Scottish Sanitary Survey Project

Sanitary Survey Report
Loch Fyne: Otter Ferry
AB 151
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Report Distribution – Loch Fyne: Otter Ferry

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1. General Description

Loch Fyne is a sea loch on the west coast of Argyll and Bute, mainland Scotland. It is approximately 65 km in length. Otter Ferry is a small settlement on the eastern shore, approximately 25 km the mouth of the loch. It is located adjacent to a long sand spit, Otter Spit, that extends over 1.5 km into the loch. An area south of the spit is classified for the production of Pacific oysters.

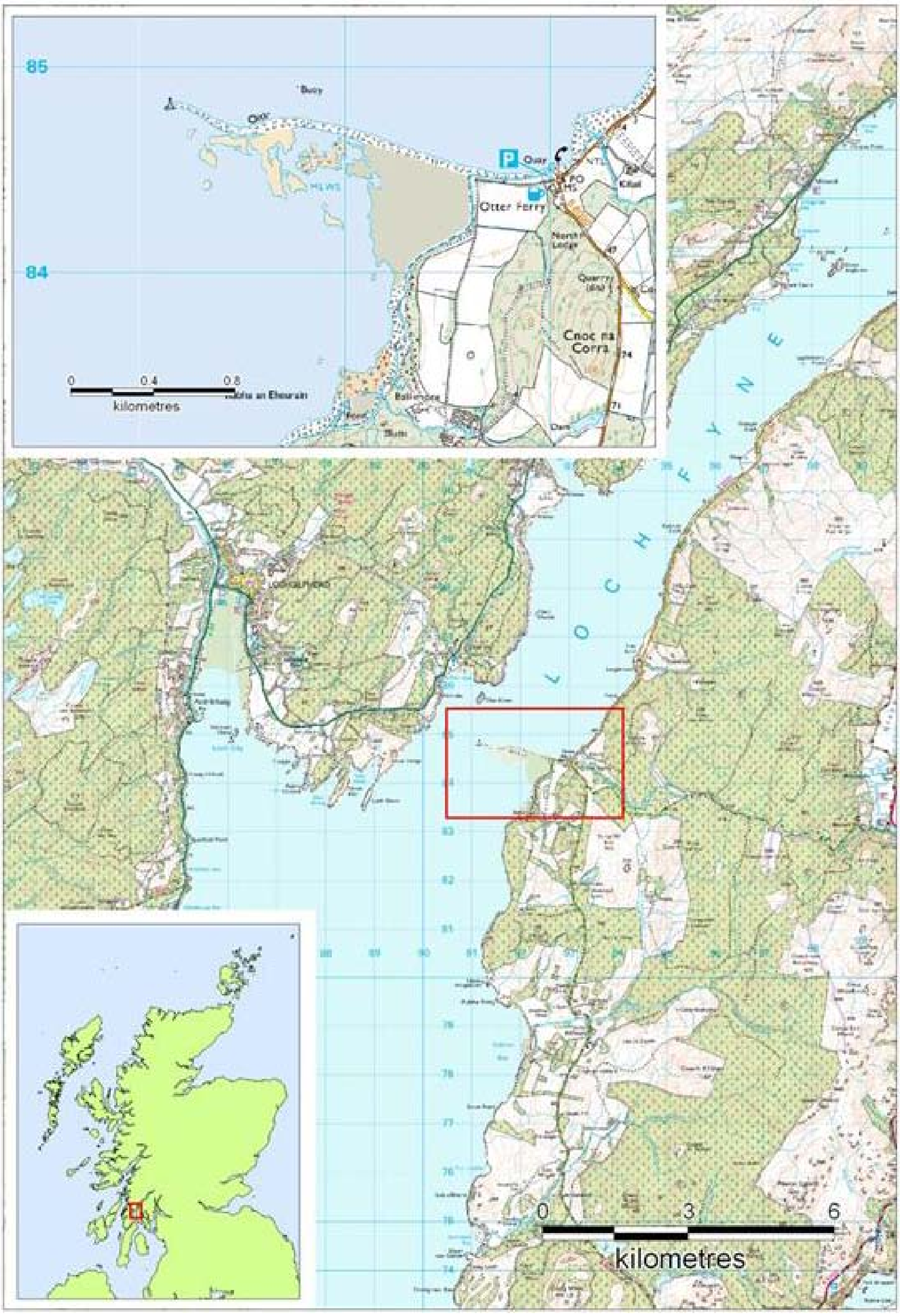


Figure 1.1 Location of Loch Fyne: Otter Ferry

2. Fishery

This survey is being undertaken as a result of its risk matrix score. The score achieved was primarily driven by the number of unusual results (i.e. results outwith classification), recent changes in classification and an unconfirmed outbreak of food-borne illness associated with the area.

