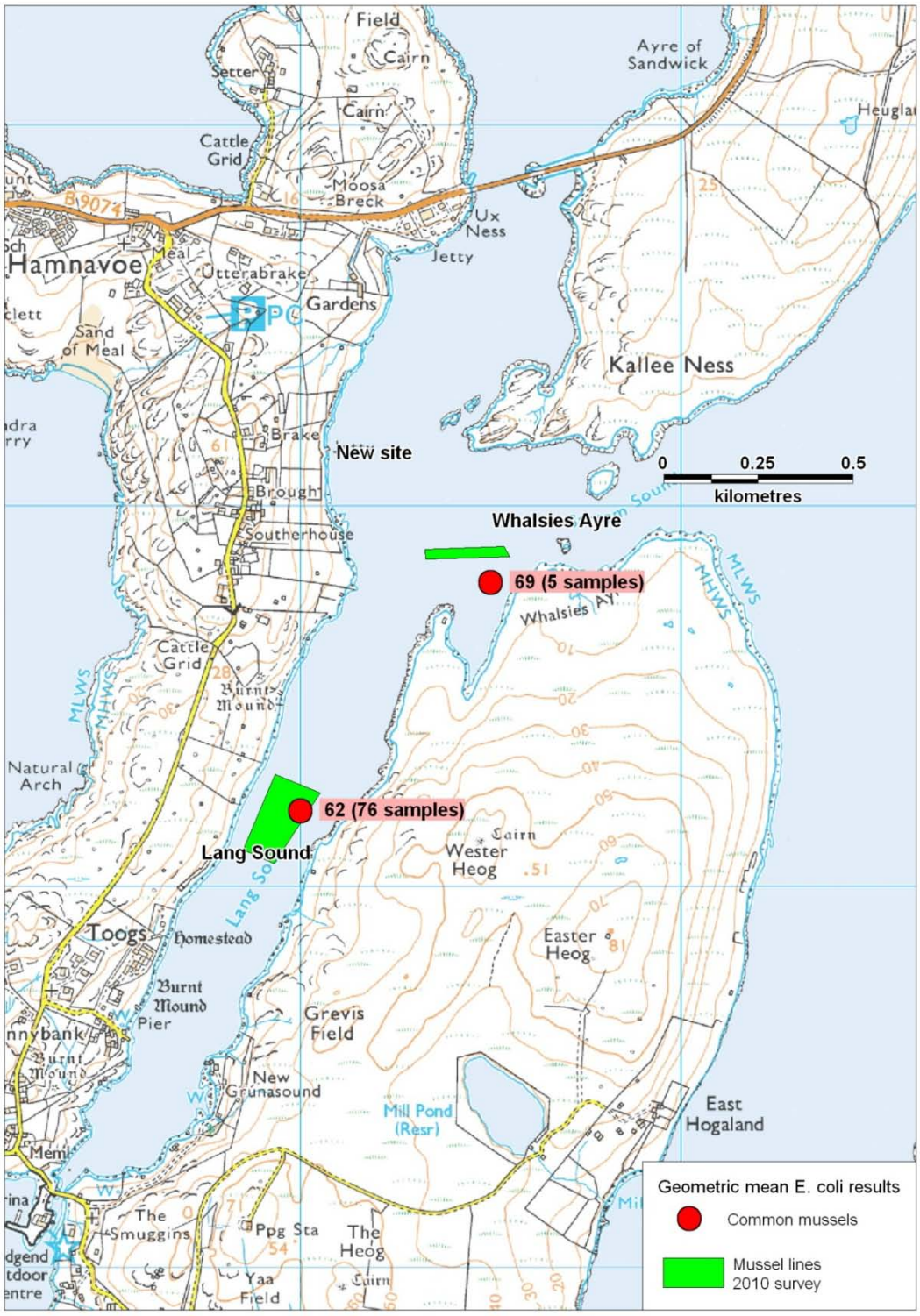

Figure 11.1 Map of historical monitoring results at Lang Sound/Stream Sound

11.4 Overall temporal pattern of results

Variation in monitoring results over time was investigated for the Lang Sound sites using a scatter plot against date fitted with trend lines calculated using two different techniques. These trend lines help to highlight any apparent underlying trends or cycles.

One of the trend lines joins the values representing the geometric mean of the previous 5 samples, the current sample and the following 6 samples and is referred to as a rolling geometric mean (black line). The other is a loess line (blue line), which stands for 'locally weighted regression scatter plot smoothing'. At each point in the data set an estimated value is fit to a subset of the data, using weighted least squares. The loess line approach gives more weight to points near to the x-value where the estimate is being made and less weight to points further away. In terms of the monitoring data, this means that any point on the loess line will be influenced more by the data close to it (in time) and less by the data further away.

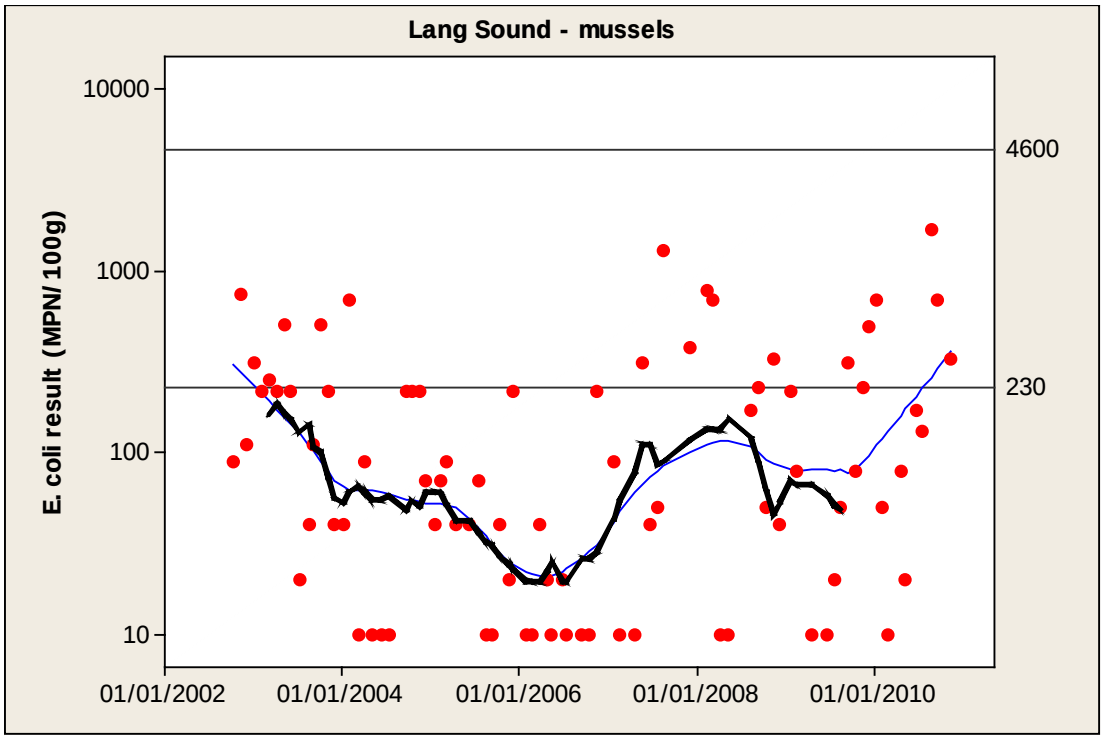

Figure 11.2 Scatterplot of *E. coli* results by date with rolling geometric mean (black line) and loess line (blue line)

Figure 11.2 shows that results improved from 2002 to 2006. Between March 2004 and April 2007, there were a larger number of results below 20 *E. coli* MPN/100 g and no results above 230 MPN/100 g. Since May 2007 results returned to the higher levels seen prior to 2004, with peak results in late 2007 and in 2010 reaching levels higher than observed in earlier years.

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 11.3 presents a scatterplot of *E. coli* result by month for mussel overlaid with loess lines to highlight any trends.

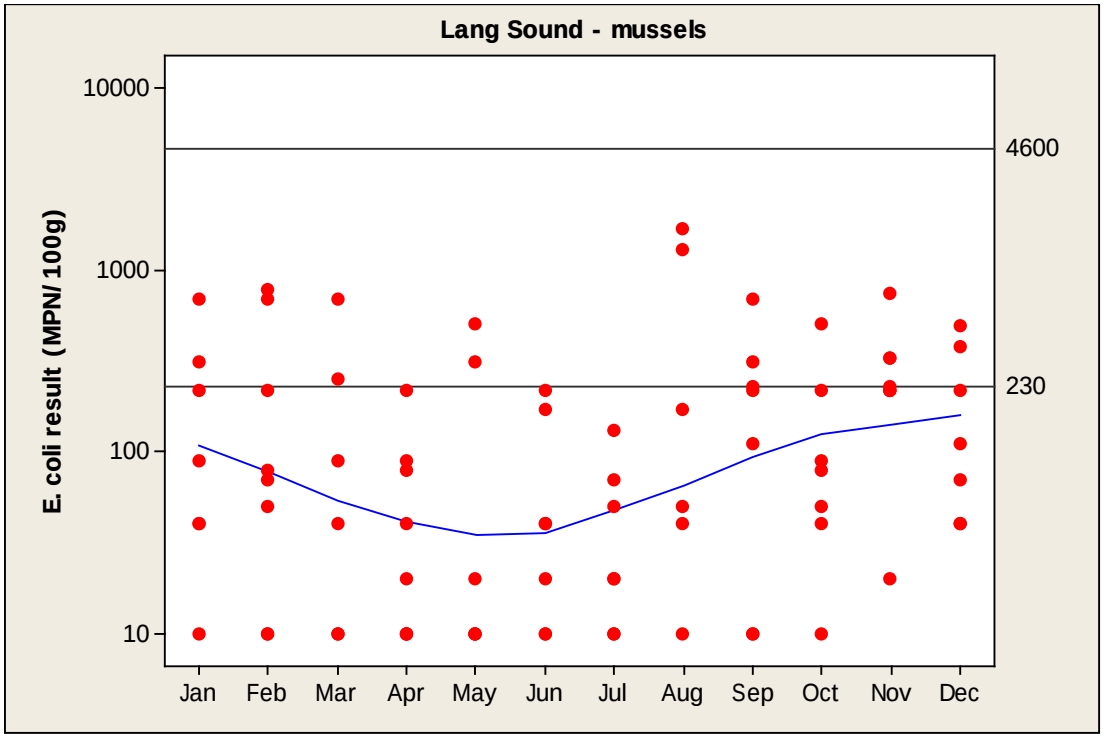

Figure 11.3 Scatterplot of results by month

Figure 11.3 suggests a tendency for lower results from April to July, with results not exceeding 230 *E. coli* MPN/100 g during April, June and July only. Highest peak results occurred during August.

