Scottish Sanitary Survey Project

Sanitary Survey Report

Whelkmulli Bay
OI 468, OI 469, OI 470, OI 471

September 2009

Cefas

FOOD STANDARDS AGENCY SCOTLAND
Buidheann Inbhe-Bidhe an Alba

Report Distribution – Whelkmulli Bay

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

** Distribution of draft and final reports to harvesters in undertaken by the relevant local authority.

Table of Contents

Appendices

1. General Description

The Wyre Whelkmulli site is located in Wyre Sound, Orkney, which is situated between the islands of Wyre and Rousay. Both islands are in the group of Orkney Islands off the north coastline of Scotland. Wyre Sound is 0.9 – 1.4 km wide and 3.6 km in length. The depth of Wyre Sound is generally shallow at 5-10 m with a drying area lining the coastline of both islands. The depth increases to 20 m when leaving both ends of the sound.

This sanitary survey was undertaken in response to an application for classification of this area for king scallops, queen scallops, Pacific oysters and common mussels.

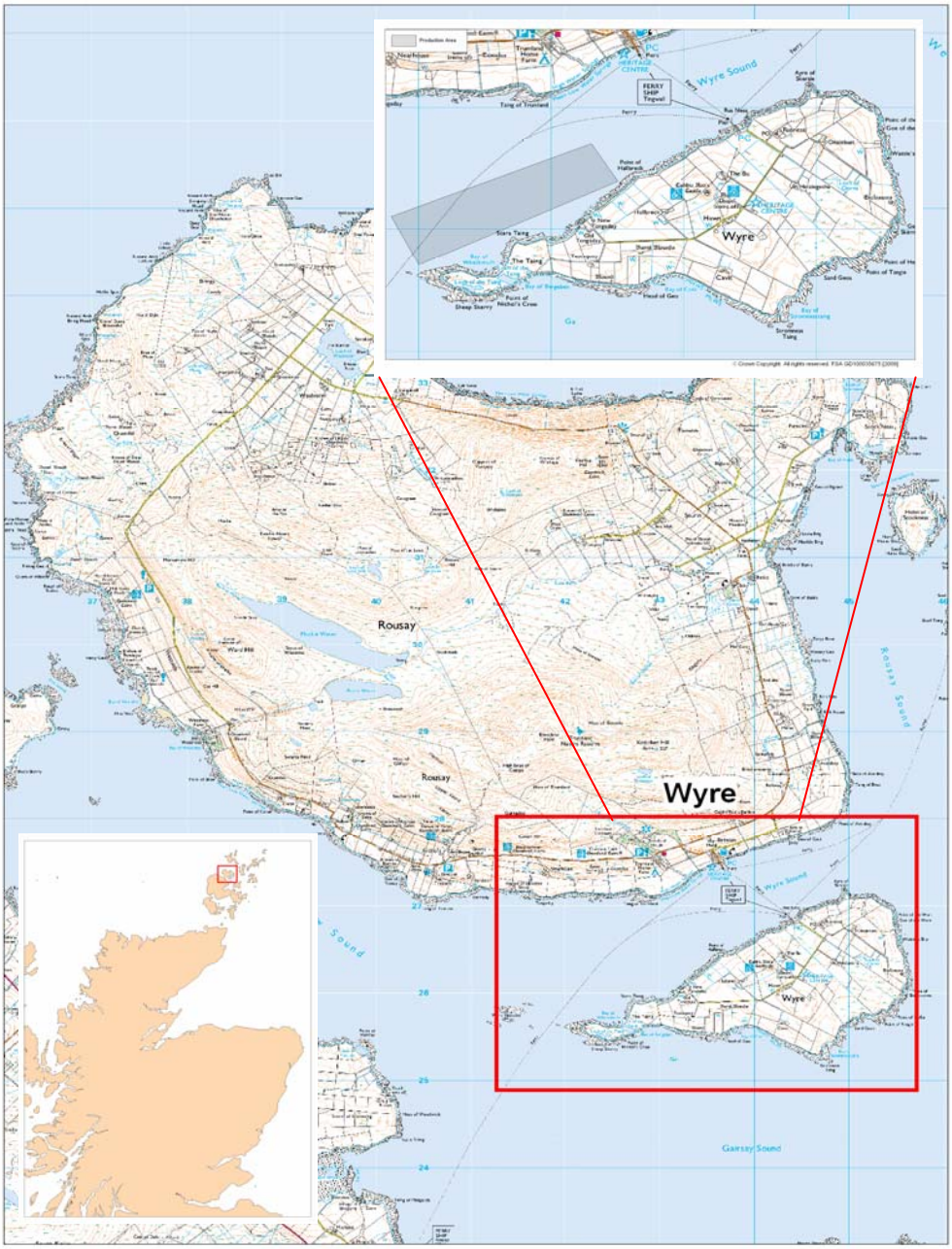

Figure 1.1 Location of Wyre Whelkmulli

2. Fishery

The application to harvest shellfish at Whelkmulli Bay requested the area be classified for four species, as listed in Table 2.1 below. Production area boundaries and RMPs have not yet been assigned.

Table 2.1 Whelkmulli Bay shellfish sites as listed on the application for harvest

Production Area	Site	SIN	Species
Whelkmulli Bay Kings	Whelkmulli Bay Kings	OI 468 878 07	King scallops
Whelkmulli Bay Queens	Whelkmulli Bay Queens	OI 469 879 15	Queen scallops
Whelkmulli Bay Oysters	Whelkmulli Bay Oysters	OI 470 880 13	Pacific oysters
Whelkmulli Bay Mussels	Whelkmulli Bay Mussels	OI 471 881 08	Common mussels

Currently, the fishery consists of one line of floats approximately 250 m in length from which plastic cages containing Pacific oysters are suspended approximately 3 m below the surface. Approximately 500,000 oysters were purchased from the Seasalter hatchery in 2008 and laid down at the site. Good growth is reported, and harvest may be possible as early as June 2010, earlier than originally anticipated. At some point in the future, and dependent on the success of the operation, expansion is planned. This would involve laying further lines of the same construction within the area identified in Figure 2.1. The grower indicated that there is space for 12-16 lines in total within the site, so high volumes of shellfish could potentially be produced at this site. Historically queen scallops have been cultured here, but currently no other species are cultured at this site, so it will only be necessary to sample and classify the site for Pacific oysters at present. The site is fairly exposed, but no storm related damage has been suffered to date.

Figure 2.1 shows the relative positions of the oyster line, the fishery boundaries as indicated on the application to harvest shellfish, and the Crown Estates lease area.

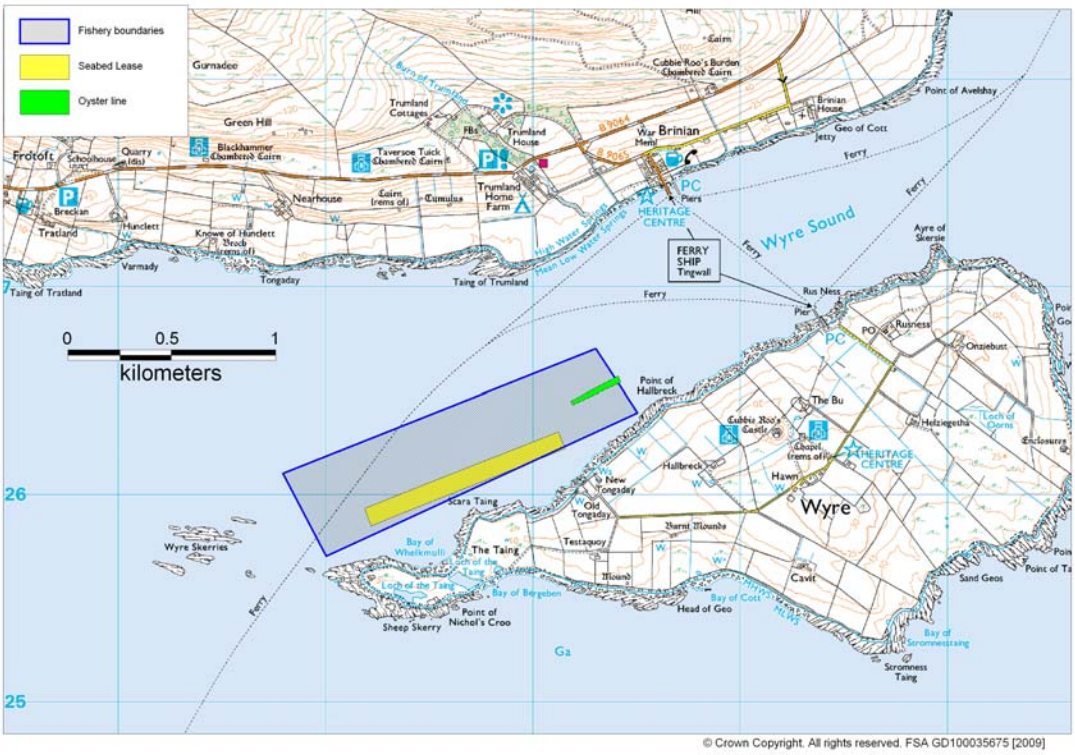

Figure 2.1 Whelkmulli Bay Fishery

3. Human Population

Figure 2.1 shows information obtained from the General Register Office for Scotland on population in the vicinity of Wyre at the time of last census (2001).

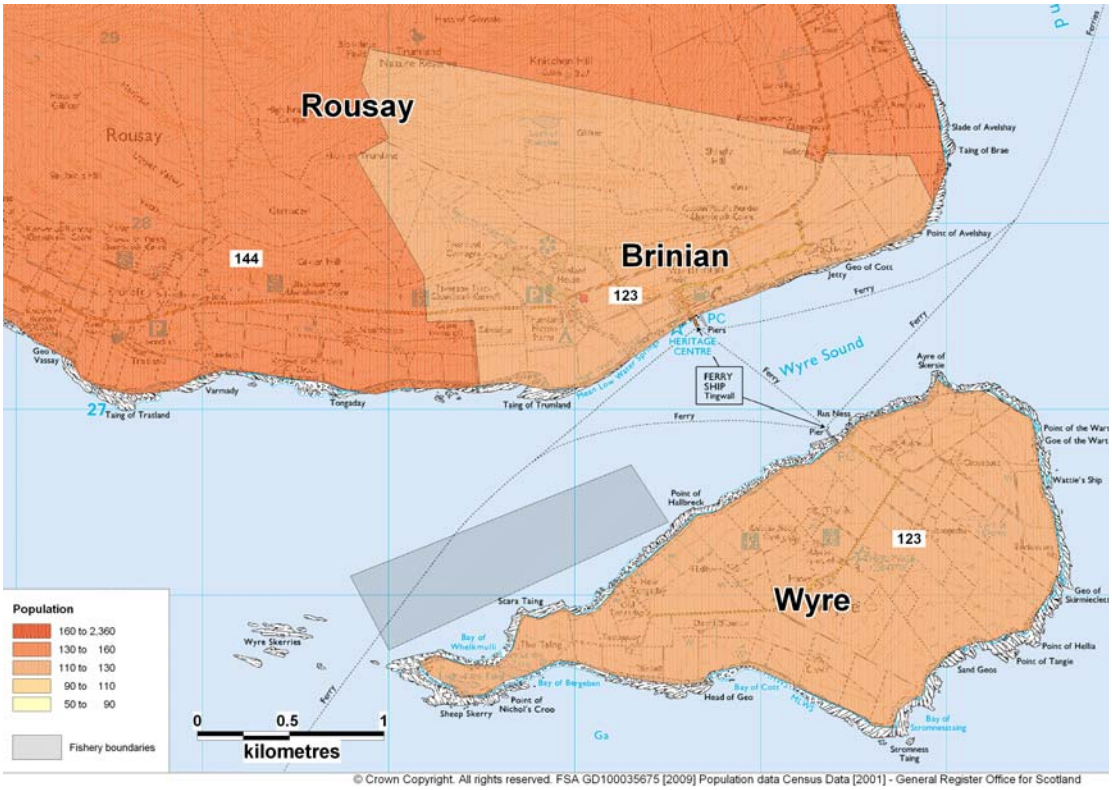

Figure 3.1 Population of Wyre

There are two population census output areas immediately bordering on Wyre Whelkmulli:

60RA000140	144
60RA000141	123
Total	267

Population in the area is low and centred around the small settlement of Brinian, on the south shore of Rousay. There are also several scattered dwellings along the south shore of Rousay, and a handful of scattered dwellings on Wyre. Therefore, inputs from human sources are likely to be relatively minor, and a large proportion of any contamination of human origin entering Wyre Sound will originate from the village of Brinian.

A small seasonal increase in population is expected at Rousay, which hosts some archaeological and wildlife related attractions. There is a small hostel and campsite at Trumland Farm, and other hotel and self catering accommodation elsewhere on the island. There is no accommodation and little in the way of attractions on Wyre, although it is likely there are occasional visitors to the island.

4. Sewage Discharges

One community septic tank was identified by Scottish Water for the area, which is consented to serve 4 people and discharges at Rousay pier. Details are presented in Table 4.1.

Table 4.1 Discharges identified by Scottish Water

NGR	Discharge Name	Discharge Type	Level of Treatment	Consented flow (DWF) m^3/d	Consent/ design pop	Q&S III Planned improve-ment?	Ref
HY 4367 2751	Rousay Pier	Continuous	Septic tank	2	4	no	WPC-N-60597

No sanitary or microbiological data is available for this discharges.

A number of discharge consents have been issued within the local area by the Scottish Environment Protection Agency (SEPA), including for the Scottish Water asset listed above. Details of these are presented in Table 4.2.