Table 2.1 Otter Ferry oyster farm

Production Area	Site	SIN	Species	RMP
Loch Fyne: Otter Ferry	Balliemore	AB 151 039	Pacific oysters	NR 920 834

The production area at Loch Fyne: Otter Ferry is currently defined as an area bounded by lines drawn between NR 9100 8400 and NR 9231 8400 and NR 9100 8300 and NR 9167 8300, extending to mean high water springs (MHWS). Pacific oysters are cultured on trestles located both above and below mean low water springs on an area of intertidal sands approximately 1 km south of Otter Spit, adjacent to the Ballimore Estate. Pacific oyster seed in purchased and initially placed on the deepest part of the site, where they are submerged for a greater proportion of the tidal cycle. As the oysters grow, they are moved to shallower trestles for hardening off. A small number of trestles are kept high on the beach to provide access during poor tides.
Oysters are harvested year round according to demand, and the harvester has depuration facilities at Otter Ferry.

The RMP lies on an area of higher shore to the south of the trestles, where a trestle has been placed specifically for sampling purposes.

The production area lies within the Loch Fyne Coastal Strip Shellfish Growing Water (SGW).

Figure 2.1 shows the location of the Loch Fyne: Otter Ferry production area, the location of the trestles and current RMP, and the extent of the shellfish growing water (SGW).

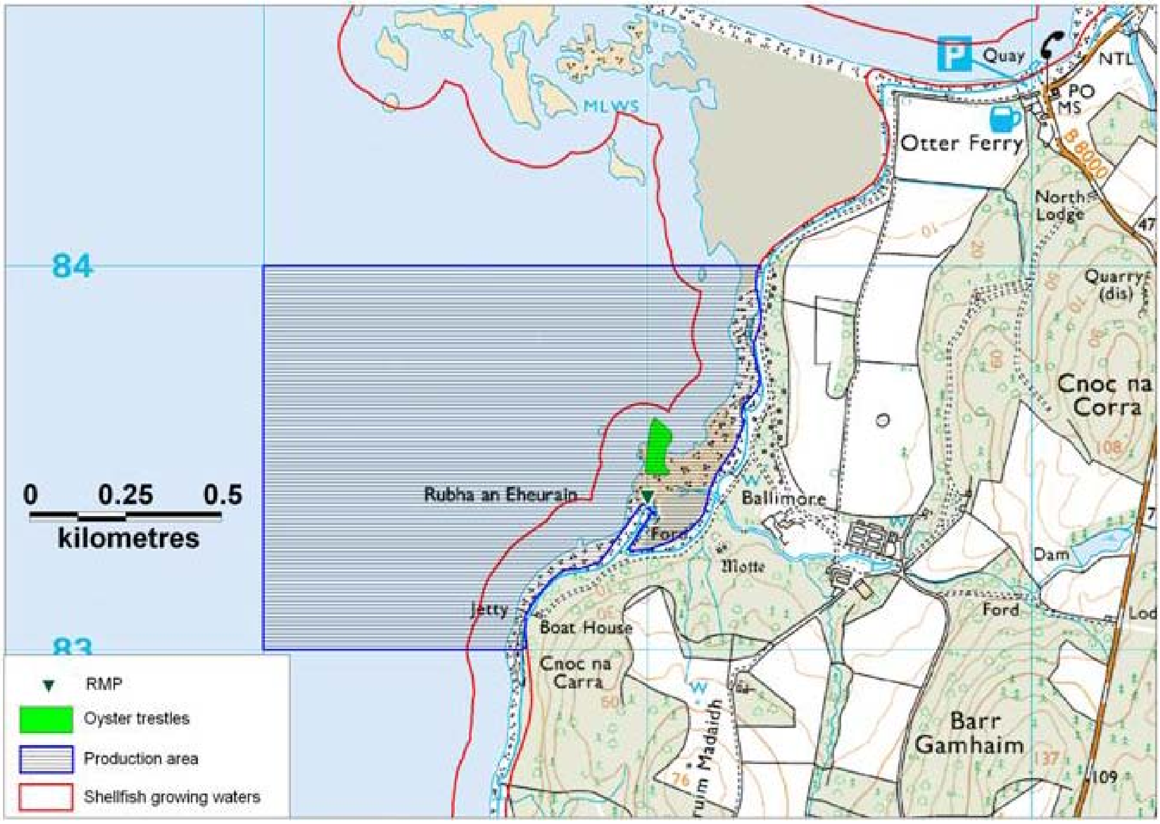
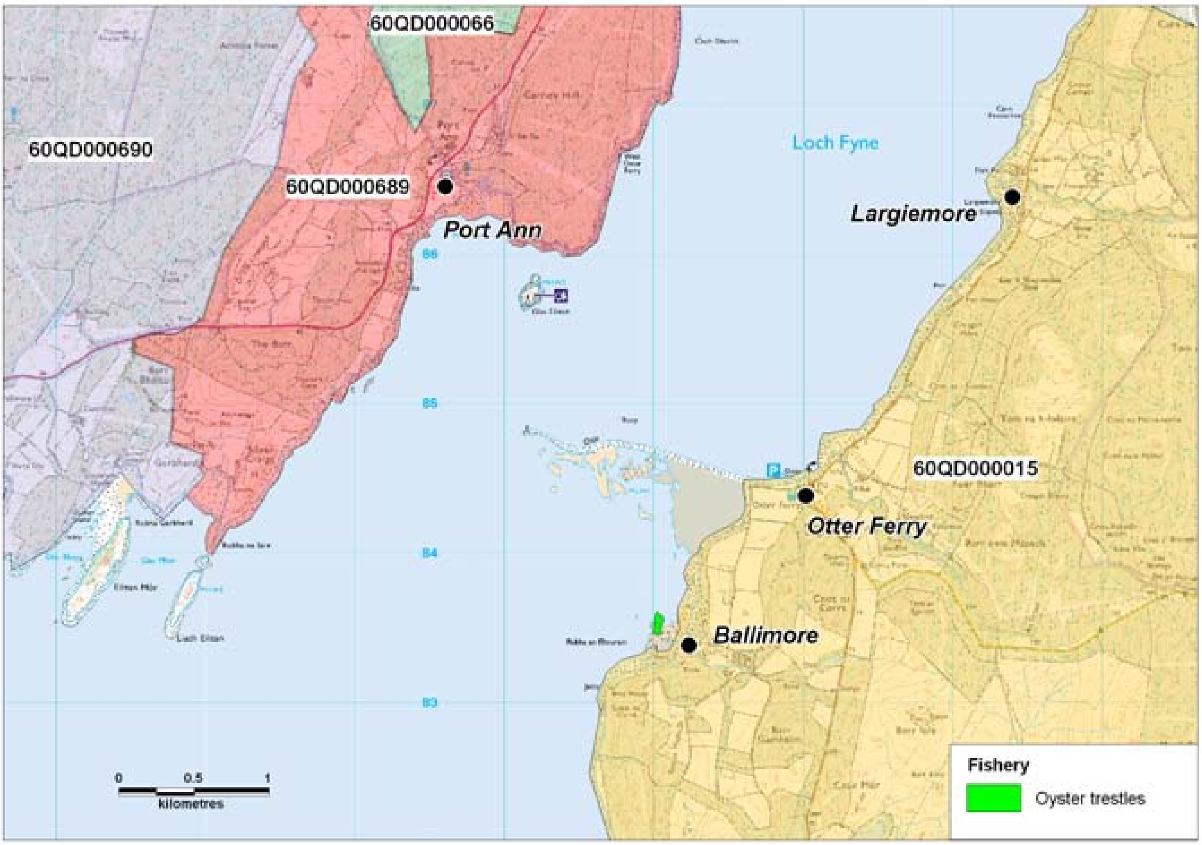