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

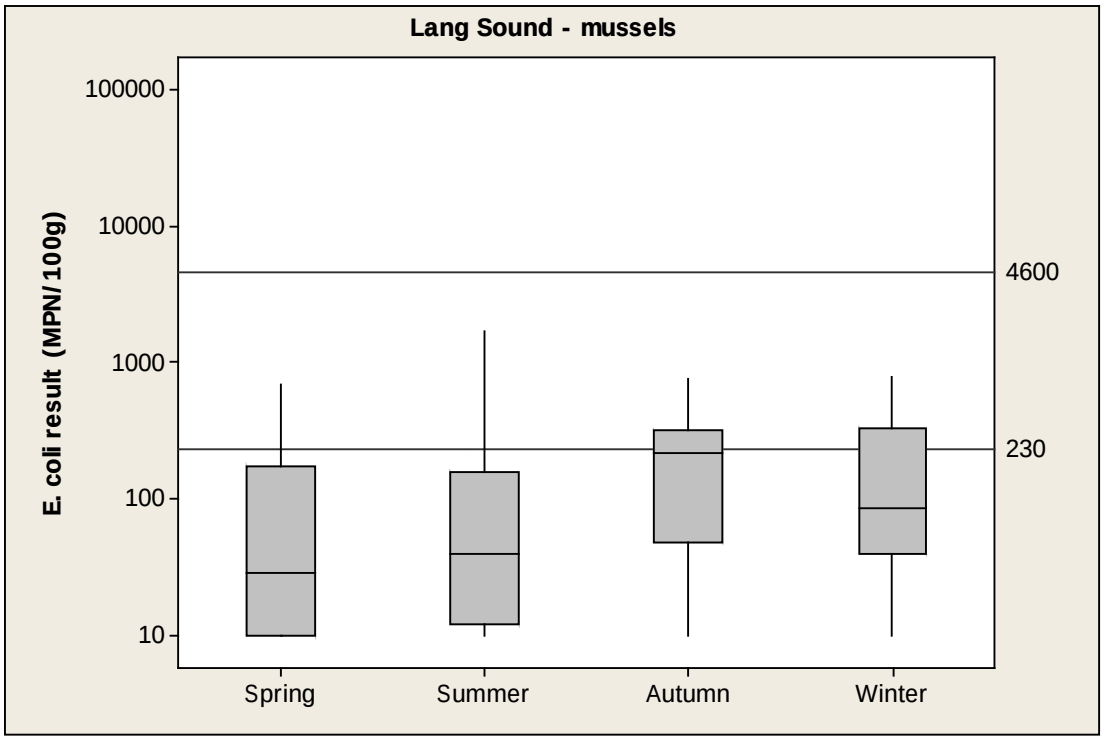

Figure 11.4 Boxplot of result by season

No significant difference was found between results by season for Lang Sound mussels (One-way ANOVA, p=0.051, Appendix 6). However, the highest individual result occurred in summer, while the median result was highest in autumn.

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 at Lerwick, approximately 8 km to the north east of the production area. Rainfall data was purchased from the Meteorological Office for the period 1/1/2003 to 31/12/2009 (total daily rainfall in mm). 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 2 and 7 days and sample results were investigated.

Two-day antecedent rainfall

Figure 11.5 presents a scatterplot of *E. coli* results against rainfall in the previous two days. A Spearman's Rank correlation was carried out between results and rainfall.

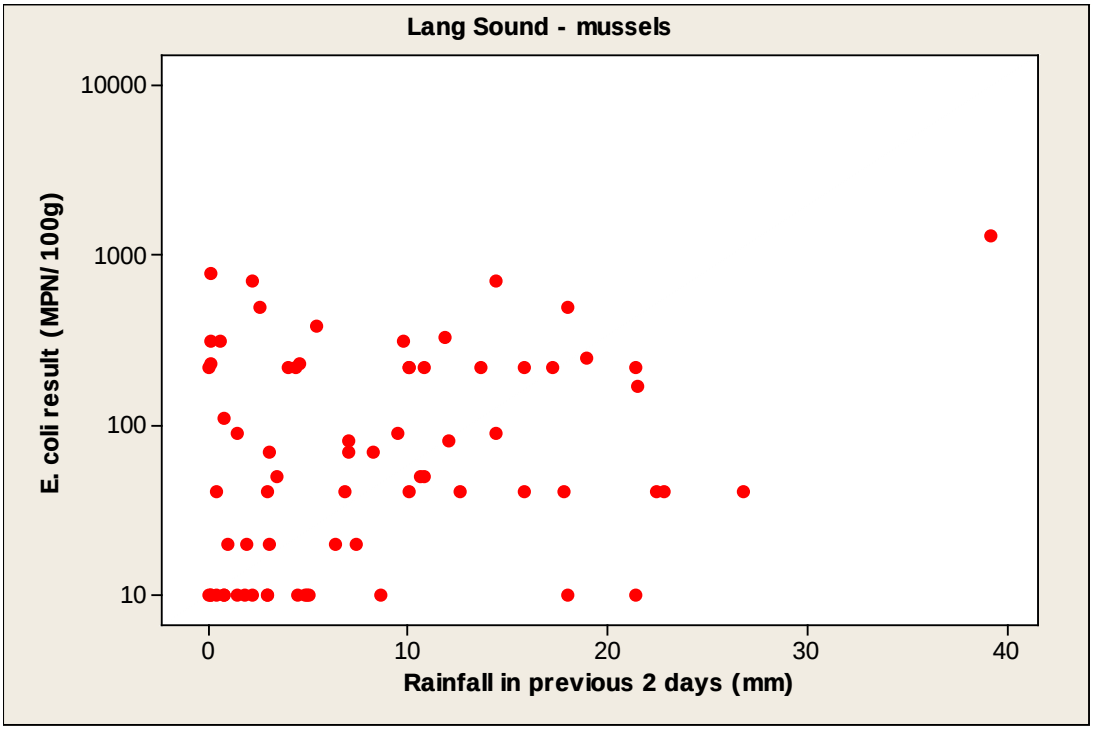

Figure 11.5 Scatterplot of result against rainfall in previous 2 days

A positive correlation was found between *E. coli* result and rainfall in the previous 2 days for Lang Sound mussels (Spearman's rank correlation=0.218, p<0.05, Appendix 6). However, this appeared to be driven in part by a single point with high

leverage (rainfall =39.2 mm, *E. coli* = 1300). Results approaching 1000 MPN/100 g coincided with very low and moderate rainfall levels, however fewer very low results occurred after rainfall greater than 10 mm in the previous 2 days.

Seven-day antecedent rainfall

Figure 11.6 presents a scatterplot of *E. coli* results against rainfall in the previous seven days.

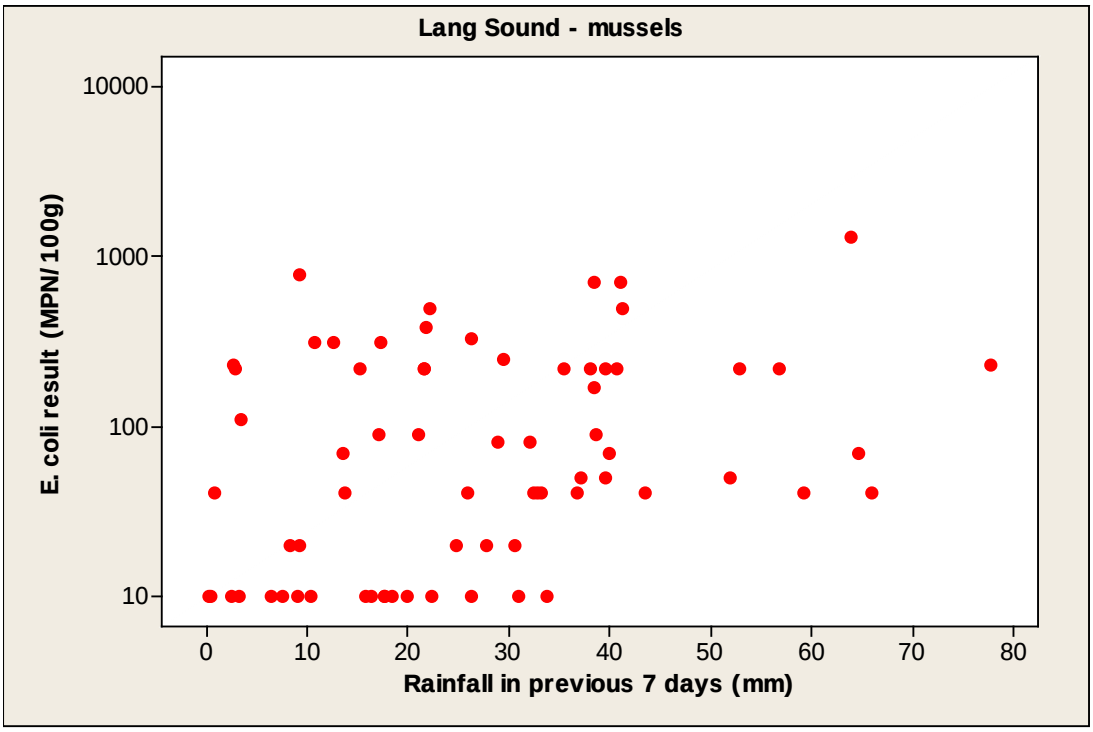

Figure 11.6 Scatterplot of result against rainfall in previous 7 days

A positive correlation was found between *E. coli* result and rainfall in the previous 7 days for Lang Sound mussels (Spearman's rank correlation= 0.337, $p<0.0025$, Appendix 6).