Table 4.2 Discharges identified by SEPA

Ref No.	NGR of discharge	Discharge Type	Level of Treatment	Consented flow (DWF) m^3/d	Consented/ design PE	Discharges to
WPC-N-60597	HY 4367 2751	Domestic	Septic tank	2	4	Wyre Sound
CAR/R/1012085	HY 4376 2797	Domestic	Septic tank		5	Land
CAR/R/1012209	HY 4060 2738	Domestic	Septic tank		6	Land
CAR/R/1025442	HY 4312 2740	Domestic	Septic tank		5	Land via soakaway
CAR/R/1025881	HY 4430 2836	Domestic	Septic tank		6	Land via soakaway
CAR/R/1027596	HY 4329 2759	Domestic	Septic tank		5	Land via soakaway
CAR/R/1027981	HY 4180 2760	Domestic	Septic tank		6	Land via soakaway

All of these, apart from the Scottish Water septic tank at Rousay pier discharge to land via soakaway systems, and so are expected to have little or no impact on water quality within Wyre Sound if they are functioning correctly, particularly given that they are all more than 100 m from the shore. As there has not historically been a requirement to register septic systems in Scotland, this list is unlikely to cover all septic tanks in the area. A physical survey of the shoreline was undertaken and observations of septic tanks and/or outfalls present along the shoreline of Wyre Sound are presented in Table 4.3.

Table 4.3 Discharges and septic tanks observed during shoreline survey

No.	Date	Grid Reference	Observation
1	12-AUG-09	HY 44409 26785	Public toilets at pier, septic tank at back presumably goes to soakaway
2	13-AUG-09	HY 44362 27761	Cast iron sewer pipe to shore, dripping, serves Brinian House and possibly also the doctors surgery
3	13-AUG-09	HY 43496 27440	Scottish Water Rousay septic tank, 20 cm cast iron pipe to underwater
4	13-AUG-09	HY 43669 27502	Vent on pier wall at Rousay, some odour, no associated discharge pipe seen

It is presumed that observation 3 on Table 4.3 is a Scottish Water septic tank, possibly serving the bulk of the population of Brinian, and so is the most significant discharge to Wyre Sound, although it was not possible to confirm this or the exact population served at the time of writing. It is also presumed that observation 4 on Table 4.3 is associated with the Scottish Water Rousay pier septic tank, which is only reported to serve a population of 4. This septic tank was not actually seen during the shoreline survey, but it is presumed that it is located under manholes and concrete by Rousay pier, and the overflow runs under the pier. In addition to these two discharges, there is a third discharge to Wyre Sound (observation 2 on Table 4.3). This is a private discharge from Brinian House, just under a kilometre to the east of Brinian. It is possible that this also serves the doctors surgery, which is just behind Brinian House. No discharges to Wyre Sound were seen on Wyre.

It is likely that most other houses outside of the settlement of Brinian, including those on Wyre are served by private septic tanks which discharge to soakaway, which should have no impact on water quality in Wyre Sound.

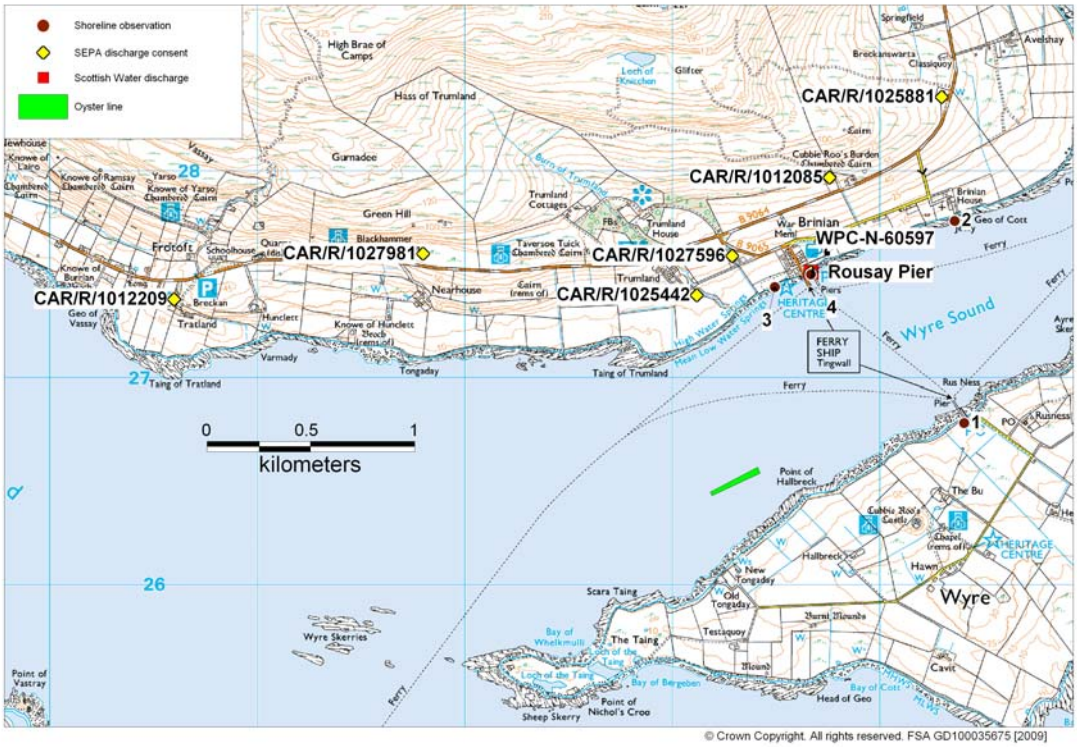

Figure 4.1 Sewage discharges at Whelkmulli Bay

Another potential source of sewage is boating activity within Wyre Sound. Wyre and Rousay are served by a small car ferry which sails several times daily to the mainland and Eglisay. The ferry actually takes a route through Wyre Sound which keeps passes north as opposed to south as shown on the Ordnance Survey map of the Wyre Skerries on its way to and from Tingwall, so it does not pass as close to the fishery as the route shown on Figure 4.1 suggests. It is not known whether the ferry discharges its waste water within Wyre Sound. At and around the harbour at Brinian a total of 7 small boats, one larger boat, and the shellfish barge were observed during the shoreline

survey. Yachts visit the area from time to time and use the moorings just off Brinian.

5. Geology and Soils

Geology and soil types were assessed following the method described in Appendix 2. A map of the resulting soil drainage classes is shown in Figure 5.1. Areas shaded red indicate poorly draining soils and areas shaded blue or grey indicate freely draining soils.

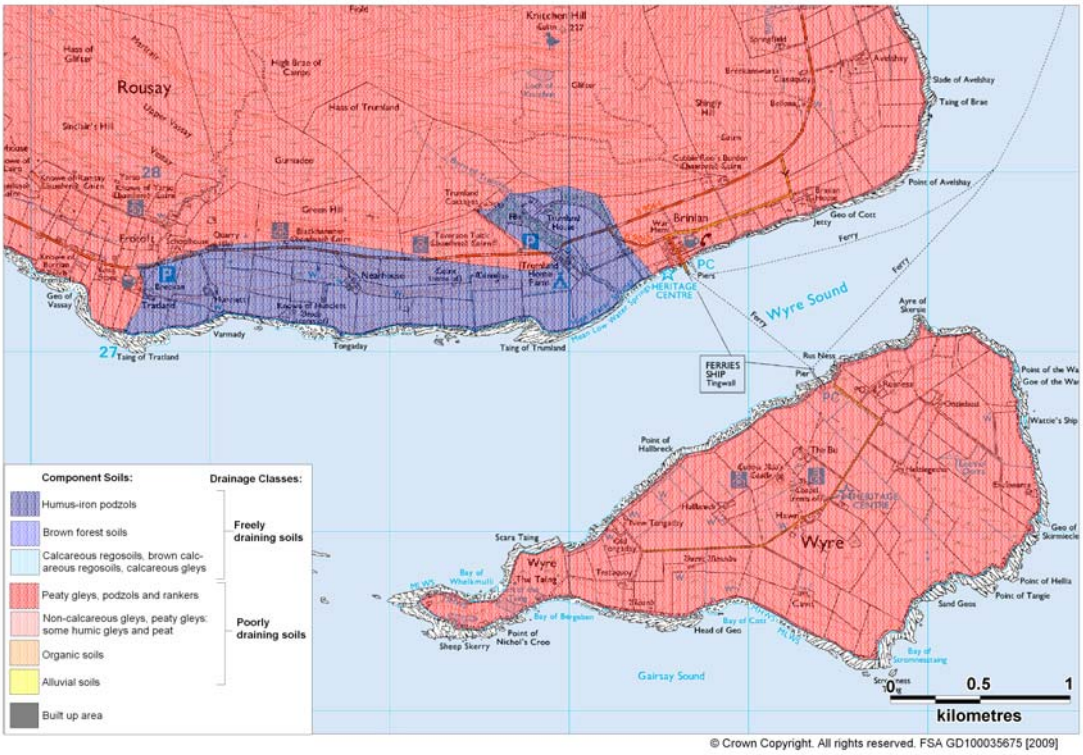

Figure 5.1 Component soils and drainage classes for Whelkmulli Bay

Two types of component soils are present in the area: peaty gleys, podzols and rankers and humus iron podzols. The humus iron podzols are freely draining; therefore the potential for runoff is reduced. The peaty gleys, podzols and rankers are poorly draining. Therefore, the potential for runoff contaminated with *E. coli* from human and/or animal waste is high for most areas, including the whole island of Wyre and the shoreline east of the ferry terminal on the mainland.

6. Land Cover

No Land Cover Map 2000 data was available for this area, and no similar substitute data sources could be identified, so no detailed land cover maps could be produced for this area.

Agricultural census data provided by the Scottish Government Rural and Environment Research and Analysis Directorate (RERAD) indicated that in 2008 for the parish of Rousay, which covers the entire of Rousay, Eglisay and Wyre, there was farmed land area of 5924 hectares. Of this, 1649 hectares were used for crops or improved grassland, 3932 hectares were rough grazing, and 167 hectares were other land, such as hard standing or farm yards. This compares to a total parish land area of 5660 hectares, indicating that 105% of the parish is farmed or grazed. This apparent dioscerepancy was raised with RERAD and no reply had been received at the time of writing.

The Ordnance Survey map of the area indicates that there is 'bracken, heath or rough grassland' at the western tip of and some central areas of Wyre, and on the higher ground at Rousay, with open fields covering other areas. The shoreline survey identified that almost all of Wyre was pasture, and that the coastal strip of Rousay was also pasture. Some pastures were used for the production of hay, while others were being grazed by cattle and sheep at the time. It was not possible to firmly differentiate between improved and unimproved pasture, but much of it appeared to be improved. Further back from the shore at Rousay the higher ground is moorland, including the RSPB Trumland reserve from which grazing animals are excluded. There is a small developed area at Brinian.

The faecal coliform contribution would be expected to be highest from developed areas (approx 1.2 – 2.8×10^9 cfu km^{-2} hr^{-1}), with intermediate contributions from the improved grassland (approximately 8.3×10^8 cfu km^{-2} hr^{-1}) and lowest from the other land cover types (approximately 2.5×10^8 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 increase would be highest, at more than 100-fold, for the improved grassland.

Therefore, on the basis of observed land cover, the potential for contaminated runoff would be highest at Brinian, low to intermediate around the rest of Wyre Sound, depending on whether the pastures were improved or not, and likely to increase after significant rainfall.

7. Farm Animals

Agricultural census data was received from the Scottish Government Rural and Environment Research and Analysis Directorate (RERAD) for the Rousay parish, which covers the entire of Rousay, Eglisay and Wyre, an area of 56.6 km^2. Recorded livestock populations for the parishes for 2008 are presented in Table 7.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reported would have made it possible to discern individual farm data.

Table 7.1 Livestock numbers in Rousay, 2008

	2007		2008	
	Holdings	Numbers	Holdings	Numbers
Pigs	*	*	*	*
Poultry	19	1065	17	969
Cattle	22	1401	23	1372
Sheep	31	8140	28	7960
Horses and ponies	6	16	5	14

* Data withheld for reasons of confidentiality

Livestock kept within this parish is predominantly sheep and cattle. Due to large area of this parish, this data does not provide information on the livestock numbers in the area immediately surrounding the production areas. The only significant source of local information was therefore the shoreline survey (see Appendix), which only relates to the time of the site visit on 12-13th August 2009. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 7.1. This information should be treated with caution, as it applies only to the survey dates and is dependent upon the point of view of the observer (some animals may have been obscured from view by the terrain).

The shoreline survey confirmed that agriculture in the area is dominated by sheep and cattle grazing. The vast majority of the land adjacent to the fishery is pasture, some of which was being grown or cut for hay or silage, and some of which had livestock on at the time of survey. A total of 65 cattle and 14 sheep were counted around the north coast of Wyre, and a total of 231 sheep, 65 cattle and 4 hogs were counted on the south shore of Rousay. It is likely that livestock are moved between fields as they are cut. Therefore, any streams draining into the production area are likely to carry some contamination of livestock origin although this may vary with time as the animals are moved around. A significant presence of cattle also suggests that slurry may be spread on some fields, although the location, timing and extent of this is uncertain.

Numbers of sheep and cattle will approximately double during spring following the birth of lambs and calves, and decrease in the autumn as they are sent to market. Therefore higher impacts from livestock may to be expected during this period.

Figure 7.1 Shoreline survey livestock observations

8. Wildlife

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 around Wyre Sound could potentially affect water quality around the fishery.

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*). Scotland hosts significant populations of both species.

A survey conducted by the Sea Mammal Research Unit in 2001 estimated a population of 769 common seals on Rousay, Wyre, Egilsay, Eynhallow, and Scockness (Sea Mammal Research Unit, 2002). The survey identified no haulout sites on Wyre, with the closest identified haulout site for this species on the south eastern corner of Rousay.

Minimum grey seal pup production in Orkney was estimated as 19332 in 2006 (Sea Mammal Research Unit, 2007). Adult numbers are estimated to be 3.5 times the pup population (Callan Duck, Sea Mammal Research Unit, personal communication), so this species is present in large numbers around Orkney. It is uncertain whether there are any breeding colonies within Wyre Sound.