Figure 2.1 Otter Ferry Fishery

3. Human Population

Data on human population from the 2001 census was obtained from the General Register Office for Scotland for the area around Otter Ferry. Figure 3.1 shows the population density for census output areas adjacent to the fishery.



2001 Population Census Data, General Register Office, Scotland.

Figure 3.1 Population map for Loch Fyne Otter Ferry

There are three population census output areas adjacent to Loch Fyne near Otter Ferry, details of which follow in Table 2.1.

Table 3.1 Otter Ferry Population

Output Area	Size (km^2)	Population	Settlements
60QD000015	81.8	109	Largiemore, Otter Ferry, Ballimore Estate
60QD000690	5.8	99	Port Ann
60QD000689	10.7	99	Kilmory Castle
60QD000066	25.7	120	Loch Gair

The area of Port Ann lies west of the fishery, on the opposite side of Loch Fyne. Although this area has roughly the same population it covers a substantially smaller area than the output area around Otter Ferry, indicating a higher population density.

The output area of greatest significance to the fishery is that incorporating the shoreline adjacent to the oyster farm. The output area adjacent to the oyster farm covers a very large geographic area stretching over 18 km from north to south and the population is not evenly distributed throughout that area. Three population centres within this area are located along the shoreline within 2km of the fishery: Largiemore, Otter Ferry and Ballimore Estate. Largiemore is a holiday village comprising of 44 chalets which are privately owned and only occupied part of the time. A further three chalets and a farm annexe are operated as holiday lets, with the farm in permanent occupation. In addition to the chalets, Largiemore has 24 yacht moorings and a slipway. Otter Ferry is a small settlement with a few buildings and a popular pub/restaurant with 7 associated yacht moorings. The Ballimore Estate operates B&B accomodation for up to 6 people, as well as being in permanent occupation. In addition to the estate house itself, small cottages line the road to Otter Ferry along the shore northwards from the house. The harvester reports the permanent population of the estate to be roughly 80.

Therefore, although the human population in the census area is small, a large proportion of it lives in relatively close proximity to the oyster farm.

The population in the area is likely to increase significantly during the summer months when visiting yachts and holiday makers are present at Otter Ferry and Largiemore.

4. Sewage Discharges

Scottish Water identified one community septic tank and associated sewage discharge for the area. This is detailed in Table 4.1. The locations of all discharges identified in this section can be found mapped in Figure 4.1.

Table 4.1 Discharge identified by Scottish Water

Consent Ref No.	NGR of discharge	Discharge Name	Discharge Type	Level of Treatment	Consented flow m^3/day	Consented Design PE
CAR/L/1008779	NR 9059 8600	Blue Rocks Cottage SEP NR 903 861	Continuous	Septic tank	30.4	46

No microbiological or sanitary data were available for this discharge. The grid reference in the discharge name refers to the location of the septic tank itself. This discharge lies approximately 2.8 km northwest of the northernmost extent of the oyster farm and at the opposite side of the loch.