11.6.2 Analysis of results by tidal height and state

Spring/Neap Cycles

When the larger (spring) tides occur every two weeks, circulation of water and particle transport distances will increase, and more of the shoreline will be covered at high water, potentially washing more faecal contamination from livestock into the area. Figure 11.7 presents a polar plot of $\log_{10}$ *E. coli* results on the lunar spring/neap tidal cycle. Full/new moons are located at 0º, and half moons at 180º. The largest (spring) tides occur about 2 days after the full/new moon, or at about 45º, then decrease to the smallest (neap tides) at about 225º, then increase back to spring tides. Results of fewer than 230 *E. coli* MPN/100g are plotted in green, those between 230 and 1000 *E. coli* MPN/100g are plotted in yellow, and those over 1000 *E. coli* MPN/100g are plotted in red. It should be noted that local meteorological conditions such as wind strength and direction can influence the height of tides and this is not taken into account.

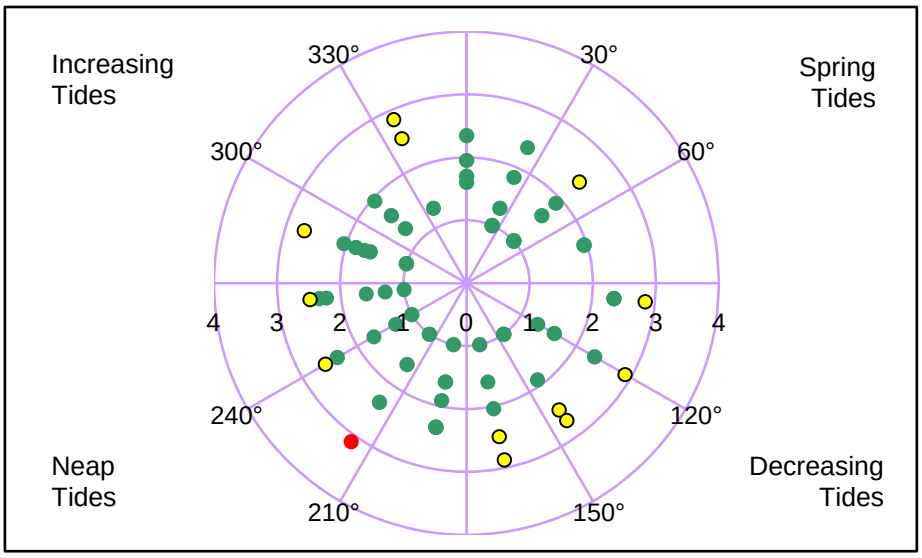

Figure 11.7 Polar plot of $\log_{10}$ *E. coli* results on the spring/neap tidal cycle

No significant correlation was found between *E. coli* results and the spring/neap cycle for (circular-linear correlation, r=0.154, p=0.176, Appendix 6).

High/Low Cycles

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

Figure 11.8 presents a polar plot of $\log_{10}$ *E. coli* results on the lunar high/low tidal cycle. High water is located at 0º, and low water at 180º. Again, results of fewer than 230 *E. coli* MPN/100g are plotted in green, those between 230 and 1000 *E. coli* MPN/100g are plotted in yellow, and those over 1000 *E. coli* MPN/100g are plotted in red.

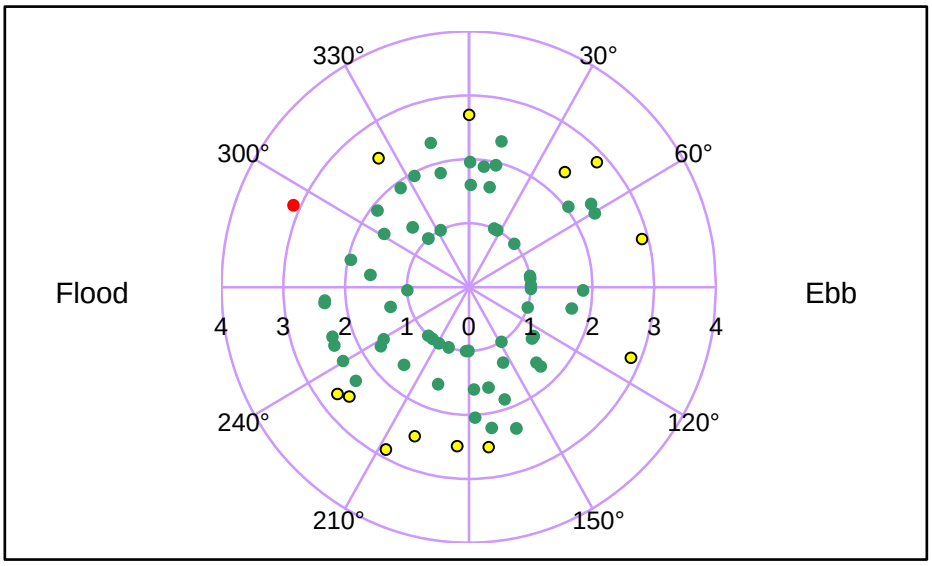

Figure 11.8 Polar plot of $\log_{10}$ *E. coli* results on the high/low tidal cycle

No significant correlation was found between *E. coli* results and the high/low tidal cycle (circular-linear correlation, r=0.164, p=0.152, Appendix 6).

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. Figure 11.9 presents a scatterplot of *E. coli* results against water temperature.

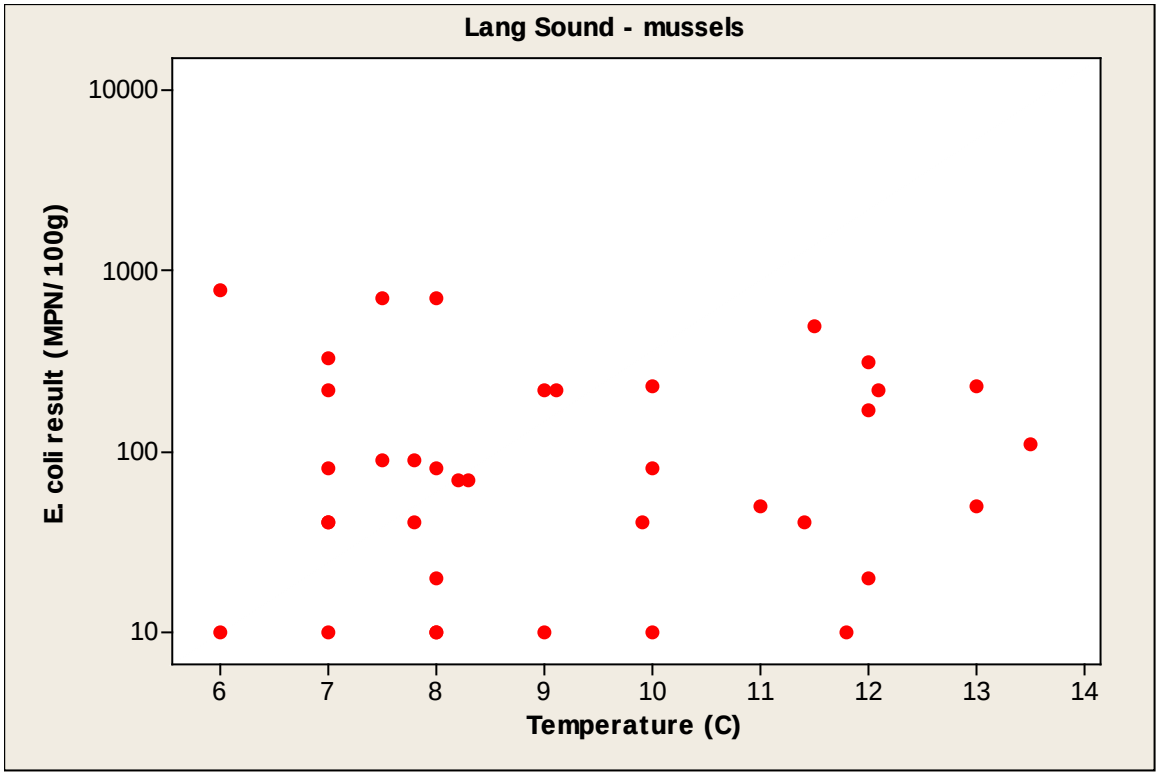

Figure 11.9 Scatterplot of result against water temperature

No significant correlation was found between *E. coli* result and water temperature for Lang Sound mussels (Spearman's rank correlation= 0.067, p>0.25, Appendix 6). The highest results occurred at some of the lowest recorded seawater temperatures. No results below 20 MPN/100 g coincided with sea temperatures above 12ºC.