Therefore it is likely that both species of seals, particularly grey seals may frequent the area. Four grey seals were seen close to the fishery, just off the western end of Wyre and another seal (species uncertain) was seen closer to the shore of Rousay during the shoreline survey confirming their presence in the area.

Whales/Dolphins

A variety of whales and dolphins are routinely observed near Orkney. It is possible that cetaceans will be found from time to time in the area, although any impact of their presence is likely to be fleeting and unpredictable, and as Wyre Sound is quite shallow, only the smaller species are likely to enter.

Birds

A number of bird species are found around Wyre Sound, but seabirds and waterfowl are the most likely to occur around or near the fisheries. Breeding seabirds were the subject of a detailed census carried out in sections during the late spring of 1999, 2000, 2001 and 2002 (Mitchell *et al*, 2004). Total counts of all species recorded within 5 km of the oyster line are presented in Table 8.1. Where counts were of occupied sites/nests/territories, actual numbers of birds breeding in the area will be higher.

Table 8.1 Counts of breeding seabirds within 5 km of the oyster line

Common name	Species	Total count	Count method	Individual/Pair
Northern Fulmar	*Fulmarus glacialis*	645	Occupied sites	pairs
Common Gull	*Larus canus*	331	Occupied territory	pairs
Great Black-backed Gull	*Larus marinus*	123	Occupied territory	pairs
Black-Headed Gull	*Larus ridibundus*	66	Occupied territory	pairs
Arctic Tern	*Sterna paradisaea*	61	Occupied territory	pairs
Arctic skua	*Stercorarius parasiticus*	32	Occupied territory	pairs
Herring Gull	*Larus argentatus*	30	Occupied territory	pairs
Great Skua	*Stercorarius skua*	21	Occupied territory	pairs
Lesser Black-backed Gull	*Larus fuscus*	20	Occupied territory	pairs
Black Guillemot	*Cepphus grylle*	17	Individuals on land	ind
Common tern	*Sterna hirundo*	2	Occupied territory	pairs

The seabird census indicated a fairly high density of breeding seabirds in the general area. Of most significance to the fishery is a colony of 66 pairs of gulls and terns which nest at the western end of Wyre, which was the largest aggregation of nesting sites recorded in the vicinity of Wyre Sound.

Waterfowl (ducks and geese) are present in the area at various times, either to overwinter or to breed during the summer. During the shoreline survey a total of 61 geese were counted towards the western end of Wyre, and on the shore adjacent to the fishery there were considerable amounts of goose droppings. Nine geese were also seen near Trumland. 29 ducks were seen on the north shore of Wyre, and four were seen in the vicinity of Trumland. Large and increasing numbers of geese overwinter in Orkney, so their presence on pastures on Wyre during the winter months is expected, possibly in larger numbers than are experienced in summer. Numbers of geese overwintering in some areas of Orkney have reached pest levels (reported in Orkney Today, February 2, 2009).

Otters

No otters were observed during the course of the shoreline survey, although it is believed that they are present in the area. However, the typical population densities of coastal otters are low and their impacts on the shellfishery are expected to be very minor.

Summary

Shoreline survey wildlife observations and breeding seabird counts in the close vicinity of the fishery are presented on Figure 8.1.

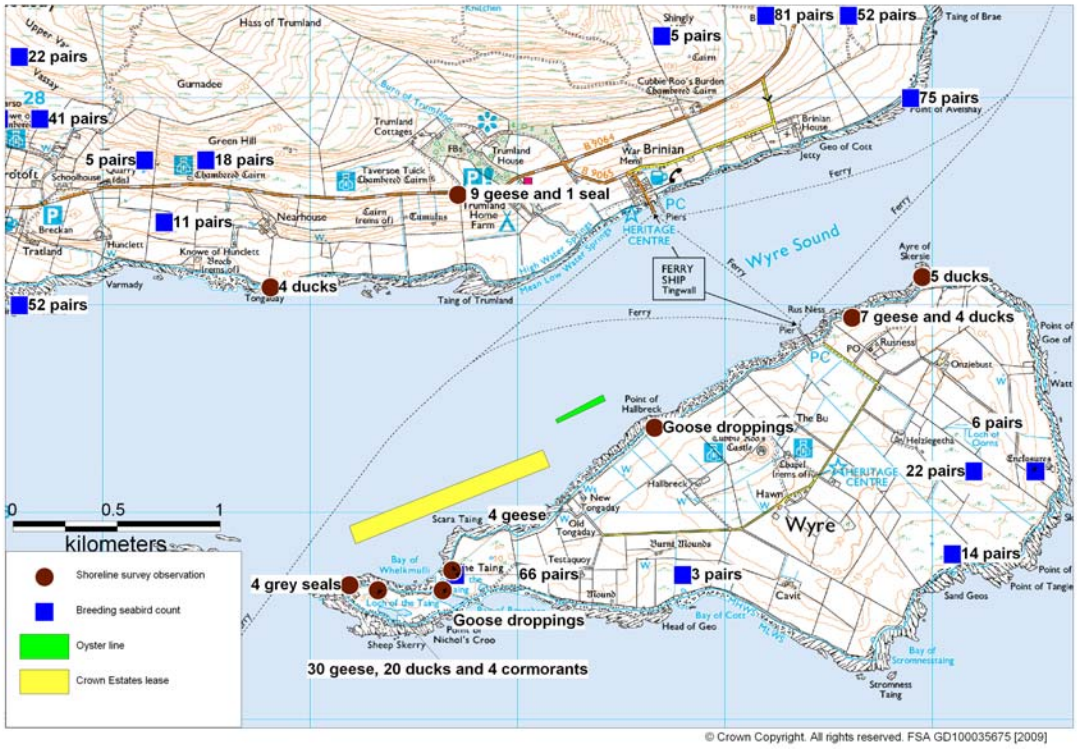

Figure 8.1 Shoreline survey wildlife observations and breeding seabird counts

The main wildlife species potentially impacting on the production area are seals, geese and seabirds. Highest concentrations of these species within Wyre Sound appear to occur in the vicinity of the fishery, towards the western end of Wyre, so although these animals are highly mobile any impacts may be concentrated around the shore of Wyre to the south of the fishery. It is likely that there is some seasonality to this, possibly with highest numbers of seabirds in the summer and highest numbers of geese in the winter if they overwinter on Wyre.

9. Meteorological data

The nearest weather station is located at Shapinsay: Balfour Castle, approximately 10 km to the south of the fishery, for which uninterrupted rainfall data is available for 2005-2008 inclusive. It is likely that the rainfall patterns at Shapinsay: Balfour Castle are similar to those experienced at Wyre and Rousay due to their proximity. The nearest weather station for which wind data is available is Kirkwall, approximately 19 km to the south of the fishery. It is likely that overall wind patterns and wind conditions on any given day are broadly similar at the fishery and at Kirkwall given their fairly close proximity, but local topography may result in some differences. This section aims to describe the local rain and wind patterns and how they may affect the bacterial quality of shellfish within Wyre 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 *.

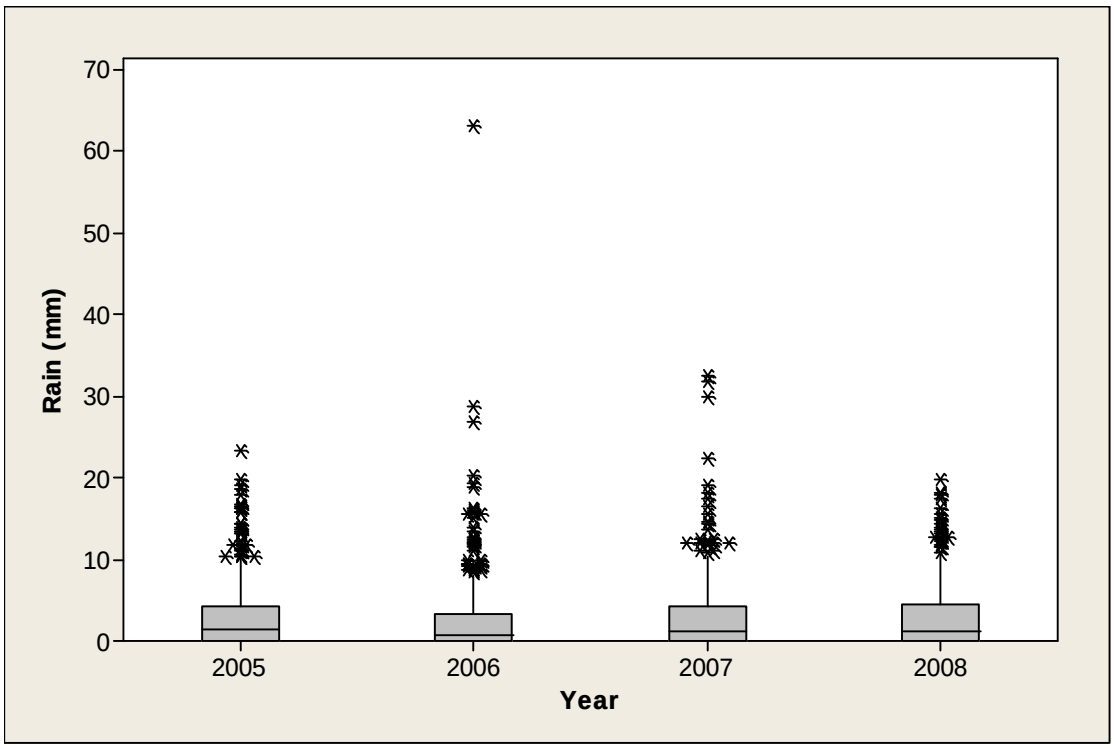

Figure 9.1 Box plot of daily rainfall values by year at Shapinsay, 2005-2008

Figure 9.1 shows that rainfall patterns were similar between the years presented here. In general, 2006 was slightly drier than the other years although it had the day with the highest rainfall – more than 60 mm.

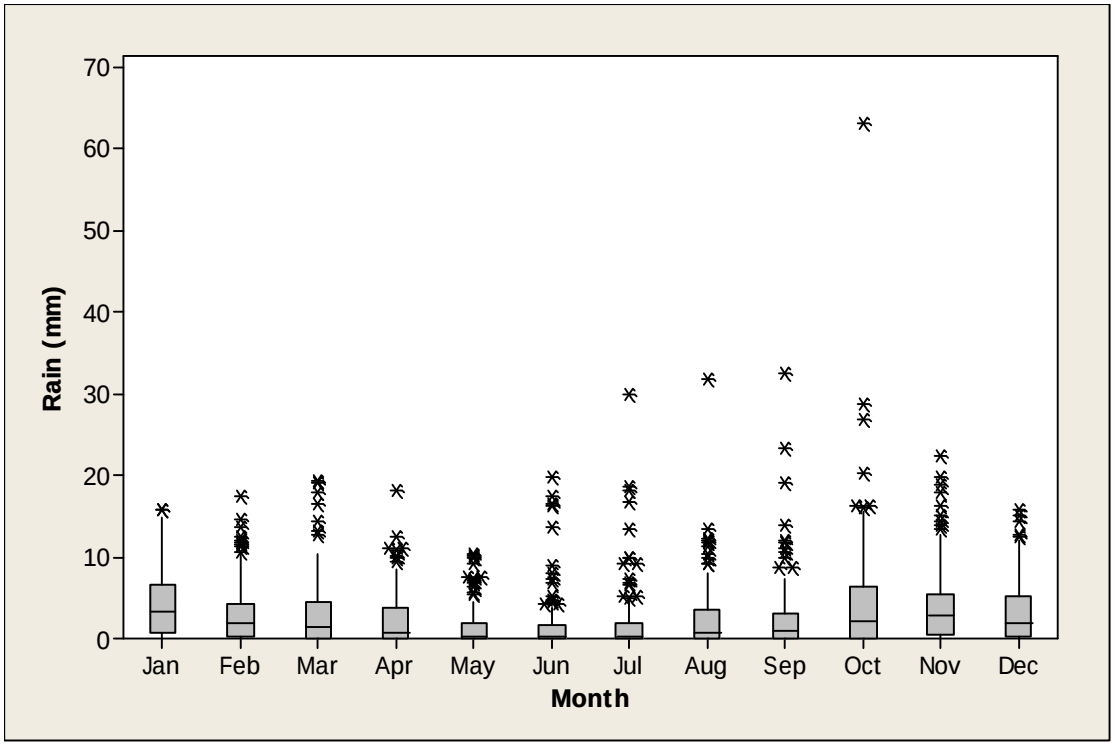

Figure 9.2 Box plot of daily rainfall vaules by month at Shapinsay, 2005-2008

The wettest months were October and January, and May to July were the driest months. Days with high rainfall can occur at any time of the year, but the highest individual daily rainfalls occurred from July to November. For the period considered here (2005-2008), 48% of days experienced rainfall of 1 mm or less, and 8% of days experienced rainfall of 10 mm or more.

It can be expected that levels of rainfall dependent faecal contamination entering the production area from these sources may be higher during the autumn and winter months. Faecal matter may build up on pastures during the drier summer months when stock levels are at their highest, and cause a 'first flush' of contaminated runoff following summer storms, although this could happen at any time of the year.

9.2 Wind

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

WIND ROSE FOR KIRKWALL
N.G.R: 3482E 10077N ALTITUDE: 26 metres a.m.s.l.