Information on consented discharges within the survey area were provided by the Scottish Environment Protection Agency (SEPA) and details of discharges nearest to the fishery are listed in Table 4.2.

Table 4.2 Discharge consents identified by SEPA

No.	Ref No.	NGR of discharge	Discharge Type	Level of Treatment	Consented/ design PE	Discharges to
1	CAR/R/1054907	NR 9306 8450	trade	depuration discharge	none	Loch Fyne
2	CAR/L/1008779	NR 905 860	continuous	primary	not stated	Loch Fyne
3	CAR/R/1037241	NR 9021 8595	domestic	septic tank	5	soakaway
4	CAR/R/1037242	NR 9018 8594	domestic	septic tank	5	soakaway
5	CAR/R/1046455	NR 8921 8459	domestic	septic tank	10	soakaway
6	CAR/R/1013646	NR 8911 8461	domestic	septic tank	6	Allt Oigh
7	CAR/R/1009119	NR 8910 8458	domestic	septic tank	5	Allt Oigh
8	CAR/R/1038816	NR 8900 8459	domestic	septic tank	5	land
9	CAR/R/1027412	NR 8865 8422	domestic	septic tank	6	Loch Fyne
10	CAR/R/1037244	NR 8904 8484	domestic	septic tank	5	soakaway
11	CAR/R/1039311	NR 8882 8499	domestic	septic tank	5	Allt Oigh

Discharge number 2 relates to the septic tank discharge identified by Scottish Water in Table 4.1. Only one of the remaining consents pertains to a discharge on the eastern shore of the loch, and it is associated with the trade discharge from a depuration shed used by the harvester. This could potentially contribute *E. coli* and faecal pathogens during times of discharge. No discharge consents were available for Largiemore, though there is likely to be at least one septic tank associated with the properties there.

A number of discharge-related observations were made during the shoreline survey of the area. These are listed in Table 4.3. Septic tank discharge from the main house at Ballimore estate discharges via a pipe through the seawall east of the trestles. The harvester reported that 4 or 5 small septic tanks were associated with the cottages on the estate. Two of these were seen, and pipework was found that was likely to be associated with a third tank although the tank itself was not located. These appeared to discharge via buried pipes to beneath the shore. A further septic tank was identified near the restaurant at Otter Ferry, and evidence of foul discharge was observed on the shoreline nearby. It was not clear, however, whether this was associated with the observed septic tank or some other discharge.

Table 4.3 Discharges and septic tanks observed during shoreline surveys

No.	Date	NGR	Description
2	11/08/2010	NR 9224 8345	Pipe, 15cm diameter, flowing 100ml=10sec., foul discharge.
3	11/08/2010	NR 9191 8322	Outfall pipe - no evidence of recent use, nothing apparent on shore above pipe.
4	11/08/2010	NR 9230 8358	Possible septic pipe running across ditch toward shore. No outlet found on shore side.
5	11/08/2010	NR 9230 8380	Septic tank (full) with outlet pipe next to tree. End of pipe disappears underground
6	11/08/2010	NR 9232 8393	Septic tank, pipe runs down bank, under shore
7	11/08/2010	NR 9298 8446	Septic tank. Oystercatcher Restaurant.
8	11/08/2010	NR 9305 8447	Puddle on shore, smells of septic waste. Sewage fungus growth on shore.

Although there were a larger number consented discharges reported to the opposite shore of the loch, the majority of these discharged to soakaway. Whether discharge from Blue Rocks Cottage would affect water quality at the fishery would depend on an assessment of contaminant movement (see Section 14). Discharges from sources at Otter Ferry would be expected to impact water quality along the shore immediately north of Otter Spit. The discharges of greatest significance to the fishery are those located closest to the trestles, ie those arising on the estate itself.