11.6.4 Analysis of results by salinity

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

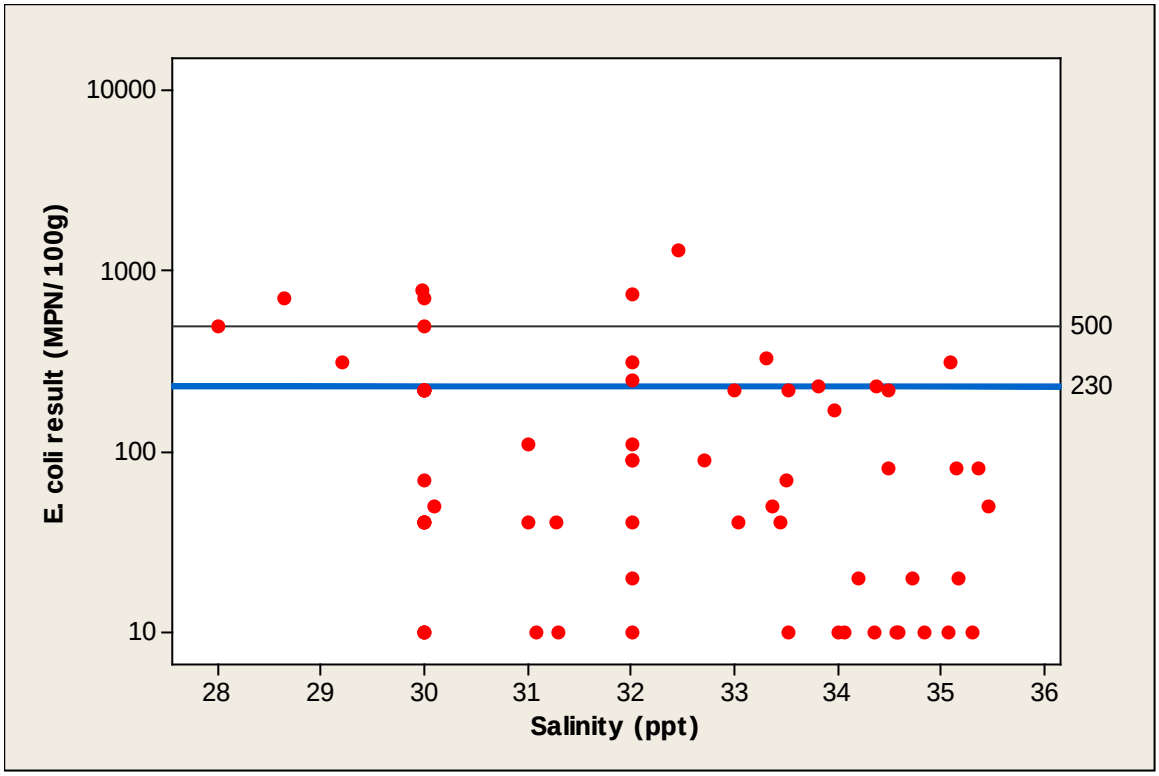

Figure 11.10 Scatterplot of *E. coli* results against salinity

A negative correlation was found between *E. coli* result and salinity for Lang Sound mussels (Spearman's rank correlation= -0.305, p<0.01, Appendix 6). Results greater than 500 *E. coli* MPN/100 g occurred at salinities below 32.5 ppt while a greater proportion of results less than 10 *E. coli* MPN/100 g occurred at salinities of 33.5 ppt and above. This suggests that a signficant contaminating source is associated with freshwater input to the area.. However, as results greater than 230 *E. coli* MPN/100 g were found to occur when salinity levels showed no freshwater influence, salinity is not an adequate predictor of contamination levels above this level.

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

Two samples gave a result of over 1000 *E. coli* MPN/100g, details of which are presented in Table 11.2.

Table 11.2 Historic *E. coli* sampling results over 1000 *E. coli* MPN/100g

Collection date	Species	*E. coli* (MPN/ 100g)	Location	2 day rainfall (mm)	7 day rainfall (mm)	Water Temp (ºC)	Salinity (ppt)	Tidal state (high/low)	Tidal state (spring/neap)
21/08/2007	Common mussels	1300	HU 380 342	39.2	64	*	32.5	Flood	Neap
24/08/2010	Common mussels	1700	HU 380 342	*	*	13	34.9	Ebb	Spring

* Data unavailable

Both samples were taken in August, one under slightly reduced salinity (32.5 ppt). No rainfall information was available for the 2010 sample.

11.8 Summary and conclusions

In terms of overall temporal trends, results for Lang Sound mussels generally improved from 2002 to 2006, then deteriorated from 2006 to 2008, and subsequently improved again slightly. No significant seasonal effect or correlation between *E. coli* results and temperature was found.

Significant positive correlations were found between *E. coli* results and rainfall in the previous 2 and 7 days. This relationship was clearer for 7-day rainfall. A negative correlation between *E. coli* results and salinity suggests that rainfall-dependent sources are of some importance to this site.

No correlations were found between tidal state on either the spring/neap or high/low cycle.

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 mussels from Lang Sound, as the classification has not remained the same for the last three years.

12. Designated Shellfish Growing Waters Data

Lang Sound does not fall within a designated shellfish growing water (SGW). The Clift Sound Burra SGW lies to the east, however the monitoring point (HU 3814 3139) lies at the south end of Clift Sound, approximately 4.7 km sea distance from the Whalsies Ayre site, in an area subject to different contaminating influences than those present in Lang Sound or Stream Sound. Therefore, the SGW monitoring results are not considered here.

13. Streams and Rivers

There are no gauging stations on rivers or burns along the Lang Sound and Stream Sound coastline.

The streams listed in Table 13.1 were measured and sampled during the shoreline survey. The locations are shown on the map presented in Figure 13.1. These were deemed to represent the potentially most significant freshwater inputs into the survey area in the vicinity of the shellfisheries. The locations of other small streams that were not measured and sampled are given in Table 1 of the shoreline survey report. There were wintry showers on the first day of the survey.

Table 13.1 Stream loadings for Lang Sound/Stream Sound

No	Grid Ref	Description	Width (m)	Depth (m)	Flow (m/s)	Flow in m^3/day	*E.coli* (cfu/ 100ml)	Loading (*E.coli* per day)
1	HU 38147 35415	Stream	0.20	0.04	0.23	159.0	130	$2.1x10^8$
2	HU 37952 34522	Land drain	-	-	30 ml/ 2 s^1	1.3	190	$2.5x10^6$
3	HU 37937 34496	Small stream	0.17	0.03	30 ml/ 2 s^1	1.3	100	$1.3x10^6$
4	HU 37933 34467	Small stream	0.11	0.05	0.09	42.8	<10	$<4.3x10^6$
5	HU 37771 33426	Stream	0.33	0.06	0.04	68.4	120	$8.2x10^7$
6	HU 37987 33931	Stream	0.45	0.06	0.09	210.0	220	$4.6x10^8$

[1]Too small to measure with a flow meter. Approximate time taken to fill a measured volume.

The two streams with the highest loadings were number 1 and number 6. The first was in the vicinity of the proposed new mussel farm in the top part of Lang Sound. The second was near the current mussel farm in the southern part of Lang Sound. All of the streams would be expected to contribute to the background *E. coli* levels in the area and streams 1 and 6 could cause decreases in water quality in the immediate area of the nearby mussel lines.

The loadings of all of the streams would be expected to increase significantly following moderate to heavy rainfall and thus their potential effects on the microbiological quality of the mussels would also increase. In addition, a number of areas of seepage were observed adjacent to the shore. These would be expected to become small watercourses after rainfall events. Given the steep sided nature of the land around the sounds, there is also the potential for direct run-off after rainfall. All of these would be potential pathways for contamination from animal faeces to enter the sounds.

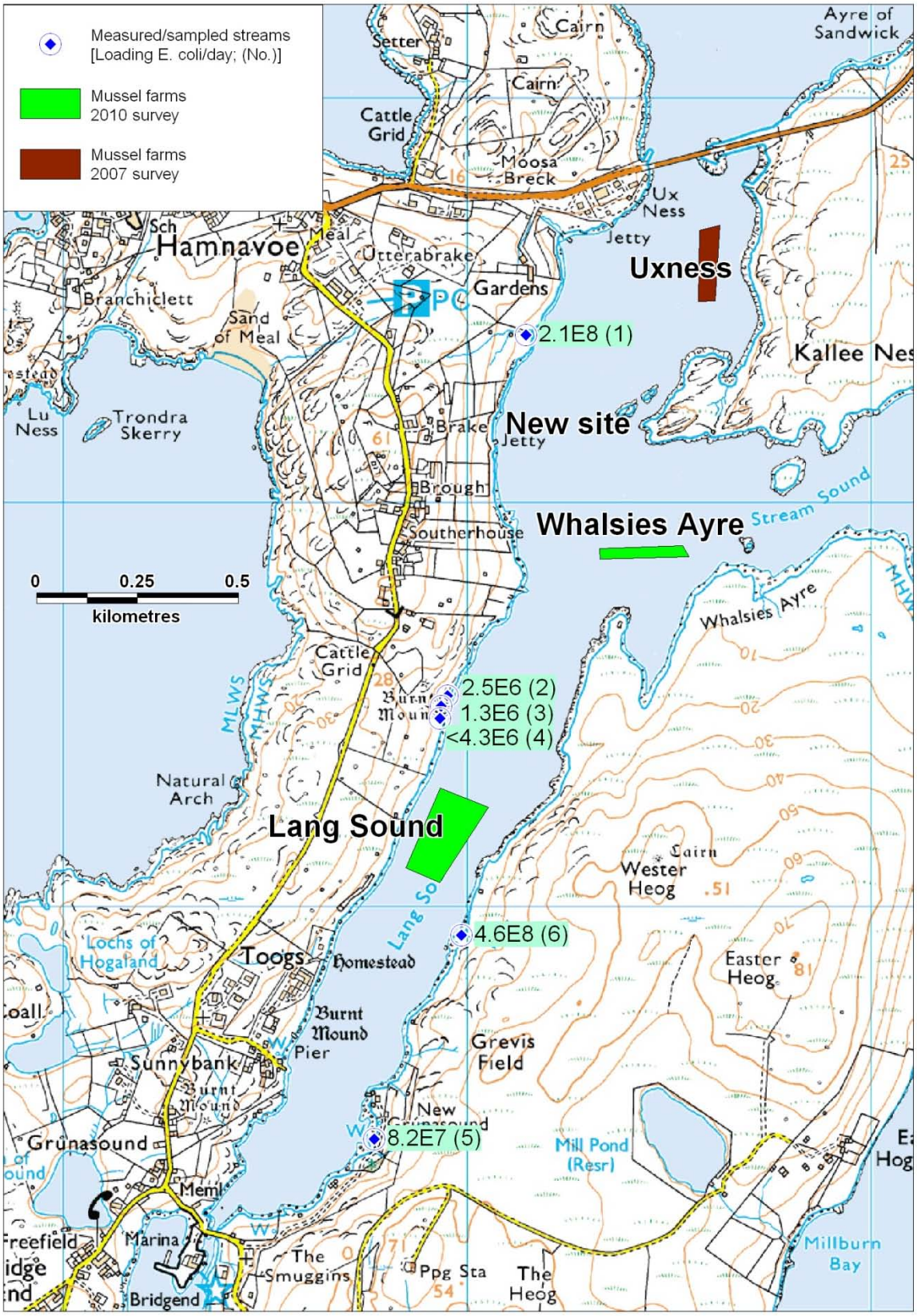

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Figure 13.1 Map of stream loadings at Lang Sound/Stream Sound