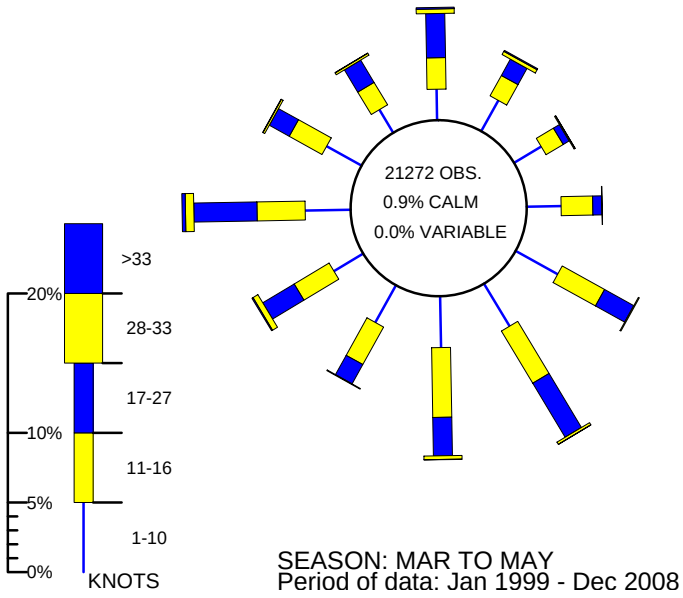

Figure 9.3 Wind rose for Kirkwall (March to May)

WIND ROSE FOR KIRKWALL
N.G.R: 3482E 10077N ALTITUDE: 26 metres a.m.s.l.

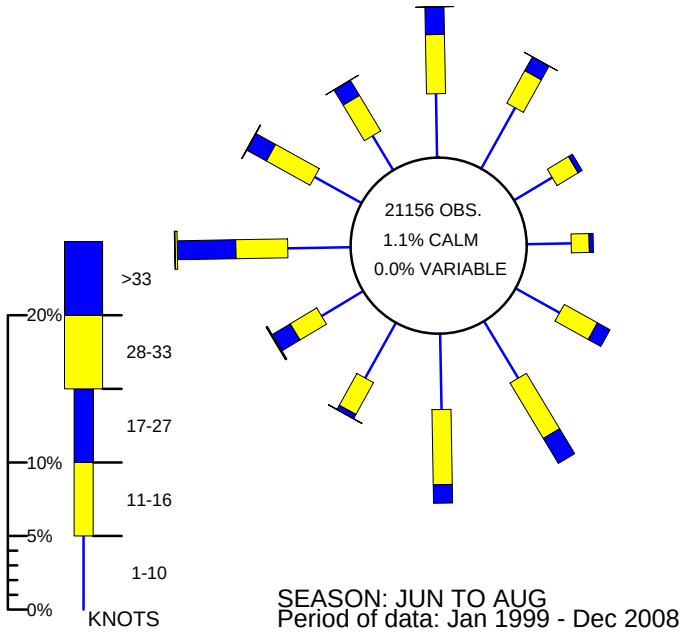

Figure 9.4 Wind rose for Kirkwall (June to August)

WIND ROSE FOR KIRKWALL
N.G.R: 3482E 10077N ALTITUDE: 26 metres a.m.s.l.

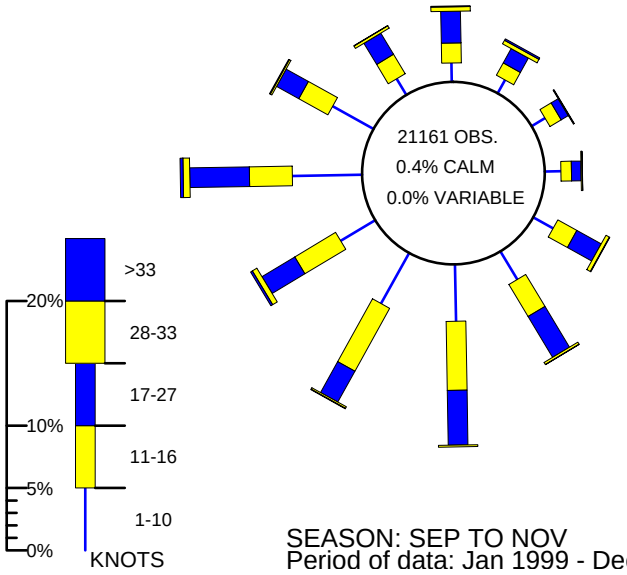

Figure 9.5 Wind rose for Kirkwall (September to November)

WIND ROSE FOR KIRKWALL
N.G.R: 3482E 10077N ALTITUDE: 26 metres a.m.s.l.

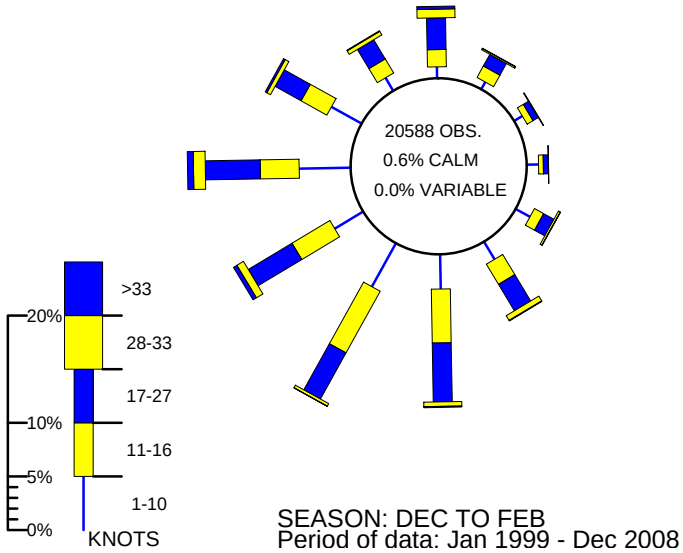

Figure 9.6 Wind rose for Kirkwall (December to February)

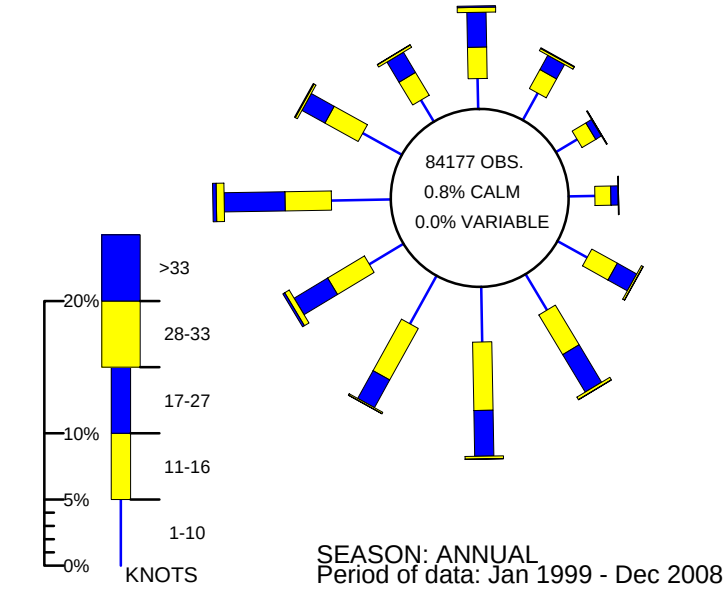

Figure 9.7 Wind rose for Kirkwall (Annual)

Orkney is one of the more windy areas of Scotland with a 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. Winds are generally lighter during the summer months. The Kirkwall weather station is located at Kirkwall airport, which is at the head of a north facing bay, and surrounded by fairly low lying land, so therefore the local topography might offer it slightly less shelter from northerly winds than from winds from other directions.

Wyre Sound has an east-west aspect, and so is most exposed to winds from these directions. Some shelter is afforded from southerly winds by the low lying island (30 m) of Wyre, while more shelter will be received from northerly winds by Rousay, which rises to 250 m. Therefore wind patterns in Wyre Sound are expected to align more along the east-west axis than they do at Kirkwall.

Wind effects are likely to cause changes in water circulation within Wyre Sound, although tides are expected to be of greater influence. 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, which compares with peak tidal flows of almost 4 knots within Wyre Sound. These surface water currents create return currents which may travel along the bottom or sides of the water body depending on bathymetry. Strong winds will increase the circulation of water and hence dilution of contamination from point sources within the sound. Winds from a northerly direction may transport contamination from the settlement of Brinian towards the fishery, depending on the tidal flows at the time.

10. Current and historical classification status

Whelkmulli Bay has not yet been classified for the harvest of shellfish.

11. Historical *E. coli* data

There is no historical *E. coli* monitoring data for Whelkmulli Bay

12. Designated Shellfish Growing Waters Data

Whelkmulli Bay does not fall within or nearby any designated shellfish growing waters.

13. River and Streams

Surface runoff is an important pathway through which faecal contamination from diffuse sources such as livestock is carried into coastal waters. Usually, the relative importance of rivers and streams as sources of contamination is assessed through measurements of stream discharge and *E. coli* levels taken during the shoreline survey. In this case, the shoreline survey was carried out following an unusually warm and dry spell, and although there were a few small streams / drainage ditches marked on the Ordnance Survey map, none was flowing at the time of shoreline survey, so it was not possible to carry out any measurements. The general locations of these are shown in Figure 13.1.

The largest stream discharging to the survey area is the Burn of Trumland, which discharges from Rousay, about 500 m to the west of Brinian. This drains an area of moorland (the Trumland RSPB reserve) from which grazing animals are excluded. It then flows through a small wooded area by Trumland house, then through pastures in its lower reaches, although here the watercourse is fenced off from the fields, so livestock are not able to access it.

The remainder of the survey area is drained by a series of small field drains. It is likely that these are impacted by contamination from livestock. The overall area drained by these watercourses is small, and Wyre Sound is a large water body with strong tides, so the combined impact of all freshwater sources on the fishery is likely to be fairly minor, although it is expected to increase at times of high runoff.

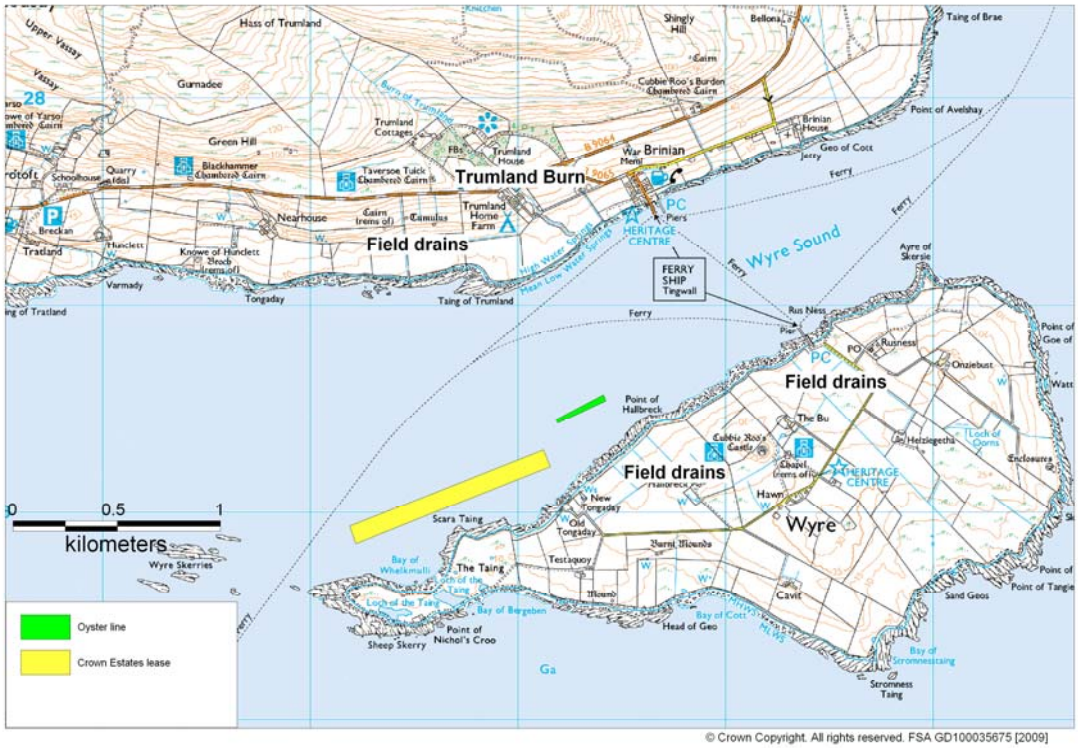

Figure 13.1 Rivers and streams

14. Bathymetry and Hydrodynamics

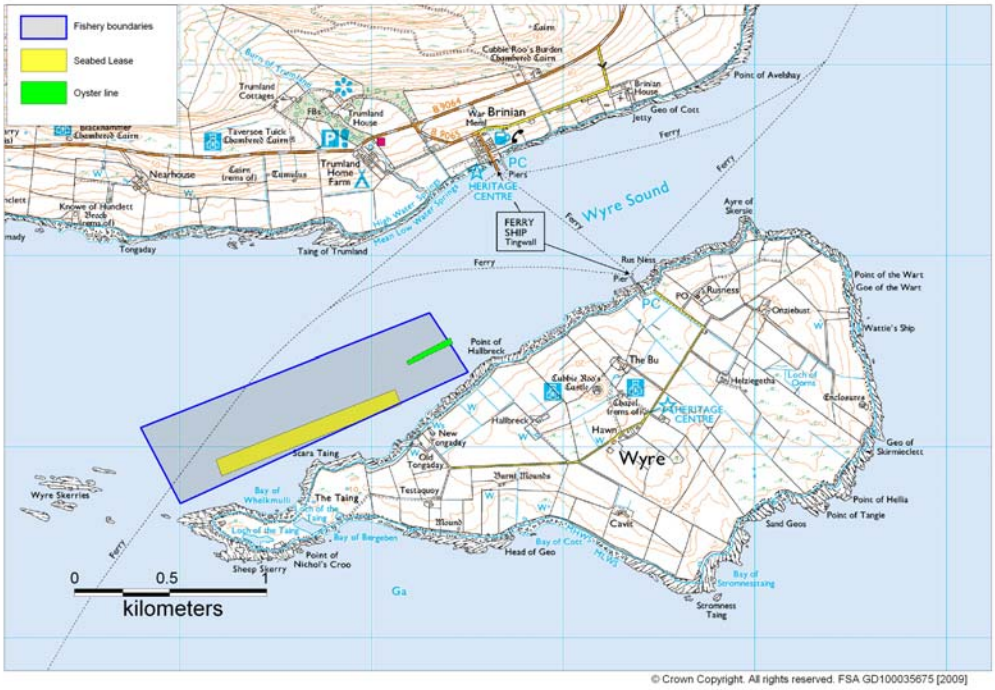

Figure 14.1 OS map of Wyre Sound

Figure 14.2 Bathymetry of Wyre Sound

Wyre Sound is located between the islands of Wyre and Rousay, and is about 3.6 km long and 1 km wide. It is shallow, with maximum depths of just over 10 m. The fishery is located within the 2-10 m depth band. The sound is open at either end. The Wyre Skerries, a group of small rocky islets which are uncovered at low water are located just to the west of the fishery.