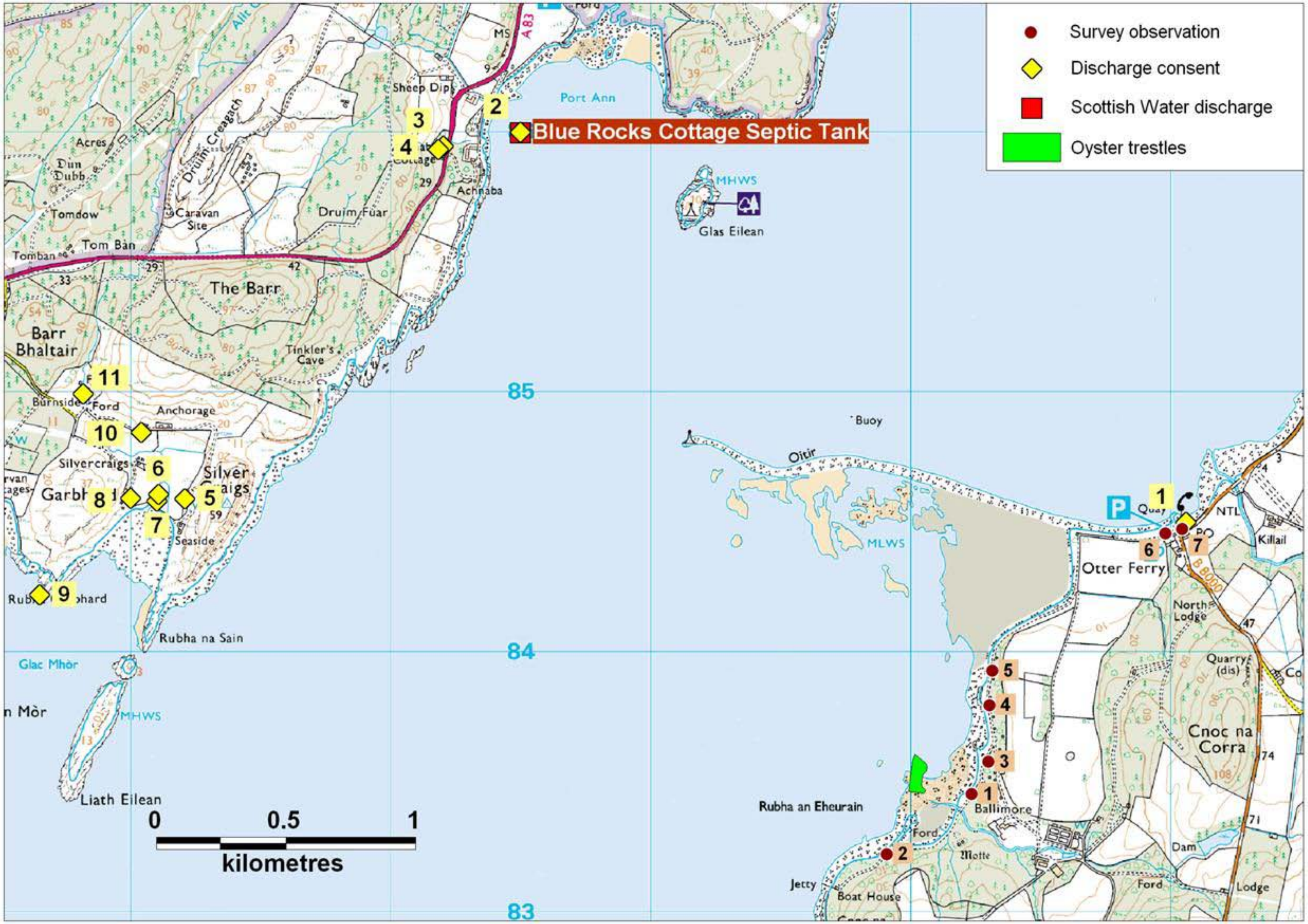


Figure 4.1 Map of discharges near Otter Ferry

5. Geology and Soils

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

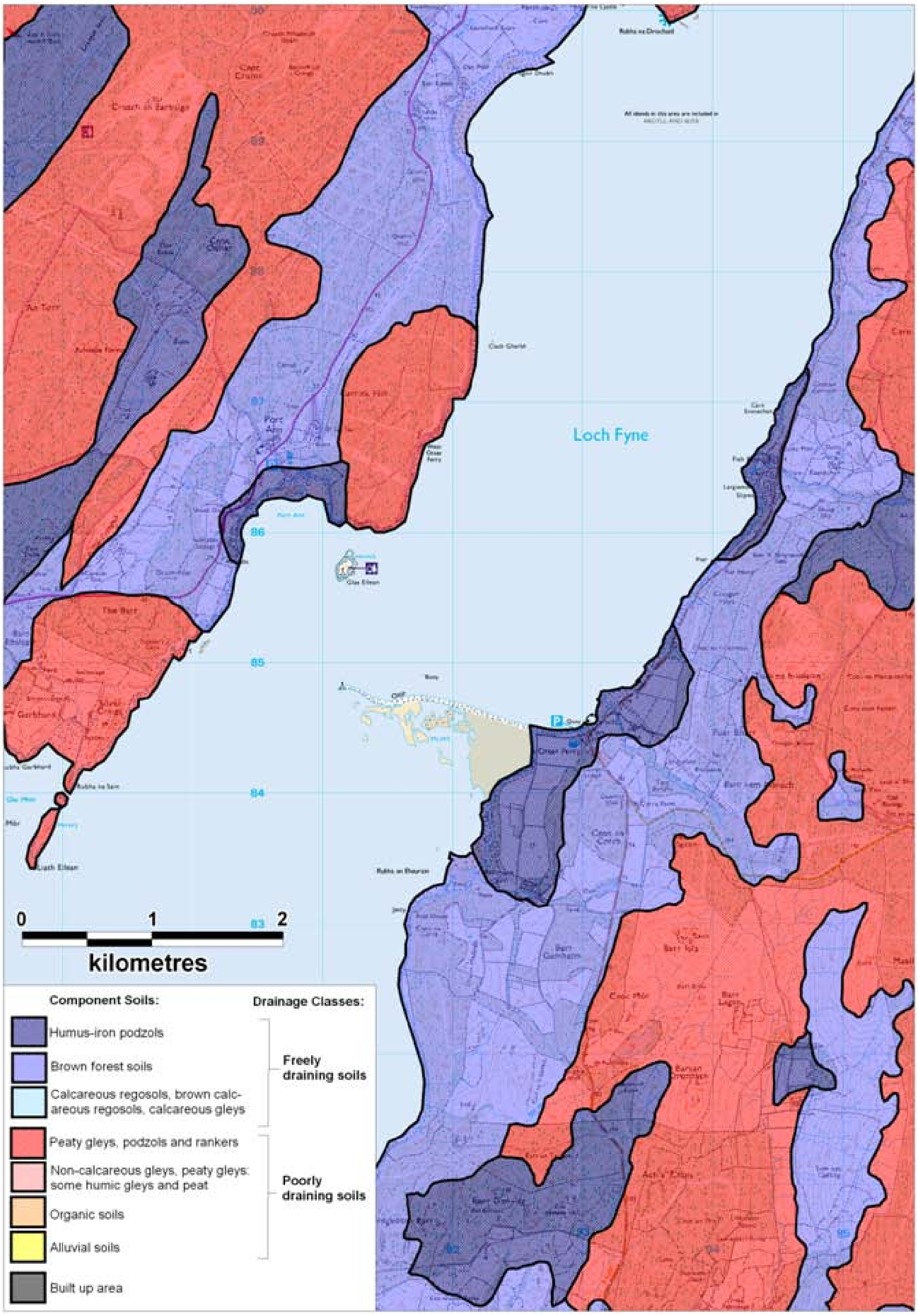


Figure 5.1 Component soils and drainage classes for Otter Ferry.

Three main soil types are present in the area around Otter Ferry. Freely-draining humus-iron podzols and brown forest soils predominate along the eastern shoreline, with poorly draining peaty soils further inland. On the western shore, both freely- and poorly-draining soils are present along the shore. Soils adjacent to the fishery and Otter Ferry are classed as freely-draining, therefore they are less likely to contribute large amounts of surface runoff due to soil permeability. Streams or burns discharging to Loch Fyne in this area may drain areas of poor soil permeability in their upper reaches, which may result in elevated runoff during periods of heavy rainfall. Overall, the risk to the fishery from contamination by runoff attributable to soil drainage is relatively low.