14. Bathymetry and Hydrodynamics

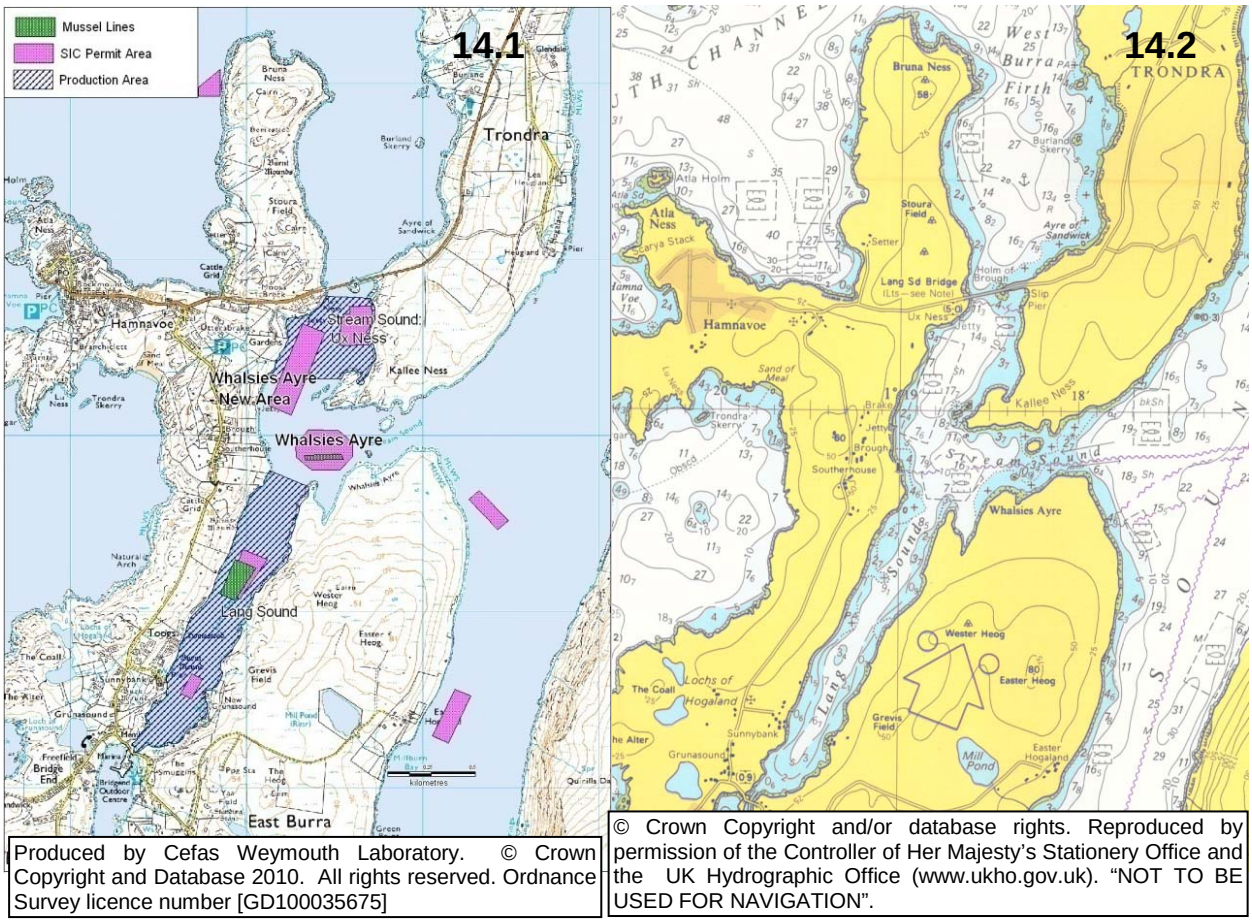

Figure 14.1 OS map of Stream Sound/ Lang Sound
Figure 14.2 Bathymetry at Stream Sound/ Lang Sound

Lang Sound lies between the islands of West and East Burra and also between the islands of West Burra and Trondra. It is connected to West Burra Firth at the northern end and to South Voe at the southern end. The connection of Lang Sound with West Burra Firth is partly restricted by a promontory at the Holm of Brough near the Burra road bridge. The connection with South Voe is more severely restricted with a concrete culvert under the road bridge at Bridge End. Stream Sound lies between the island of Trondra and the island of East Burra and is connected to Clift Sound to the east and Lang Sound to the west. The OS map (Figure 14.1) and Hydrographic Chart (Figure 14.2) show a very limited drying area around the edges of Stream Sound/Lang Sound.

The chart shows a deep channel stretching from just south of Burra Bridge to just north of Bridge End in the south. There are two basins within this channel. One (max depth 17.7 m) is located in Lang Sound between Trondra and West Burra. The other (max depth 16.2 m) is located in Stream Sound to the north of the confluence with Lang Sound. The channel in Stream Sound between Kallee Ness (Trondra) and Whalsies Ayre (East Burra) to the east of this deep is relatively shallow (maximum depth 3.7 m). Depths in the vicinity of the mussel farms are between 5 and 10

metres at the Lang Sound and new sites, with the Whalsies Ayre site located in slightly deeper water (up to 16 m).

14.1 Tidal Curve and Description

The two tidal curves below are for Scalloway, approximately 1.5 km from Whalsies Ayre. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 BST on 11/05/10 and the second is for seven days beginning 00.00 BST on 18/05/10. Together they show the predicted tidal heights over high/low water for a full neap/spring tidal cycle, including the dates of the shoreline survey.

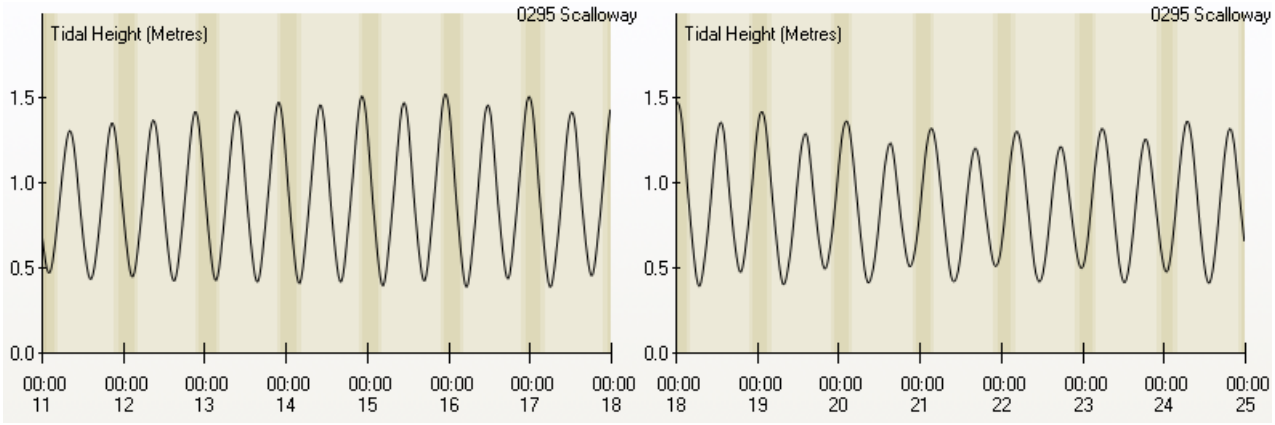

Figure 14.3 Tidal curves for Scalloway

The following is the summary description for Scalloway from TotalTide:
0295 Scalloway is a Secondary Non-Harmonic port.
The tide type is Semi-Diurnal.

HAT	1.9 m
MHWS	1.6 m
MHWN	1.3 m
MLWN	0.6 m
MLWS	0.5 m
LAT	0.3 m

Predicted heights are in metres above Chart Datum. The tidal range at spring tide is 1.4 m, and at neap tide 0.7 m, and so tidal ranges in the area are relatively small.

14.2 Currents

No tidal stream information was available for the vicinity of Whalsies Ayre/Lang Sound.

Shetland Seafood Quality Control had undertaken a number of current meter studies in the nearby sounds to provide information in support of applications to SEPA to discharge from marine cage fish farms. Two were immediately relevant to the Whalsies Ayre/Lang Sound survey. One of these was undertaken within Lang Sound

on behalf of Shetland Halibut Company Ltd. The other was undertaken at Kallee Ness, in Clift Sound near the junction with Stream Sound, on behalf of Shetland

Fisheries Centre Ltd. Data from the studies were provided to Cefas with the agreement of the companies.

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

Table 14.1 Survey periods for the fish farm current meter studies

Location	NGR	Survey period
Lang Sound	HU 3828 3527	23/11/2007– 11/12/2007
Kallee Ness	HU 3935 3511	11/01/2010 - 26/01/2000

Unfortunately, the deployment locations meant that there was no direct information on currents in the southern part of Lang Sound. Plots of the current directions and speeds at the two locations, together with the wind direction and speeds over the relevant periods, are shown in Figure 14.5.

The plots show that the currents in the area are weak, with the highest recorded during the surveys being less than 30 cm/s (0.6 knots). At the Kallee Ness site, in Clift Sound just off the confluence with Stream Sound, the currents were weaker than in Lang Sound. There was a predominating WNW current at depth which lost its dominance towards the surface. At the Lang Sound site, the predominant, and fastest, currents at near-bottom and mid-depth were south-westerly. Near to the surface, there was also a significant northerly current. This tended to coincide with times when winds were blowing from the south-west.

The flood tide will flow into Lang Sound from three directions: from the north through West Burra Firth, the east via Clift Sound and the south via South Voe. The strongest of these is expected to be from West Burra Firth, as it is the most open and nearest the open sea. Weaker flows would be expected from the other two directions, and the south-flowing flood tide into Lang Sound is likely to meet the north-flowing flood tide into South Voe. This is expected to complicate tidal movement at or near the southern end of the sound as flows between South Voe and Lang Sound are likely to be very dependent upon weather conditions and wind at the time.