14.1 Tidal Curve and Description

The two tidal curves below are for Tingwall. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 GMT on 07/08/09 and the second is for seven days beginning 00.00 GMT on 14/08/09. 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.

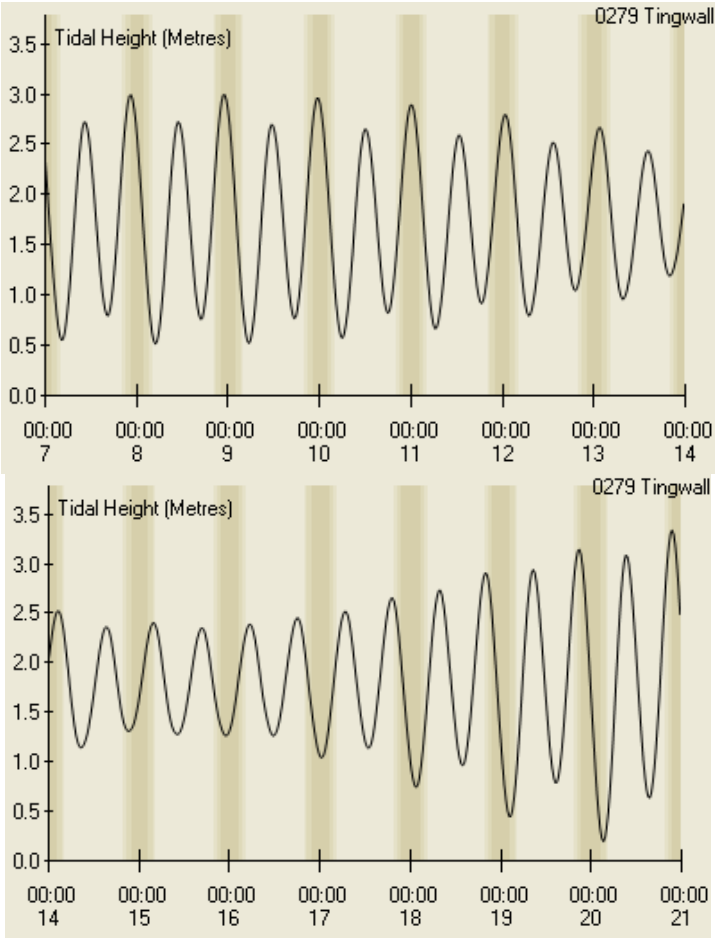

Figure 14.3 Tidal curves for Tingwall

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

HAT	3.6 m
MHWS	3.1 m
MHWN	2.4 m
MSL	1.90 m
MLWN	1.3 m
MLWS	0.6 m

The tidal range at spring tide is therefore approximately 2.5 m and at neap tide 1.1 m.

14.2 Currents

Currents in coastal waters are driven by a combination of tide, wind and freshwater inputs. This section aims to make a simple assessment of water movements around the area.

Tidal stream information was available for stations in Gairsay Sound (SN027V), south of Wyre, and in Eynhallow Sound (SN028A), to the south west of Rousay. There was no tidal stream information for Wyre Sound itself. The locations of these stations are presented in Figure 14.4, and their tidal diamonds are presented in Tables 14.1 and 14.2.

Table 14.1 Tidal streams for SN027V (taken from TotalTide)

Time	Direction	Spring rate (m/s)	Neap Rate (m/s)
-06h	053°	0.7	0.3
-05h	062°	0.7	0.3
-04h	072°	0.5	0.2
-03h	200°	0.1	0.1
-02h	238°	0.6	0.3
-01h	243°	0.8	0.3
HW	256°	0.6	0.3
+01h	258°	0.4	0.2
+02h	212°	0.3	0.1
+03h	173°	0.3	0.1
+04h	075°	0.3	0.1
+05h	043°	0.5	0.2
+06h	048°	0.7	0.3

Table 14.2 Tidal streams for SN028A (taken from TotalTide)

Time	Direction	Spring rate (m/s)	Neap Rate (m/s)
-06h	304°	1.3	0.5
-05h	309°	1.2	0.5
-04h	306°	1.0	0.4
-03h	304°	0.7	0.3
-02h	100°	0.1	0.0
-01h	123°	1.0	0.4
HW	121°	1.6	0.6
+01h	120°	1.7	0.6
+02h	121°	1.3	0.5
+03h	121°	0.7	0.3
+04h	285°	0.1	0.1
+05h	300°	1.0	0.4
+06h	303°	1.3	0.5

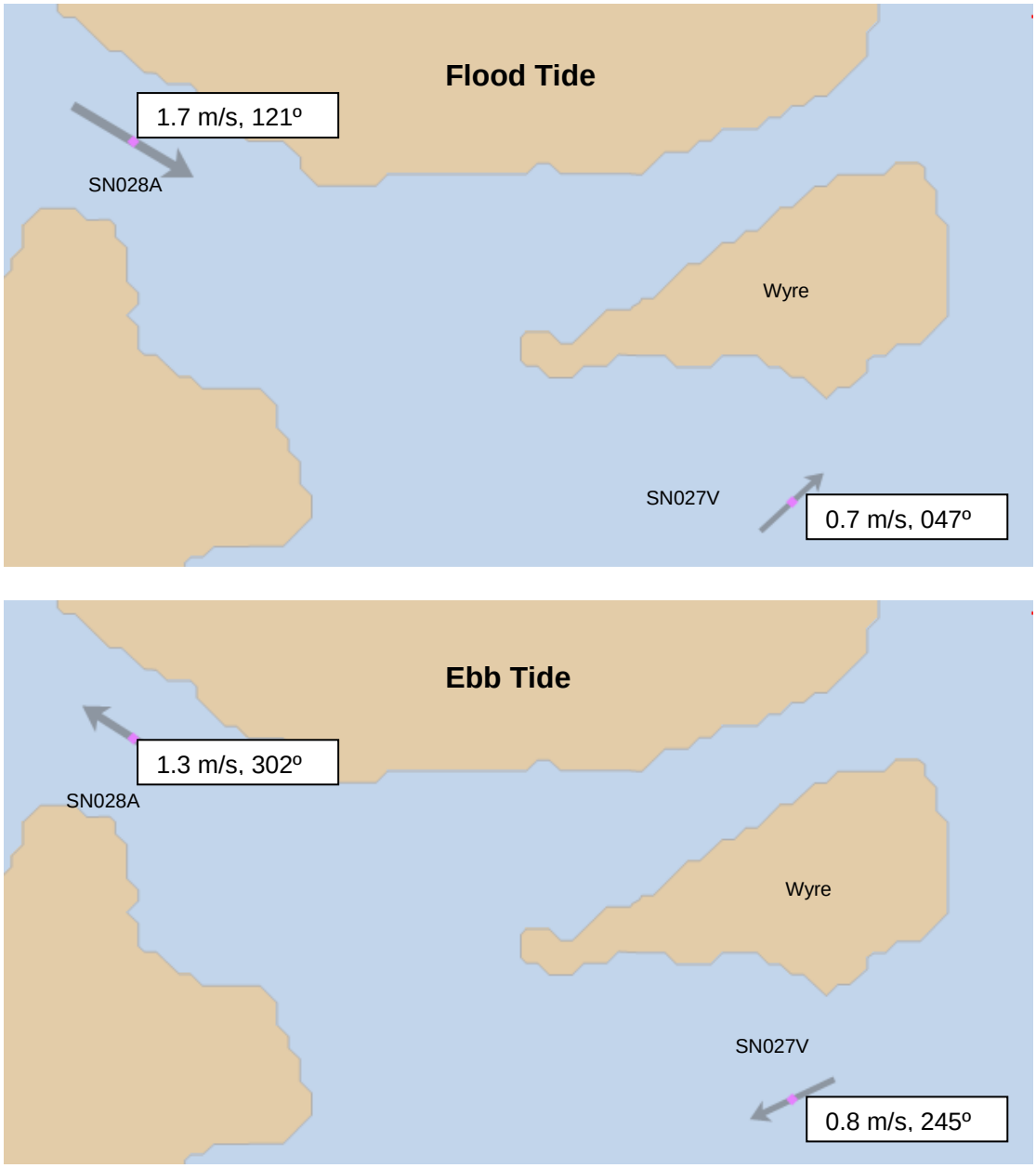

Figure 14.4 Tidal flows and direction at peak flow at stations SN027V and SN028A (taken from TotalTide)

The tidal diamonds indicate that tidally driven flows within Wyre Sound are likely to move in a southwest-northeast direction on the flood tide, and an northeast-southwest direction on the ebb tide. Tidal flow rates and directions at peak flow on a spring tide are illustrated in Figure 14.4. Flow rates were high in Eynhallow Sound, reaching 1.7 m/s on spring tides. Tidal flows were slower in Gairsay Sound, reaching 0.8 m/s on spring tides. The grower reports that tides within Wyre Sound can approach 4 knots (2.1 m/s).

Flows along the southwestern end of Wyre will be complicated by the Wyre Skerries and the shallows north and east of them, and tides are likely to flow slower on the near shoreline due to friction with the land surface. The strength of the tides means that water within the sound will be exchanged

several times each tide. Contamination originating from sources on Rousay is likely to be carried along the shore of Rousay and out of Wyre Sound by tidal flows. Therefore it will mainly be carried past the fishery, although of course some mixing will occur, so it is possible that there is a gradient of decreasing contamination levels with distance from the shore, although it is not known how far from the shore contamination will be above background levels, and this will depend on strength of tide and possibly winds. During larger tides, more of the foreshore will be inundated washing more contamination such as the large amounts of goose droppings seen on the shore towards the western end of Wyre into the sea.

Strong winds will create a surface current in the same direction as the wind. Wyre Sound is open to the east and west, so winds from this direction are likely to affect circulation in the area the most. For some wind directions, the surface currents created may facilitate the movement of contamination from point sources towards the fishery, for example a north easterly wind may create currents which move contamination from Brinian towards the shellfishery. Wind driven surface currents will create a return current, which may flow along the bottom or the sides of a water body depending on wind direction and local bathymetry. Onshore winds will increase wave action, which may resuspend contamination in the water.

Density (freshwater) driven flows are usually of greatest importance in enclosed estuaries and sea lochs which have considerable freshwater inputs and restricted tidal exchange. The area in which the fishery is located has an open aspect, strong tidal flows and does not receive any large freshwater inputs. Salinity measurements taken during the shoreline survey indicated that the salinity was that of full strength seawater throughout the sound. Therefore, it is anticipated that freshwater driven currents are of negligible importance to water circulation patterns within Wyre Sound.

14.3 Conclusions

Strong tidally driven flows are likely to dominate water circulation within Wyre Sound. The strength of the tides means that the water within the sound will be exchanged several times each tide leading to substantial removal or dilution of pollutants entering the sound. Contaminants entering the sound within the main tidal stream are likely to be carried out of the sound relatively quickly. Effects very near the shore (within 20 meters) may differ significantly from those in the main body of the sound. Faecal contamination entering the sound from the shore is likely to remain in slower-flowing water immediately along the shoreline and may get caught up in more complex circulation patterns likely to exist along the western end of Wyre.

15. Shoreline Survey Overview

The shoreline survey was carried out on the 12-13th August 2009 following a prolonged period of hot, dry weather.

The fishery consisted of one line of floats approximately 250 m in length from which plastic cages containing Pacific oysters were suspended. Good growth is reported, and harvest is planned for 2010 or 2011. There is considerable scope for expansion of the fishery, and this would involve laying further lines of the same construction. Currently no other species are cultured at this site.

Population on Wyre is low, and limited to a handful of dwellings which are all likely to be served by individual private septic tanks discharging to soakaway, as was observed at the public toilets at the pier on Wyre. No septic tank discharges to water were seen on the north shore of Wyre. The main settlement on the adjacent coast of Rousay is Brinian, which is served by a Scottish Water communal septic tank which discharges to Wyre Sound a short distance to the west of the harbour. A private sewer outfall to Wyre Sound was seen at Brinian House, about 1 km to the east of Brinian harbour. No other discharges observed to Wyre Sound, suggesting that other dwellings along the south coast of Rousay were probably all served by septic tanks discharging to soakaway.

Car ferries sail several times daily from Rousay and Wyre, although they keep to the north of the fishery site in order to avoid obstacles. At and around the harbour at Brinian a total of 7 small boats, one larger boat, and the shellfish barge were observed. Yachts visit the area from time to time. A small seasonal increase in population is expected at Rousay, which hosts some archaeological and wildlife related attractions. There is a small hostel and campsite at Trumland Farm, and other hotel and self catering accommodation elsewhere on the island. There is a restaurant and craft shop at Brinian. There is no accommodation and little in the way of attractions on Wyre, although it is likely there are occasional visitors to the island.

The vast majority of the land adjacent to the fishery is pasture, some of which was being grown or cut for hay or silage, and some of which had livestock on at the time of survey. It is likely that much of this pasture is improved, although it was not possible to be certain about this. A total of 65 cattle and 14 sheep were counted around the north coast of Wyre, and a total of 231 sheep, 65 cattle and 4 hogs were counted on the south shore of Rousay.