6. Land Cover

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

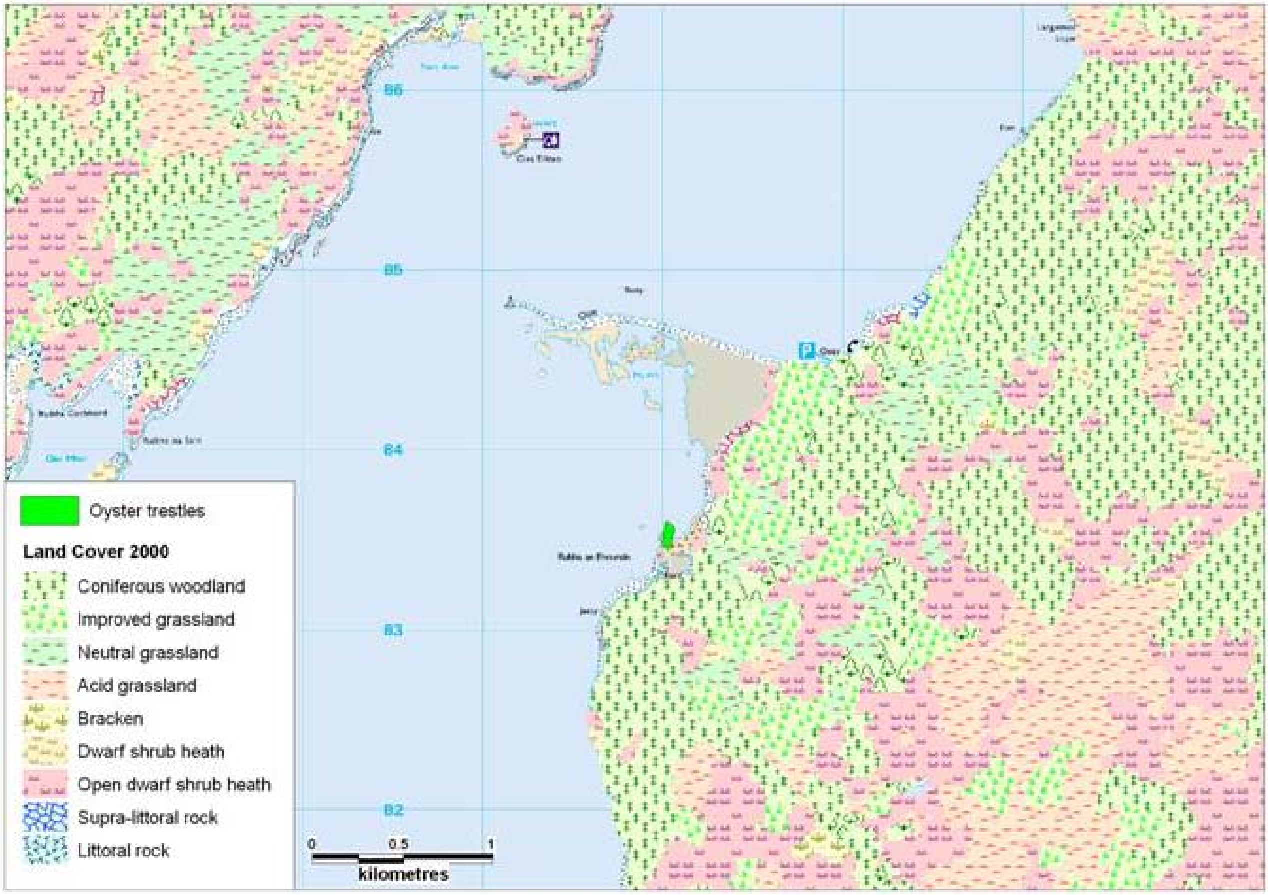


Figure 6.1 LCM2000 class land cover data for Otter Ferry

A variety of land cover types cover the shoreline adjacent to the Loch Fyne Otter Ferry oyster trestles. On the shore adjacent to the oyster site are large areas of improved grassland, coniferous woodland and some smaller patches of neutral grassland and open dwarf shrub heath. Further inland are larger areas of acid grassland with smaller areas of woodland, bracken and dwarf shrub heath. On the shoreline opposite the oyster site there are areas of neutral grassland, open dwarf shrub heath, acid grassland and coniferous woodland. Although no developed areas are identified in the Landcover 2000 data, it should be noted there are areas of hardstanding and buildings at Otter Ferry and on the Ballimore Estate, adjacent to the fishery.

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

Therefore, the overall predicted contribution of contaminated runoff from these land cover types would be low to intermediate, and would be expected to increase significantly following rainfall events. Runoff from paved areas around the estate would be most likely to contribute contaminated runoff to the oyster farm. These would be carried via the stream at Ballimore and impacts may be higher to the southern end of the oyster farm.

7. Farm Animals

Agricultural census data to parish level was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the parishes Kilfinan and Kilmichael Glassary. 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 7.1 Livestock numbers in Kilfinan and Kilmichael Glassary parishes 2008 - 2009

	Kilfinan (129.2 km^2)				Kilmichael Glassary (249.1 km^2)			
	2008		2009		2008		2009	
	Holdings	Numbers	Holdings	Numbers	Holdings	Numbers	Holdings	Numbers
Pigs	*	*	*	*	0	0	0	0
Poultry	*	*	*	*	10	166	11	176
Cattle	9	1,236	9	1,101	13	1,558	15	1,499
Sheep	10	11,186	9	10,400	21	15,802	20	14,103
Horses and ponies	*	*	*	*	6	18	8	21

* Data withheld for reasons of confidentiality

The dominant types of livestock kept in the both parishes are sheep and cattle, with sheep roughly 10 times more numerous. The number kept in both parishes declined between 2008 and 2009. Information on the spatial distribution of animals on land adjacent to or near the fishery can provide an indication of the potential amount of organic pollution from livestock entering the shellfish production area. However, due to the large geographic areas of the parishes, and the missing data from Kilfinan parish, the only information available regarding the numbers of animals present near the fishery is that recorded during the shoreline survey (Section 15 and Appendix 7). This information relates only to the time of the site visit on the 11 August 2010 and is dependent upon the point of view of the observer.

The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 7.1. The harvester reported that roughly 1000 sheep were kept on the estate and that these were grazed on fields around the area and brought into barns during the winter. Bedding from the barns is scraped up and spread on the fields after the sheep are put back out in spring. A small number of cattle are also kept (<10) further uphill from the estate, though these were not directly observed.