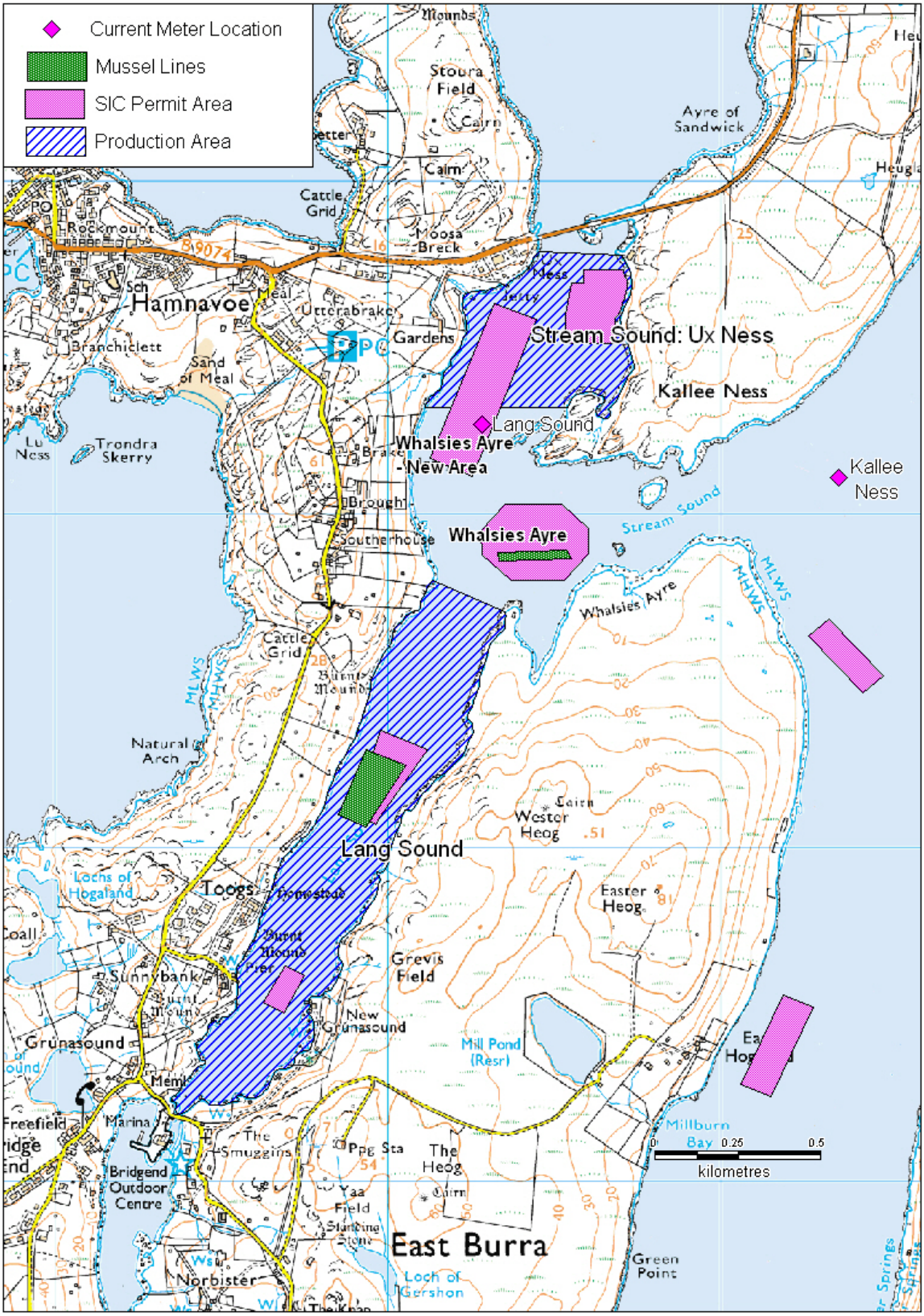

Figure 14.4 Current meter locations

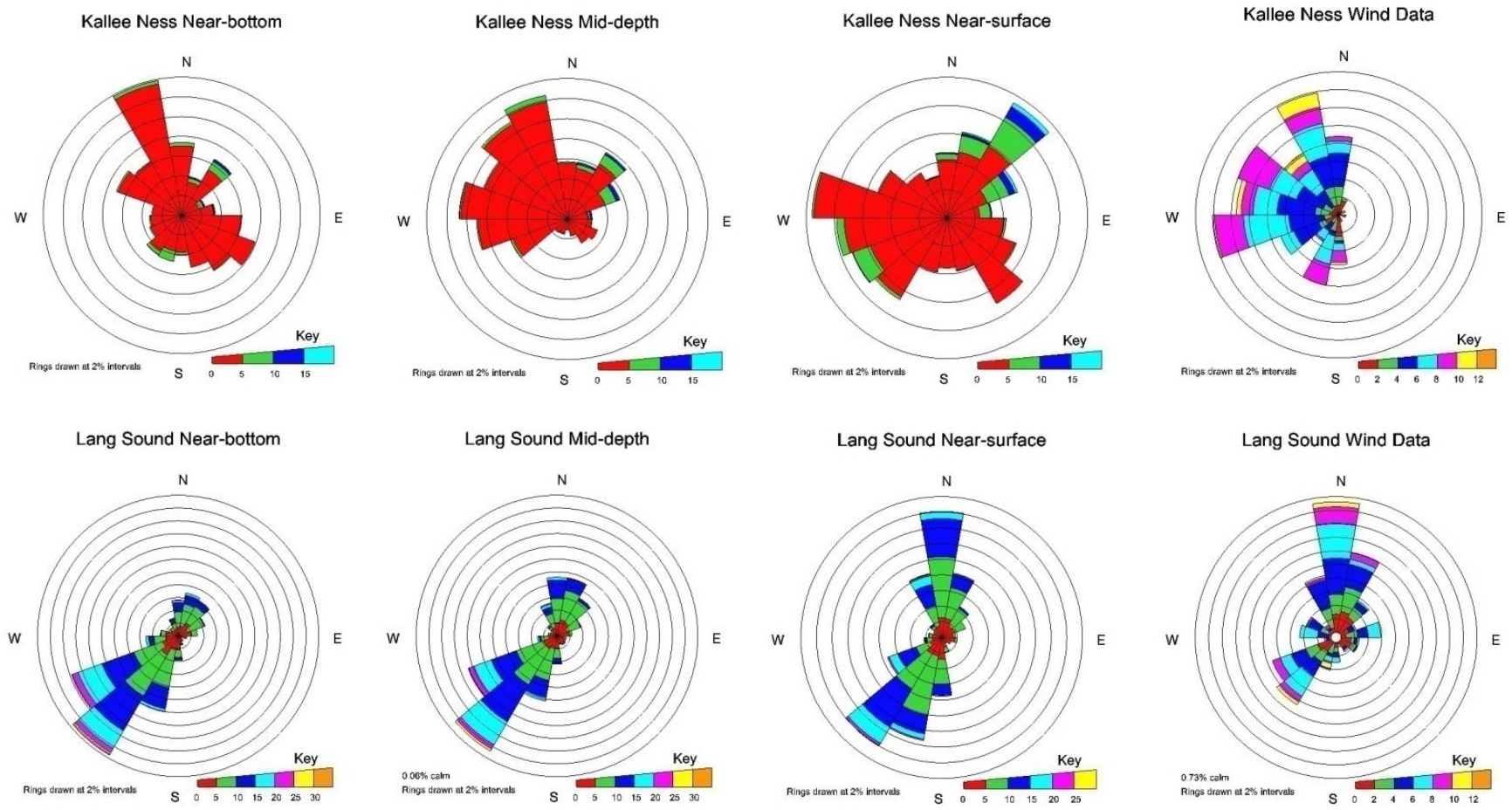

Figure 14.5 Current and wind plots for the Kallee Ness and Lang Sound fish farm surveys

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

14.3 Conclusions

The tidal range in Lang Sound and Stream Sound is small and the tidal currents are weak. Contaminants arising within northern Lang Sound tend to be taken southwards by the predominant southerly currents, although wind driven near-surface currents could also take contamination in a northerly direction. Contamination arising within Stream Sound may be taken towards Whalsies Ayre over part of the tidal cycle.

A lack of information regarding currents in the southern part of Lang Sound makes it difficult to accurately assess the effect of currents in the vicinity of the Lang Sound mussel site. Current speeds at the Land Sound site are not likely to exceed those observed in the north part of the sound and may be slower. Due to the relatively shallow water, low current speeds and narrow width of the southern part of Lang Sound, contaminants entering this part of the sound will be subject to somewhat limited dilution and transport. Whether the net transport is southward into South Voe or northward toward the fisheries is not clear.

There will be relatively limited dilution of contaminants in the shallow areas at the edges of both sounds and in the eastern half of Stream Sound. More dilution will occur in the deeper areas where the mussel lines are located, especially those in the vicinity of Whalsies Ayre and the northern section of Lang Sound.

15. Shoreline Survey Overview

The shoreline survey was conducted on 11th and 12th May 2010 with intermittent wintry showers on the first day.

The fishery at Lang Sound consisted of nine double mussel lines. The fishery at Whalsies Ayre consisted of three double mussel lines. It was identified that one of the harvesters had applied for permission to locate more lines in Lang Sound in the vicinity of Brake. Prior to the survey, Cefas was informed that the oysters that had been classified at the southern end of Lang Sound had been moved to the top of South Voe, near Bridge End, and these were therefore not covered in the shoreline survey.

Several septic tanks and/or outfall pipes were seen around the shores of the area, apart from the Kallee Ness and the northern end of East Burra. These observations included the Bridge End Pumping Station and associated discharge pipe. That discharge pipe could not be sampled as it extended into the centre of the sound. One very high water sample result was obtained from a private pipe at Brake: this was therefore likely to be a septic tank discharge.

Sheep and sheep droppings were observed around most of the shoreline. Although most sheep were seen on the eastern shore of Lang Sound, more sheep droppings were observed on the western shore. Sheep on the western shore tended to be more confined to crofts. Four ponies were observed on Kallee Ness, together with a several large piles of pony droppings. Four ponies were also seen at Toogs. Six seals were seen in the area, one was resting on top of a mussel line float.