Further from the shore on Rousay, behind Brinian and Trumland, is the Trumland RSPB reserve, which is moorland, and no grazing is permitted here. A total of 61 geese were counted towards the western end of Wyre, and on the shore adjacent to the fishery there were considerable amounts of goose droppings. Nine geese were also seen near Trumland. 29 ducks were seen on the north shore of Wyre, and four were seen in the vicinity of Trumland. Four seals were seen by the western end of Wyre, and one was seen off

Trumland. The RSPB reserve behind Trumland is not believed to support any aggregations of birds large enough to be of significant impact to the fishery.

Although there were a few small streams / drainage ditches marked on the Ordnance Survey map, none was flowing at the time of shoreline survey. As the weather in the week preceding the shoreline survey was warm and dry, it is likely that conditions encountered on the shoreline survey were unusually dry. These freshwater inputs are expected to usually be minor, as the catchment area they drain is small.

Tides within Wyre Sound are fairly strong, and were running at about 2 knots at the time the fishery was visited.

Mussel and oyster samples taken from either end of the fishery had very low levels of contamination (20 or <20 *E. coli* MPN/100g). The mussel samples originated from Rousay pier, and the oysters were purchased locally by the harvester as his own stock was too small to sample at the time of survey. Samples of both were deployed at either end of the fishery over 2 weeks before the survey. Seawater samples taken at the fishery also had very low levels of contamination (<1 *E. coli* cfu/100ml). Seawater samples taken from the shore at Rousay also had low levels of contamination (2, 2, and 1 *E. coli* cfu/100ml). Higher levels of contamination were found in some of the 5 seawater samples taken from the north shore of Wyre, ranging from <1 to 140 *E. coli* cfu/100ml. The highest occurred at Tongaday, close to a field of cattle and near a stretch of shoreline where a considerable amount of goose droppings were seen. Salinity measurements indicated there was no freshwater influence in Wyre Sound at the time of survey.

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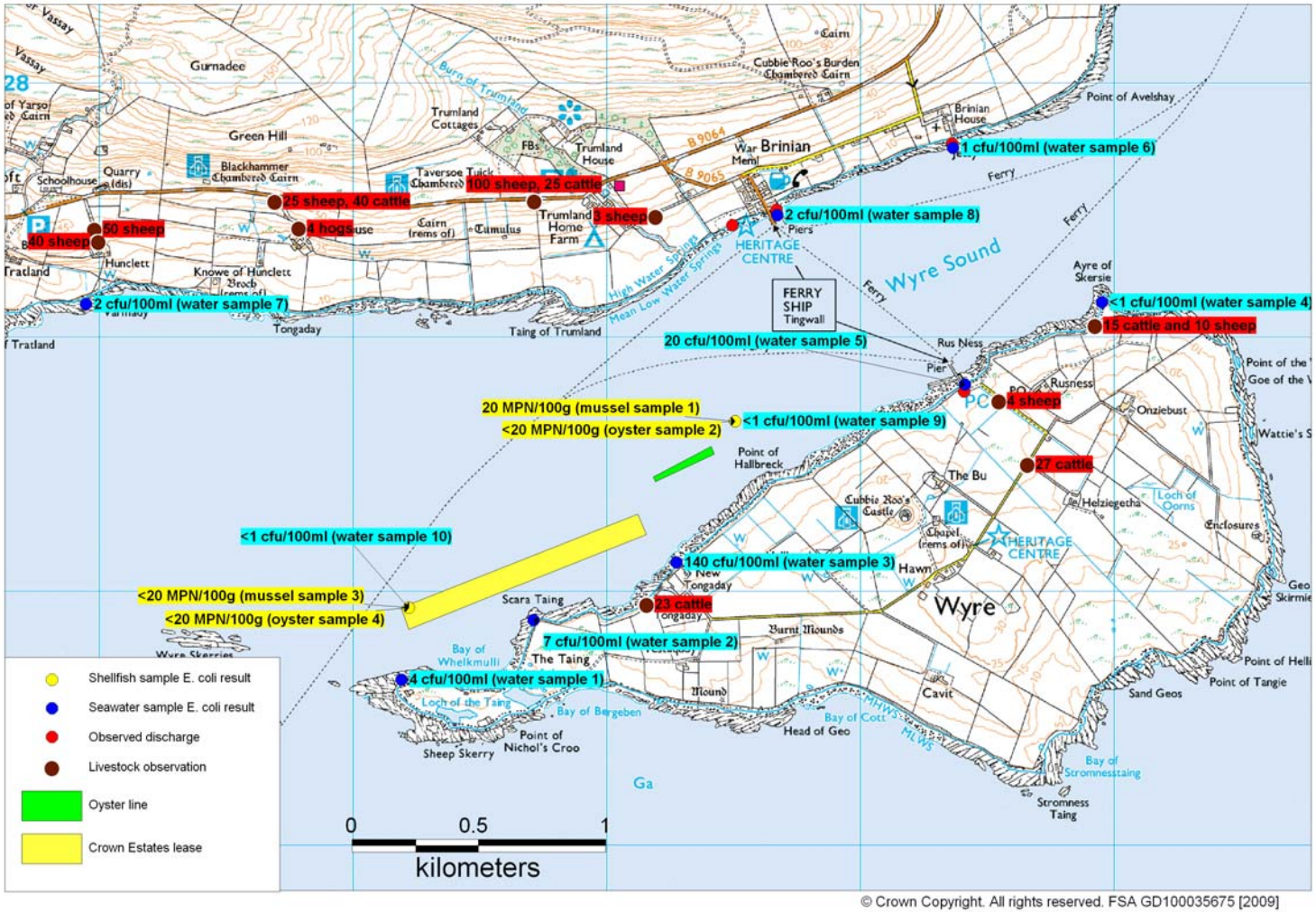

Figure 15.1 Summary of shoreline survey findings for Whelkmulli Bay

16. Overall Assessment

Human sewage impacts

A total of three sewage discharges to Wyre Sound were identified, all from the area of Brinian. This includes two Scottish Water septic tanks and one small private discharge. No discharges to Wyre Sound were seen on Wyre. It is believed that all properties on Wyre, and all properties within the survey area on Rousay outside of Brinian are served by private septic tanks discharging to soakaway, so these should have little or no impact on water quality in Wyre Sound.

Wyre and Rousay are served by a small car ferry which sails several times daily to the mainland and Eglisay, which passes north of the Wyre Skerries on its way to and from Tingwall. It is not known whether the ferry discharges its waste water within Wyre Sound. At and around Brinian harbour several small boats were observed.

Agricultural impacts

Agriculture in the area is dominated by sheep and cattle grazing. The vast majority of the land adjacent to the fishery is pasture including all of Wyre and the coastal strip of Rousay. These fields were generally drained by a series of small field drains, which are likely to carry some contamination of livestock origin. A significant presence of cattle also suggests that slurry may be spread on some fields, although the location, timing and extent of this is uncertain.

Wildlife impacts

The main wildlife species potentially impacting on the production area are seals, geese and seabirds. Highest concentrations of these species within Wyre Sound appear to occur in the vicinity of the fishery, towards the western end of Wyre, so although these animals are highly mobile any impacts may be concentrated around the shore of Wyre to the south of the fishery. It is likely that there is some seasonality to this, possibly with highest numbers of seabirds in the summer and highest numbers of geese in the winter if they overwinter on Wyre.

Seasonal variation

A small seasonal increase in population is expected at Rousay, which hosts some archaeological and wildlife related attractions. There is no accommodation on Wyre, although there is a ferry and it is likely that there are at least occasional day visitors to the island.

Numbers of sheep and cattle will approximately double during spring following the birth of lambs and calves, and decrease in the autumn as they are sent to

market. Therefore higher impacts from livestock may be expected during this period.

There may also be a seasonal pattern in the presence of geese and seabirds in the area possibly with higher numbers of geese in the winter and higher numbers of seabirds in the summer.

The weather is wetter and windier in the winter months, so more rainfall dependent contamination such as runoff from pastures may generally be expected at these times, although high rainfall events can occur at any time of the year.

Rivers and streams

There are a few small streams / drainage ditches marked on the Ordnance Survey map, none was flowing at the time of shoreline survey. The largest stream discharging to the survey area is the Burn of Trumland, which discharges from Rousay, about 500 m to the west of Brinian. The remainder of the survey area is drained by a series of small field drains. It is likely that these are impacted by contamination from livestock. The overall area drained by these watercourses is small, and Wyre Sound is a large water body with strong tides, so the combined impact of all freshwater sources on the fishery is likely to be generally minor.

Meteorology, hydrology, and movement of contaminants

Strong tidally driven flows are likely to dominate water circulation within Wyre Sound. Therefore, contamination from sources on the north shore of Wyre will tend to be carried past the fishery along the shore, with contamination levels higher closer to the shore. Circulation of contaminants is expected to be more complex around the western end of Wyre, where higher levels of contamination were observed in near-shore seawater samples. Wind driven currents may affect tidal circulation at times of high winds, although this is likely to be of secondary importance to tidal effects.

Temporal and geographical patterns of sampling results

The only sampling results available were those from samples taken on the shoreline survey. Mussel and oyster samples taken from either end of the fishery had very low levels of contamination. Seawater samples taken at the fishery had very low levels of contamination. Seawater samples taken from the shore at Rousay also had low levels of contamination. Higher levels of contamination were found in some of the 5 seawater samples taken from the north shore of Wyre. Salinity measurements indicated there was no freshwater influence in Wyre Sound at the time of survey.

17. Recommendations

As only Pacific oysters are currently cultivated at this site, it is not necessary to classify the area for common mussels, king scallops or queen scallops at the present time.

The location of the RMP should be informed by the actual location of the shellfish, the location of any sources of contamination together with patterns of water movement in the area and the results of any bacteriological testing. Given the pattern of flow through Wyre Sound, it is unlikely that sources on Rousay have much affect on water quality at the site under normal conditions.

Currents are likely to flow strongly within Wyre Sound, with their direction dependent on whether the tide is flooding or ebbing at the time. Currents in the vicinity of the western end of the proposed fishery, however, are likely to be complicated by the Wyre Skerries and associated shallows. As this is includes the area of shoreline identified as having higher levels of contamination, it is possible that the circulation of contaminants here will differ from those at the eastern end where the oyster lines are currently anchored. Therefore, in the absence of further sampling data, it is recommended that the production area boundaries be established as close as possible to the existing line and as far as possible from the shore.

Recommended production area boundaries are lines drawn between HY 4339 2674 and HY 4352 2654 and between HY 4352 2654 and HY 4294 2623 and between HY 4294 2623 and HY 4281 2649 and between HY 4281 2649 and HY 4339 2674.

Shellfish and water samples taken during the shoreline survey showed little difference in levels of contamination between either end of the site, and that levels of contamination along the north shore of Wyre were higher than in open water at the fishery. The nearest known discharges of sewage waste are located north east of the lines, and though these are thought unlikely to impact the fishery under most conditions, it would be prudent in the absence of any further information to locate the RMP near the eastern end of the line, at HY 4343 2653.

A tolerance of 20 m is recommended to allow for movement of lines with tide and wind. The oysters are all suspended at approximately the same depth, and no stratification is expected within Wyre Sound, so samples should be collected from the same depth as the stock (3 m below the surface). As there is no monitoring history it is recommended that the area be monitored on a monthly basis.

The recommended production area does not include the entire area into which the grower may wish to expand, which comes to within about 20 m of the shore of Wyre, as it is possible water quality may deteriorate with proximity to the shore here. Should additional lines be laid, or further species be added to the site, the production area boundaries and the location of the RMP will require review.

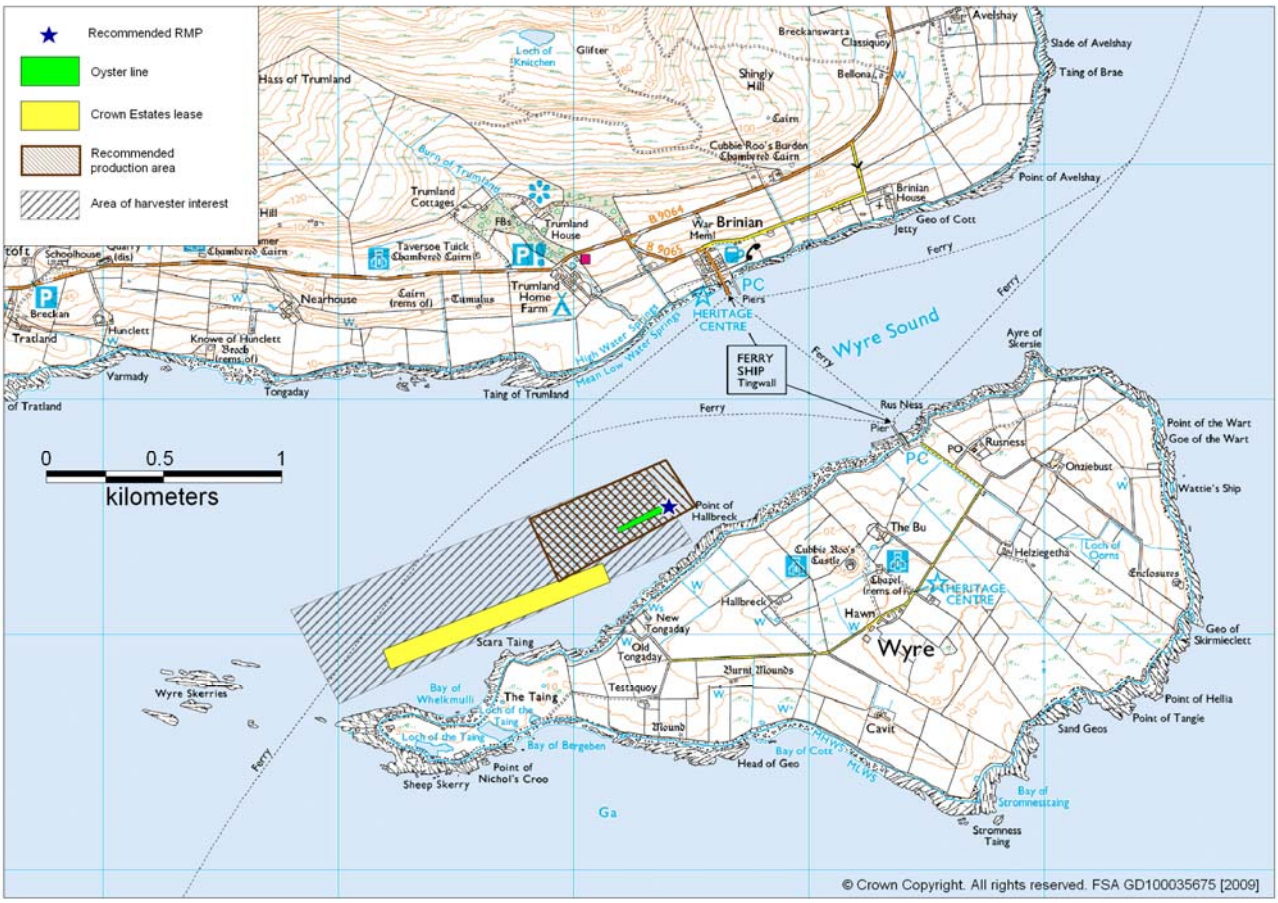

Figure 17.1 Map of recommendations at Whelkmulli Bay

18. References

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19. List of Tables and Figures