Only a small number of boats were seen within Lang Sound/Stream Sound: a greater number were moored in South Voe.

Water samples taken from streams and land drains around the sounds contained low concentrations of *E. coli* (all <500 *E. coli* cfu/100 ml).

Most seawater samples yielded results of <1 *E. coli* cfu/100 ml. These included those taken at the mussel lines. The exceptions were samples taken from shore at three locations around the sounds. One of these (8 *E. coli* cfu/100ml) was taken from the East Burra shore opposite the Lang Sound mussel lines.

All mussel samples bar one yielded *E. coli* results of <20 or 20 E. coli MPN/100 g. The exception was the sample taken from the top of the southern end of the lines at the Lang Sound site. This gave a result of 490 *E. coli* MPN/100 g.

The potentially most significant sources of faecal contamination were the septic tank outlets, the pumping station, and the sheep. The large amount of faeces produced by the ponies on Kallee Ness could also be a source of localised contamination following rainfall.

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

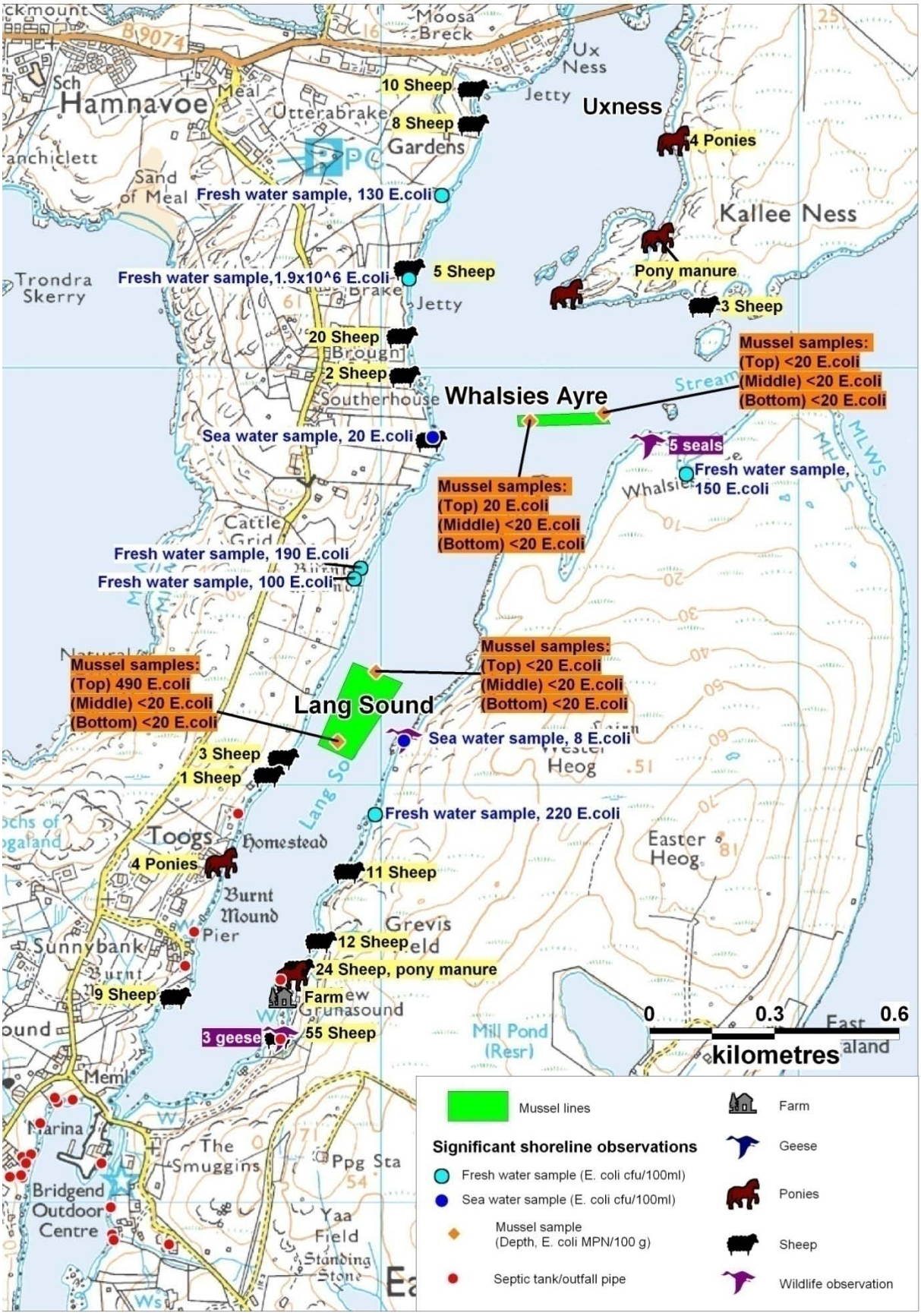

Figure 15.1 Summary of shoreline survey findings for Stream Sound and Lang Sound

16. Overall Assessment

Human sewage impacts

Although the human population in the area is relatively small, the potential for localised impact from sewage is high due to the low level of treatment and presence of properties not connected to mains sewerage. The largest source of sewage to the sound is the community discharge located south of the Lang Sound site. The Bridge End outfall lies only 200 m south of the mussel farm and so would be expected to more acutely compromise water quality at the fishery when active However, no evidence of flow was observed at the time of survey and both water and shellfish samples taken from the area contained very low concentrations of *E. coli*. The sampling history at the site indicated moderate levels of contamination, with few shellfish samples exceeding 1000 *E. coli* MPN/100 g. However, the reported sampling location was nearer the northern end of the mussel farm where there would have been more opportunity for dilution of contaminants arising from this source. It should be noted that the sampling location was only reported to the nearest 100 m and therefore could theoretically have come from anywhere within the northern 2/3 of the farm. Shellfish samples taken from the Lang Sound site during the shoreline survey indicated significantly higher levels of contamination in the near-surface sample taken from the southern end of the farm nearest the discharge.

At the north end of the sound, smaller, more local sources of sewage are likely to be of greater importance to bacteriological quality of the mussels. A septic tank discharge is located on shore immediately west of the new site area and this would be expected to most significantly impact the part of the mussel lines nearest to the discharge. Septic tanks likely to be associated with two shore bases at either end of the bridge at Uxness may affect water quality in the vicinity. The larger of these is located on the west shore and discharges from there would be more likely to impact the new site than the Uxness site on the opposite side of the sound.

Agricultural impacts

Agricultural activity along the shores of the sound is predominantly crofting, with one farm noted on the southeast shore. Sheep and/or sheep droppings were observed along much of this area, though the largest numbers of these were present at the south end of the sound. At the north end of the sound, sheep were primarily found on the west shore with ponies and pony droppings found on the east shore. Impacts on the fishery are most likely nearest the shore where direct deposition or rainfall runoff will wash faecal matter into the waters of the sound. The Lang Sound site is most likely to be impacted at its southern end and along the western side where the lines most closely approach the shore. The new site would also tend to be most impacted along its western side, where it is nearest the shore. The Whalsies Ayre site lies further from shore than the other two and so while it might not receive direct impact from sources near the lines, it is likely to be impacted by the elevated background levels of contamination from these sources as they diffuse and spread away from shore.

Significant areas of improved grassland were identified in land cover data and these were predominantly along the western shore and the southern end of the sound. It is not known whether slurry is applied to these areas, however if it were this could constitute a significant source of faecal contaminants especially if applied to the more poorly-draining soils on the west side of the sound.

Wildlife impacts

Seabird nesting sites in the area could lead to seasonal impacts during summer east of the Lang Sound site, east of the Whalsies Ayre site and north of the Uxness site where the largest number of nesting birds were found. An area where seabirds appear to regularly feed was identified during the shoreline on the east shore opposite the Lang Sound site, though it is not clear whether this is used seasonally by the birds nesting immediately to the south or used year-round by other seabirds in the area. Seals were observed on and near the Whalsies Ayre site, and geese were noted along the southeast shoreline. While localised impacts could be high where animals defecate directly on or near the mussel lines, the timing and location of this type of impact is not predictable and the likelihood is assumed to be even across the fishery. Faecal material carried by rainfall runoff from nesting areas is likely to be highest north of Uxness where the largest number of nesting birds was observed.

Seasonal variation

Analysis of historical monitoring results indicated that while there was no statistically significant variation in *E. coli* results by season, there did appear to be a tendency for lower results from April to July and generally higher results between September and March. The highest peak result occurred in August. Weather records for Lerwick indicated that weather was generally wetter from September to March, and this broadly corresponds with the trend in monitoring results, which tend to be lower during the drier months from April and July. A significant positive correlation was found between *E. coli* monitoring results and rainfall. There is an outdoor education centre at Bridge End, south of Lang Sound and this is likely to be more fully occupied during the summer months, leading to a seasonal increase in human population in the area. Livestock populations are likely to be highest in summer, when lambs are present, leading to higher rates of faecal deposition on land around the sound between May and September.

Rivers and streams

The sound is surrounded by relatively little land area and a number of small watercourses discharge into the south part of the sound while only one was identified along the north shore of the sound. Of these, the largest in terms of both water volume and calculated *E. coli* loading discharges less than 150 m southeast of the Lang Sound site. This would be expected to cause a decrease in bacteriological water quality in the vicinity of the southeast corner of the Lang Sound site, depending on prevailing wind and current movements. A further stream with a smaller, but still significant, *E. coli* loading discharged near the farm on the southeast shore of the sound.

The second largest watercourse discharges to the northern end of the sound, approximately 250 m north of the jetty at Brake and the area permitted for the new site. This would be expected to cause a localised decrease in water quality, which may impact the new site depending upon where it is installed.

The watercourses discharging to the west shore drain a very narrow strip of land less than 0.5 km across that is composed of predominantly poorly drained soils. The slopes of the areas drained are roughly 20%, so there would be an increased tendency for the water to runoff quickly from this area. Therefore, the correlation found between rainfall two and seven days prior to sampling and *E. coli* results is unlikely to be related to discharges from these streams. However, the observed correlation could be related to increases in contamination over shorter time periods occurring within the longer periods used for the analysis.

The watercourses discharging to the east side of the sound drain a larger area of more freely drained soils and so may be more permanent features that respond more slowly to rainfall. These streams were found during shoreline survey sampling to carry higher loadings of faecal bacteria than those along the west shore.

Hydrography and movement of contaminants

Currents are relatively weak in the sound, and the direction of current travel at any given time in the southern half of the sound is likely to be somewhat variable. Currents measured near the new site in north Lang Sound tended to flow in a southwesterly direction at depth while wind direction tended to affect surface currents, with southwesterly winds tending to drive surface currents northward.

Under prevailing southwesterly wind conditions, contaminants at or near the surface will tend to move northward while contaminants present at the middle or bottom of the water column would tend to move southward. Tidal flow and associated wind data from a monitoring site east of Kallee Ness showed a less clear directionality, with winds tending to be funnelled by the surrounding land into a predominantly westerly direction and mid and bottom currents showing little movement.

It is not clear whether the net transport of contaminants entering the southern end of Land Sound is likely to be northward or southward based on the information available. Contaminants arising from the septic tank discharge to the south may persist in the area for some time if current speeds are slower than those observed in the north part of the sound.

Temporal and geographical patterns of sampling results

Analysis of classification monitoring data for both the Lang Sound and Whalsies Ayre sites showed little difference in geometric mean *E. coli* values. However, monitoring at Whalsies Ayre had been undertaken only since late 2009 and only 5 results were available for consideration and the dates did not coincide with sampling at Lang Sound. The maximum result at Lang Sound was 1700, indicating that it is at times subject to significant faecal contamination. Monitoring history for Lang Sound was available back to 2002 and since commencement of the monitoring programme there was an extended period, from March 2004 to April 2007, when monitoring results did

not exceed 230 *E. coli* MPN/100 g. Since 2007, peak results have exceeded 1000 *E. coli* MPN/100 g and there have been fewer results <20 *E. coli* MPN/100 g, indicating a degradation in bacteriological water quality since that time. The monitoring point at the Lang Sound site is toward the northwestern end of the current mussel farm, and therefore potentially farther away from the nearest contaminating sources than the southern end of the farm.

Conclusions

The majority of potential sources of faecal contamination to Lang Sound are located at the south end of the sound, south of the Lang Sound mussel farm. Contaminants from these sources are likely to persist in the southern end of the sound due to slow current speeds and somewhat limited opportunity for dilution. Wind driven surface currents are likely to be a more important factor in the transport of contaminants carried in surface waters, and prevailing wind directions would tend to carry these northward. The location of the discharge from the North Toogs/Bridge End septic tank is sufficiently close to the Lang Sound mussel farm to pose a risk of contamination particularly at the southern end of the mussel farm.

Smaller sources of both human and agricultural faecal contamination were identified at the northern end of the sound along the west shore adjacent to and north of the new site west of Kallee Ness. These sources would be likely to contribute to localised contamination to waters nearby and depending upon the final location of the new site could potentially pose a significant source of contamination to mussel lines nearest these sources.

17. Recommendations

Production area

Stream Sound: Uxness (Including New site and Whalsies Ayre)
It is recommended that the both the unnamed new site and Whalsies Ayre be incorporated into the existing Stream Sound: Uxness production area. The current boundaries should be amended to exclude areas where contamination levels may be higher due to runoff from land or small discharges. These are the western shoreline between Brake and Ux Ness, where three private septic tanks and a stream discharge at the shoreline, the small inlet on the eastern shoreline near Kallee Ness, where pony droppings were observed on the shore, The production area should be extended at its southern boundary to include the two new sites.

The recommended production area boundaries are therefore described as being the area bounded by lines drawn between HU 3845 3579 to HU 3868 3579 and from HU 3870 3558 to HU 3861 3537 and from HU 3861 3516 to HU 3866 3483 and from HU 3857 3477 to HU 3813 3480 and from HU 3807 3515 to HU 3836 3568 extending to MHWS.

Lang Sound
It is recommended that the Lang Sound production area be curtailed at it s southern boundary to exclude both septic tank outfalls. No change is recommended to the northern boundary of the area. Therefore, the recommended production production area boundaries are described as the area bounded by lines drawn between HU 3835 3470 to HU 3813 3480 and HU 3772 3400 to HU 3801 3400 extending to MHWS.

RMP

Stream Sound: Uxness (Including New site and Whalsies Ayre)
The nearest potential continuous source of faecal contaminants to the fishery is the septic tank discharge on shore immediately west of the new site. Although there are other possible sources in the north end of the sound, as far as was possible these have been excluded from the recommended production area boundaries. Therefore, it is recommended that the RMP be placed at HU 3815 3518.

Lang Sound
The closest, and largest, point source of contamination to the sound lies 200 m to the south of the Lang Sound mussel farm. Therefore, it is recommended that the RMP be relocated to the southern end of the farm to reflect the impact from this discharge as well as non-point source contamination coming from the stream and farm located along the southeast shore. It is recommended that the RMP be placed at HU 3790 3409.

Tolerance

The recommended sampling tolerance for both production areas is 40 m to allow for movement of the longlines.

Depth of sampling

Stream Sound: Uxness (Including New site and Whalsies Ayre)
Localised sources of faecal contamination are likely to be carried in freshwater and/or discharge to the near surface of the sound. Therefore, it is recommended that samples be obtained from a depth of 1-3 metres.

Lang Sound
Contamination from the sources to the south are likely to be either well mixed or carried in fresh water at or near the surface, therefore sampling depth is recommended to be 1-3 metres.

Frequency

Stream Sound: Uxness (Including New site and Whalsies Ayre)
As production area has been expanded to include two new sites, and the RMP has been relocated, it is recommended that monitoring be undertaken monthly until sufficient history has been obtained to support a stability assessment of the site for reduction in sampling frequency.

Lang Sound
This area is potentially subject to intermittent contamination by a nearby emergency outfall, for which the spill frequency is not known. This area has not qualified for reduced sampling frequency as the classification has not remained the same for the past three years. Therefore, it is recommended that monthly monitoring be continued. It is further recommended that the LFA seek to obtain agreement from Scottish Water that they will notify the local authority and the harvester immediately in the case of a spill so that the impact can be assessed and the area closed to harvesting until the risk has cleared.

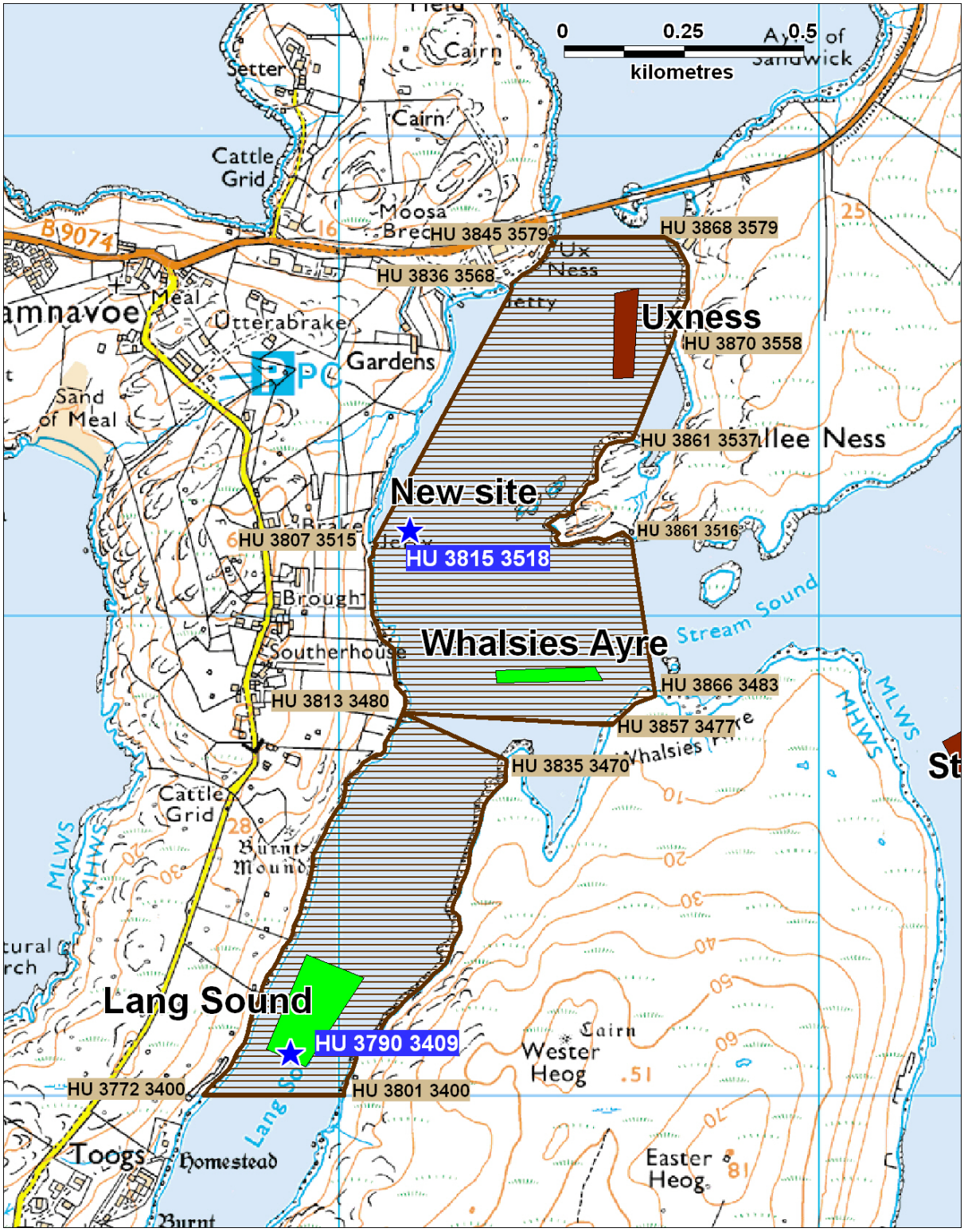

Figure 17.1 Map of recommendations at Lang Sound/Stream Sound

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19. List of Figures and Tables