Tables

Figures

Appendices

1. **Sampling Plan**
2. **Geology and Soils Information**
3. **General Information on Wildlife Impacts**
4. **Tables of Typical Faecal Bacteria Concentrations**
5. **Hydrographic Methods**
6. **Shoreline Survey Report**

Sampling Plan for Whelkmulli Bay Oysters

PRODUC-TION AREA	SITE NAME	SIN	SPECIES	TYPE OF FISHERY	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
Whelkmulli Bay Oysters	Whelkmulli Bay Oysters	OI 470 880 13	Pacific oyster	Suspend-ed cages	HY 4343 2653	343430	1026530	20 m	3 m	Hand	Monthly	Orkney Islands Council	Julie Murphy Alan Tait	Julie Murphy

Geology and Soils Assessment

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

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

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

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

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

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

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

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

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

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

Glossary of Soil Terminology

Calcareous: Containing free calcium carbonate.

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

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

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

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

General Information on Wildlife Impacts

Pinnipeds

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

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

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

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

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

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

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

Cetaceans

A variety of cetacean species are routinely observed around the west coast of Scotland.

Table 8.1 Cetacean sightings in 2007 – Western Scotland.

Common name	Scientific name	No. sighted*
Minke whale	*Balaenoptera acutorostrata*	28
Killer whale	*Orcinus orca*	183
Long finned pilot whale	*Globicephala melas*	14
Bottlenose dolphin	*Tursiops truncatus*	369
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. Source: Hebridean Whale and Dolphin Trust.

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). 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

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

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

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

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

Other

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

Otters leave faeces (also known as spraint) along the shoreline or along streams.

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	$1.7 \times 10^{7*}$ (+)	1.4×10^7	2.0×10^7	282	$2.8 \times 10^{6*}$ (-)	2.3×10^6	3.2×10^6
Crude sewage discharges	252	$1.7 \times 10^{7*}$ (+)	1.4×10^7	2.0×10^7	79	$3.5 \times 10^{6*}$ (-)	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	$1.0 \times 10^{7*}$ (+)	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	$3.3 \times 10^{5*}$ (-)	2.9×10^5	3.7×10^5	184	$5.0 \times 10^{5*}$ (+)	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	$2.8 \times 10^{5*}$ (-)	2.2×10^5	3.5×10^5	93	$5.1 \times 10^{5*}$ (+)	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.

Hydrographic Methods

1.0 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.

2.0 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.

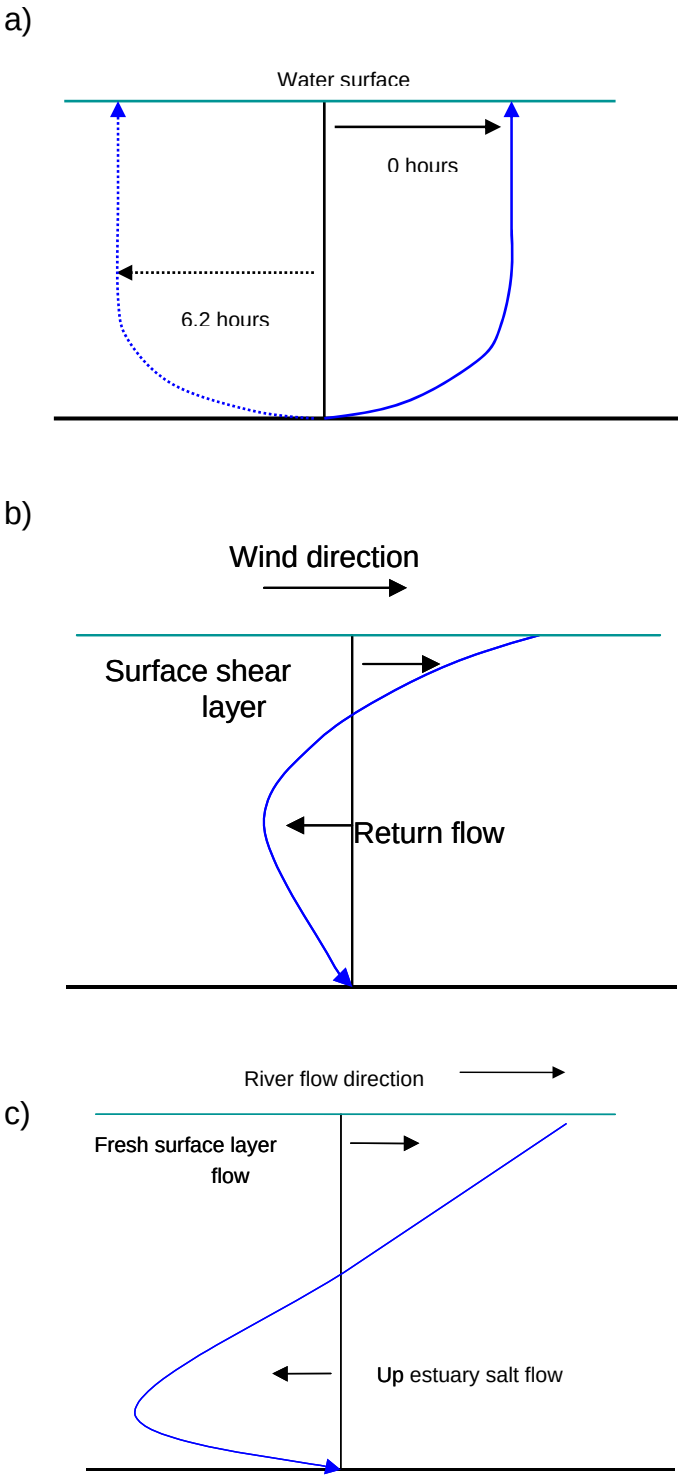

Figure 1 Typical vertical profiles for water currents.
The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction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

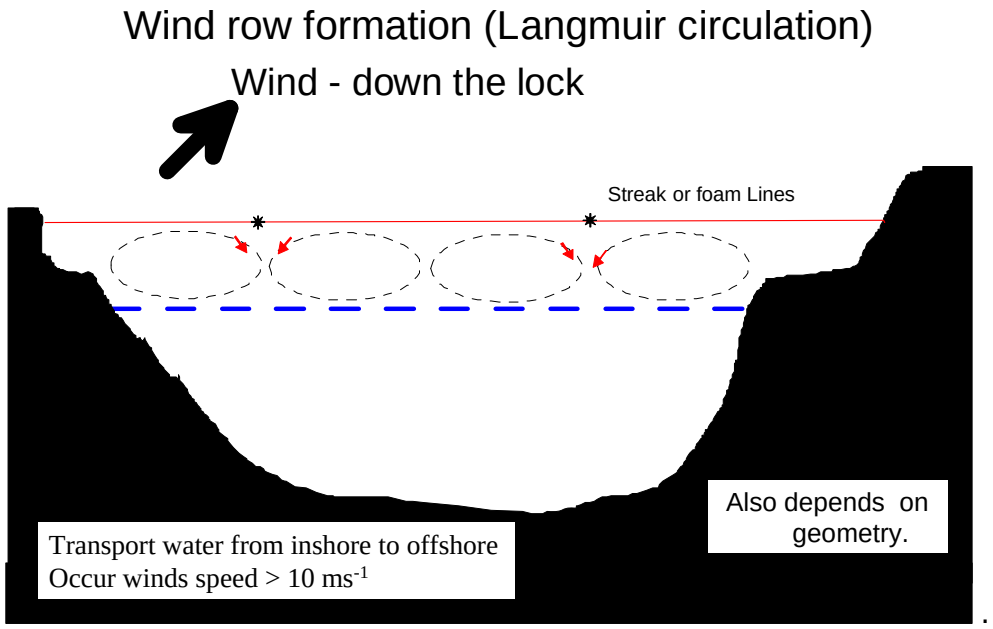

Figure 2 Schematic of wind driven ‘wind row’ currents.
The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

Shoreline Survey Report

Prod. area:	Whelkmulli Bay
Site names:	Whelkmulli Bay Kings (OI 468 878 07), Whelkmulli Bay Queens (OI 469 879 15), Whelkmulli Bay Oysters (OI 470 880 13), Whelkmulli Bay Mussels (OI 171 881 08)
Species:	King scallops, queen scallops, Pacific oysters, common mussels
Harvester:	Martin Besant, Rousay shellfish
Local Authority:	Orkney Islands Council
Status:	New application
Date Surveyed:	12-13 August 2009
Surveyed by:	Julie Murphy, Alastair Cook
Existing RMP:	not yet assigned
Area Surveyed:	See Map in Figure 1

Weather observations

12 August: Heavy showers. Winds NW force 5. Air temp 15 °C.
13 August: Fine. Winds N force 1. Air temp 15 °C.
The survey was undertaken following a period of warm, dry weather.

Site Observations

Specific observations made on site are listed in Table 1 and mapped in Figure 1.

Fishery

Currently, the fishery consists of one line of floats approximately 250 m in length from which plastic cages containing Pacific oysters are suspended. The oysters were laid down about a year ago, and good growth is reported, and harvest may even be possible in 2010, earlier than originally anticipated. At some point in the future, and dependent on the success of the operation, expansion is planned. This would involve laying further lines of the same construction within the area identified in Figure 1. Currently no other species are cultured at this site, although historically queen scallops have been cultured here. The site is fairly exposed, but no storm related damage has been suffered to date.

Sewage/Faecal Sources

Human – Population on Wyre is low, and limited to a handful of dwellings which are all likely to be served by individual private septic tanks. No septic tank discharges to water were seen on the north shore of Wyre, suggesting that any septic tanks here discharge to soakaway. The main settlement on the adjacent coast of Rousay is Brinian, which is served by a Scottish Water communal septic tank which discharges to Wyre Sound a short distance to the west of the harbour. Outside of the settlement of Brinian, there were a few scattered dwellings. One private sewer outfall to Wyre Sound was seen at

Brinian House, about 1 km to the east of Brinian harbour. No other discharges observed to Wyre Sound, suggesting that other dwellings along the south coast of Rousay were probably served by septic tanks discharging to soakaway.

Livestock – the vast majority of the land adjacent to the fishery is pasture, some of which was being grown or cut for hay or silage, and some of which had livestock on at the time of survey. A total of 65 cattle and 14 sheep were counted around the north coast of Wyre, and a total of 231 sheep, 65 cattle and 4 hogs were counted on the south shore of Rousay.

Seasonal Population

A small seasonal increase in population is expected at Rousay, which hosts some archaeological and wildlife related attractions. There is a small hostel and campsite at Trumland Farm, and other hotel and self catering accommodation elsewhere on the island. There is a restaurant and craft shop at Brinian. There is no accommodation and little in the way of attractions on Wyre, although it is likely there are occasional visitors to the island. Car ferries sail to Rousay and Wyre from the mainland several times daily.

Boats/Shipping

Car ferries sail several times daily from Rousay and Wyre, although they keep a considerable distance to the north of the fishery site in order to avoid obstacles. At and around the harbour at Brinian a total of 7 small boats, one larger boat, and the shellfish barge were observed. Yachts visit the area from time to time.

Land Use

Wyre and the lower lying coastal areas of Rousay are pasture, some of which was being grazed, some of which was being used for the production of hay or silage. Further from the shore on Rousay, behind Brinian and Trumland, is the Trumland RSPB reserve, which is moorland.

Wildlife/Birds

A total of 61 geese were counted towards the western end of Wyre, and on the shore adjacent to the fishery there were considerable amounts of goose droppings. Nine geese were also seen near Trumland. 29 ducks were seen on the north shore of Wyre, and four were seen in the vicinity of Trumland. Four seals were seen by the western end of Wyre, and one was seen off Trumland. The RSPB reserve behind Trumland is not believed to support any large aggregations of birds

Other information

Although there were a few small streams / drainage ditches marked on the Ordnance Survey map, none was flowing at the time of shoreline survey. As

the weather in the week preceding the shoreline survey was warm and dry, it is likely that conditions encountered on the shoreline survey were unusually dry.

Tides within Wyre Sound are fairly strong, and were running at about 2 knots at the time the fishery was visited, and can approach 4 knots at times. Salinity profiles taken on the fishery site indicated there was no freshwater influence here.

Sampling

Water and shellfish samples were collected at sites marked on Figures 2 and 3. The mussel samples originated from Rousay pier, and the oysters were purchased locally by the harvester as his own stock was too small to sample at the time of survey. Samples of both were deployed at either end of the fishery over 2 weeks before the survey at a depth of 3 metres. All samples were packed in coolboxes and transported to the laboratory at Shetland Seafood Quality Control for analysis.

Bacteriology results follow in Tables 2 and 3. Salinity profile results are presented in Table 4.

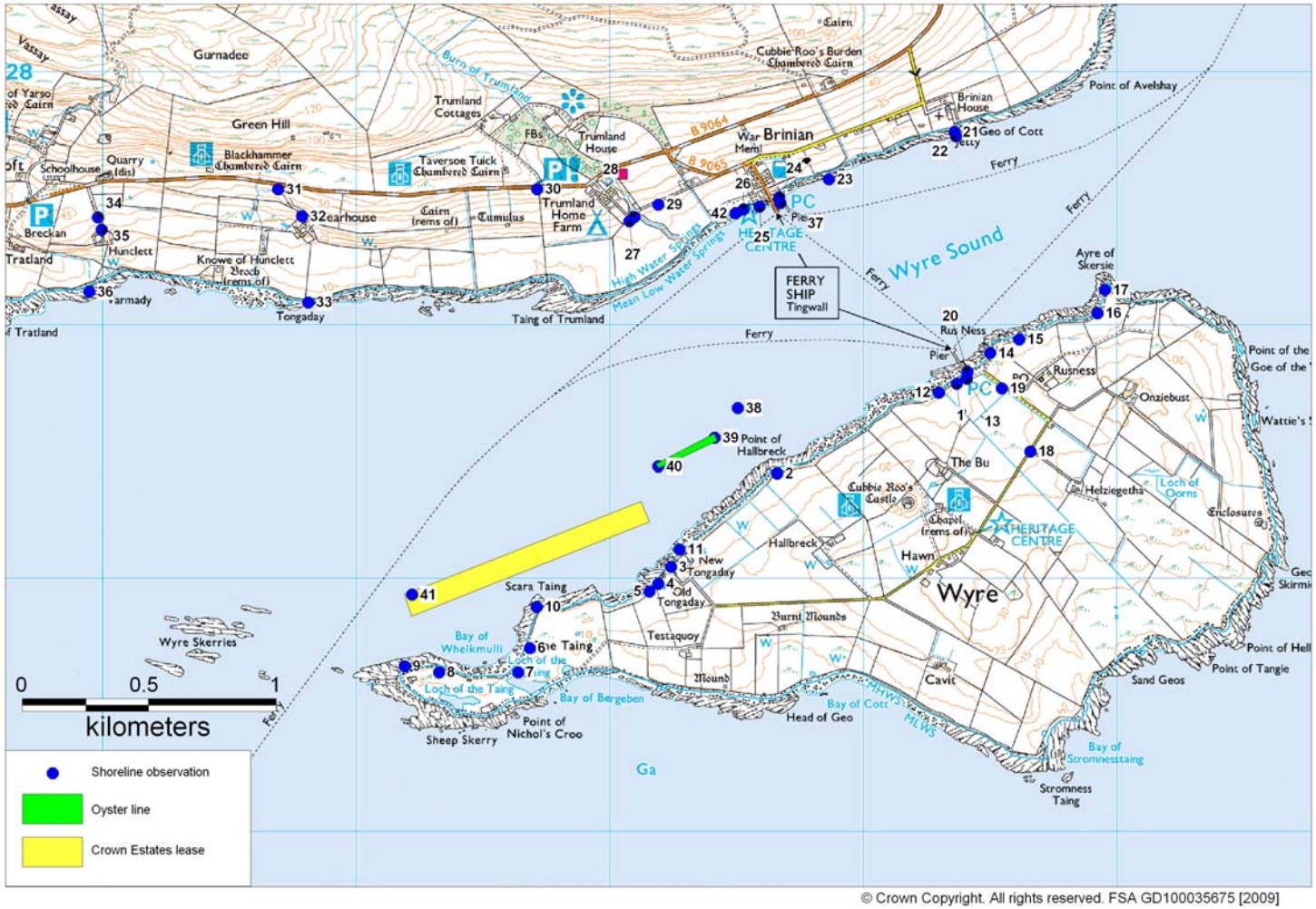

Figure 1. Map of Shoreline Observations

Table 1. Shoreline Observations

No.	Date and time	Position	Photograph	Observation
1	12-AUG-09 9:01:02AM	HY 44369 26766		Small chicken shed
2	12-AUG-09 9:17:21AM	HY 43661 26412	Figure 4	Goose droppings on rocks
3	12-AUG-09 9:34:04AM	HY 43242 26043		2 houses here uninhabited
4	12-AUG-09 9:40:42AM	HY 43192 25977	Figure 5	Well (not a septic tank)
5	12-AUG-09 9:42:49AM	HY 43157 25947		23 cattle
6	12-AUG-09 9:56:21AM	HY 42685 25723		4 geese
7	12-AUG-09 9:57:57AM	HY 42639 25627		Goose and cattle droppings
8	12-AUG-09 10:05:00AM	HY 42327 25627		30 geese, 20 ducks and 4 cormorants
9	12-AUG-09 10:09:41AM	HY 42191 25651	Figure 6	Seawater sample 1, 4 grey seals
10	12-AUG-09 10:30:07AM	HY 42712 25886		Seawater sample 2
11	12-AUG-09 10:50:36AM	HY 43275 26113		Seawater sample 3
12	12-AUG-09 11:13:55AM	HY 44299 26731		Field drain, not flowing
13	12-AUG-09 11:17:51AM	HY 44409 26785		Public toilets at pier, septic tank at back presumably goes to soakaway
14	12-AUG-09 11:28:00AM	HY 44501 26887		Disused aquaculture/holding tanks.
15	12-AUG-09 11:32:59AM	HY 44615 26941		7 geese, 4 ducks
16	12-AUG-09 11:41:55AM	HY 44925 27045		15 cattle and 10 sheep
17	12-AUG-09 11:44:39AM	HY 44953 27137		5 ducks, seawater sample 4
18	12-AUG-09 12:25:18PM	HY 44660 26498		27 cattle
19	12-AUG-09 2:51:37PM	HY 44547 26748		4 sheep
20	12-AUG-09 2:55:00PM	HY 44412 26813		Seawater sample 5
21	13-AUG-09 9:00:05AM	HY 44362 27761	Figure 7	Cast iron sewer pipe to shore, dripping, serves Brinian House and possibly also the doctors surgery
22	13-AUG-09 9:01:26AM	HY 44366 27745		Seawater sample 6
23	13-AUG-09 9:17:01AM	HY 43865 27574		4 small boats on moorings on this side of the harbour
24	13-AUG-09 9:26:54AM	HY 43669 27502	Figure 8	Vent on pier wall, some odour, no associated discharge pipe seen
25	13-AUG-09 9:29:16AM	HY 43591 27466		Orange drain pipe (surface drain from hard standing)
26	13-AUG-09 9:31:35AM	HY 43528 27456		Orange drain pipe (roof runoff from shed)
27	13-AUG-09 10:03:48AM	HY 43077 27408		16 sheep
28	13-AUG-09 10:05:05AM	HY 43097 27425		Dry stream
29	13-AUG-09 10:09:39AM	HY 43192 27474		3 sheep in field on seaward side of track

No.	Date and time	Position	Photograph	Observation
30	13-AUG-09 10:20:29AM	HY 42714 27535		100 sheep, 25 cattle, 9 geese and 1 seal seen from here
31	13-AUG-09 10:30:06AM	HY 41691 27534		25 sheep, 40 cattle
32	13-AUG-09 10:31:54AM	HY 41786 27428		4 hogs
33	13-AUG-09 10:37:54AM	HY 41810 27087		4 ducks
34	13-AUG-09 10:49:51AM	HY 40980 27424		50 sheep
35	13-AUG-09 10:51:13AM	HY 40995 27375		40 sheep
36	13-AUG-09 11:04:04AM	HY 40947 27129		Seawater sample 7
37	13-AUG-09 11:25:11AM	HY 43673 27480		Seawater sample 8, 3 small boats, 1 larger boat, 1 shellfish barge
38	13-AUG-09 12:29:14PM	HY 43506 26669		Seawater sample 9, mussel sample 1, oyster sample 2, salinity profile 1
39	13-AUG-09 12:37:38PM	HY 43414 26552		End of line
40	13-AUG-09 12:38:58PM	HY 43191 26439		End of line
41	13-AUG-09 12:44:55PM	HY 42220 25934		Seawater sample 10, salinity profile 2, mussel sample 3, oyster sample 4, oyster sample for norovirus
42	13-AUG-09 1:14:16PM	HY 43496 27440	Figure 9	Scottish Water septic tank, 20 cm cast iron pipe to underwater

Photographs referenced in the table can be found attached as Figures 4-9.

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.

Table 2. Water Sample Results

Sample No.	Date and time	Position	*E. coli* (cfu/100ml)	Salinity (ppt)
Wyre 1	12-AUG-09 10:09:41AM	HY 42191 25651	4	34.66
Wyre 2	12-AUG-09 10:30:07AM	HY 42712 25886	7	34.74
Wyre 3	12-AUG-09 10:50:36AM	HY 43275 26113	140	34.76
Wyre 4	12-AUG-09 11:44:39AM	HY 44953 27137	<1	34.76
Wyre 5	12-AUG-09 2:55:00PM	HY 44412 26813	20	34.67
Wyre 6	13-AUG-09 9:01:26AM	HY 44366 27745	1	34.92
Wyre 7	13-AUG-09 11:04:04AM	HY 40947 27129	2	35
Wyre 8	13-AUG-09 11:25:11AM	HY 43673 27480	2	35.03
Wyre 9	13-AUG-09 12:29:14PM	HY 43506 26669	<1	35.06
Wyre 10	13-AUG-09 12:44:55PM	HY 42220 25934	<1	35.09

Table 3. Shellfish Sample Results

Sample No.	Date and time	Position	Species	*E. coli* (MPN/100g)
Wyre 1	13-AUG-09 12:29:14PM	HY 43506 26669	Mussel	20
Wyre 2	13-AUG-09 12:29:14PM	HY 43506 26669	Pacific oyster	<20
Wyre 3	13-AUG-09 12:44:55PM	HY 42220 25934	Mussel	<20
Wyre 4	13-AUG-09 12:44:55PM	HY 42220 25934	Pacific oyster	<20

Table 4. Salinity profiles

Profile No.	Date and time	Position	Depth (m)	Salinity (ppt)	Temperature (°C)
1	13-AUG-09 12:29:14PM	HY 43506 26669	0	34.7	14.1
1	13-AUG-09 12:29:14PM	HY 43506 26669	2.5	34.7	14.1
1	13-AUG-09 12:29:14PM	HY 43506 26669	5	34.7	14.1
1	13-AUG-09 12:29:14PM	HY 43506 26669	7.5	34.7	14.1
1	13-AUG-09 12:29:14PM	HY 43506 26669	10	34.7	14.1
2	13-AUG-09 12:44:55PM	HY 42220 25934	0	34.7	14.2
2	13-AUG-09 12:44:55PM	HY 42220 25934	2.5	34.7	14.2
2	13-AUG-09 12:44:55PM	HY 42220 25934	5	34.7	14.1
2	13-AUG-09 12:44:55PM	HY 42220 25934	7.5	34.7	14.1
2	13-AUG-09 12:44:55PM	HY 42220 25934	10	34.7	14.1

Figure 2. Water sample results map

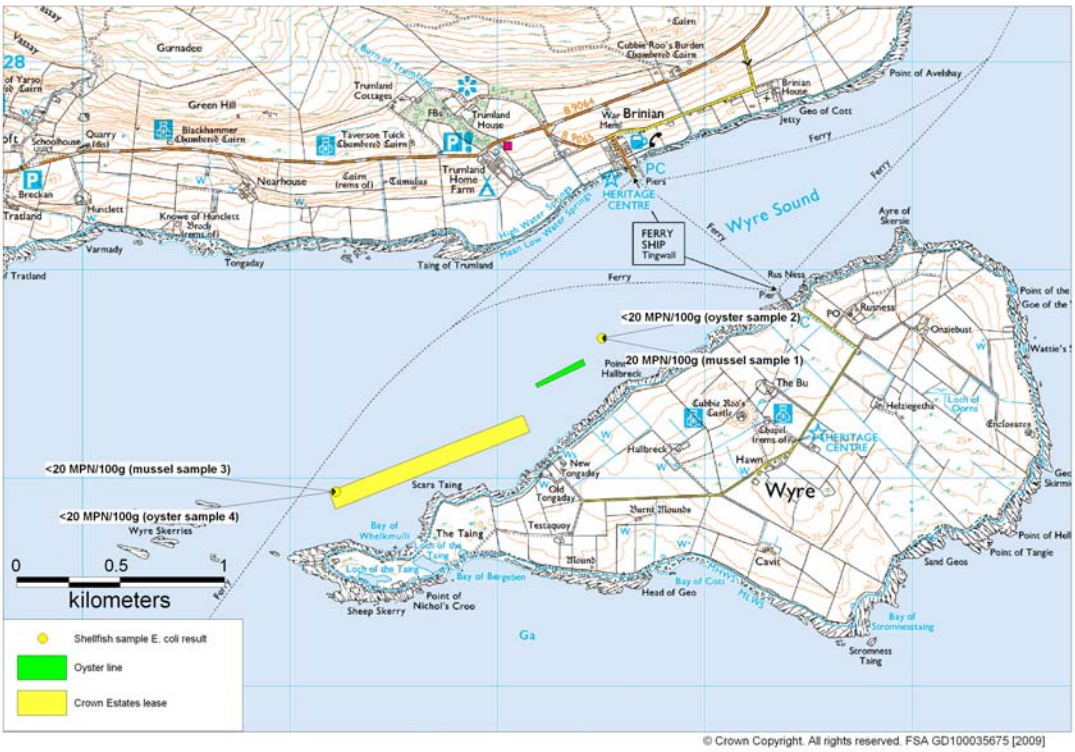

Figure 3. Shellfish sample results map

Figure 4 Goose droppings on Wyre

Figure 5 Water well

Figure 6 Site of seawater sample 1, grey seals visible

Figure 7 Iron sewage pipe to shore

Figure 8 Vent on pier wall

Figure 9 Septic tank