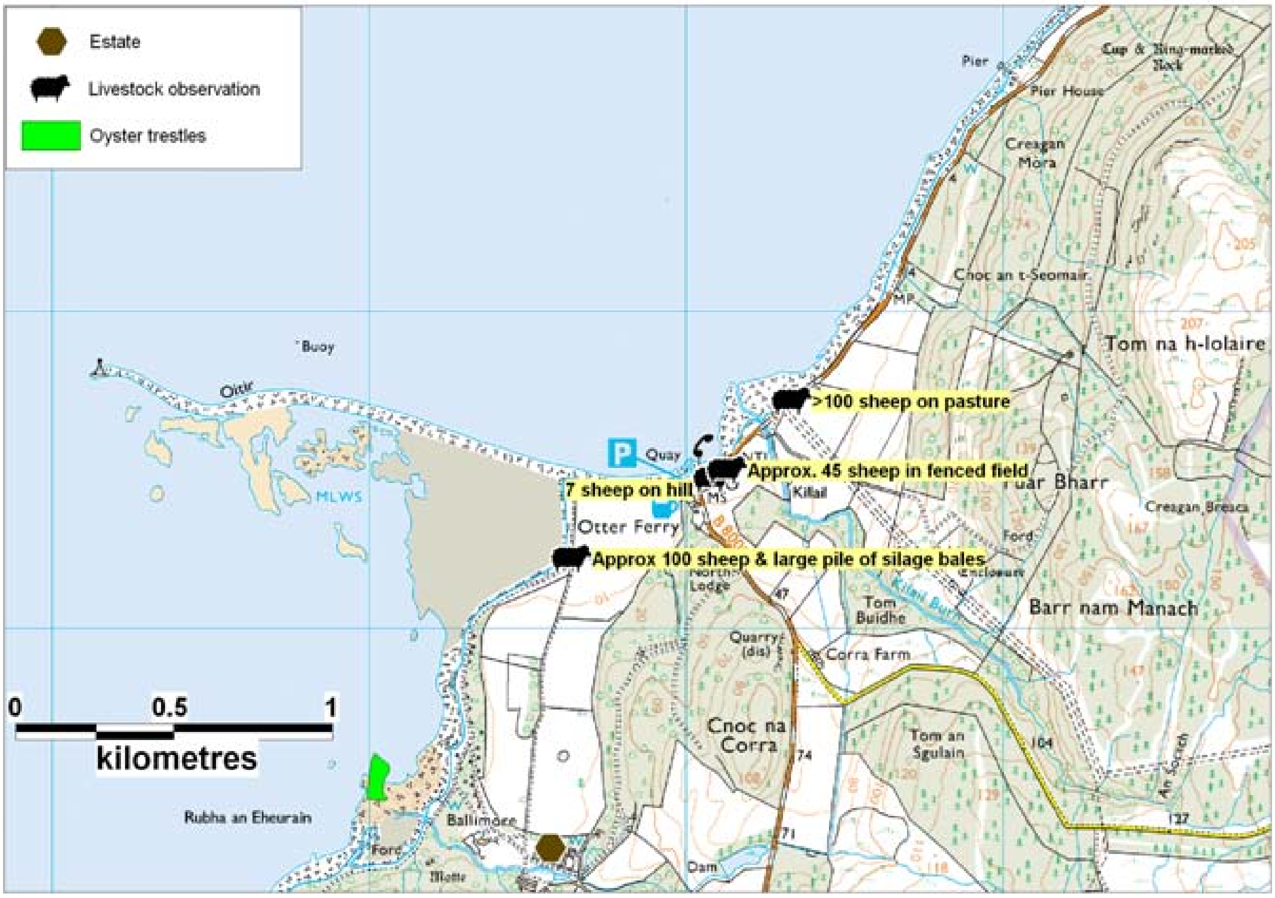


Figure 7.1 Livestock observations at Otter Ferry

The estate farm buildings are located adjacent to a stream and any runoff from hardstanding areas would be carried to the fishery via the burn, making it a potential route for contamination from livestock barns when animals are kept on site.

A strip of woodland separates the pasture areas nearest the oyster farm from the shoreline, providing a buffer against direct runoff from faecal matter applied to the pasture areas. North of this, the pasture lies inland of the road although there is a wider area of mud and this is further from the fishery. North of the oitir, or sandspit, at Otter Ferry pasture lines both sides of the Kilail Burn and this is likely to carry runoff contaminated with sheep manure to Loch Fyne.

Of most importance to water quality at the fishery are the barns and farm areas adjacent to the stream at Ballimore, which would carry any faecally-contaminated runoff directly to the trestles. The risk of this is highest during winter when livestock are housed. There is the potential for runoff from pastureland north of the fishery. Although further from the oyster trestles this could contribute to background levels of contamination within the general area.

8. Wildlife

There are no conservation areas near the oyster fishery at Otter Ferry.

Birds
Seabird 2000 counts for seabirds within 5km of the site are listed in Table 8.1 below.

Table 8.1 Seabird counts within 5km of the site.

Common name	Species	Count	Method
Herring Gull	*Larus argentatus*	1	Occupied nests
Common Gull	*Larus canus*	2	Individuals on land
Great Black-backed Gull	*Larus marinus*	50	Occupied territory or nests

Only a very small number of seabirds were observed in the area, the majority of these on two small islands near the western shore of the loch to the north and south of the sand spit at Otter Ferry.

The intertidal areas around the sandspit are likely to attract wading birds, though only small numbers of ducks and oystercatchers were observed during the shoreline survey. The Loch Fyne ICZM Plan identifies the area as important for nesting seabirds, though few breeding birds were identified in the Seabird 2000 data. The area is known to host large numbers of eider ducks, with a flock of 954 reported at Otter Ferry during the summer of 2001 (SOC 2001).

Duringthe shoreline survey, large numbers of pheasants were observed along the estate tracks.

Seals
Harbour seals are known to be present in the area, with haulout sites in Loch Gilp and further along the coast to the south of Otter Ferry. Roughly 30-50 animals were reported at either location during seal population surveys during 2007 and 2008 (SCOS 2009).

Deer
As much of the land along the east side of Loch Fyne is forested, it is likely to host substantial populations of deer. However, no census data were available for the North Otter or Ormidale forests, which lie inland of the Otter Ferry oyster farm. It is likely that deer contribute to the faecal indicator bacteria loadings found in streams in discharging to Loch Fyne.

Summary
Species potentially impacting on water quality at Otter Ferry include eider ducks, wading birds, deer, and seals. However, the impacts of these on the fishery will be unpredictable. There will be some seasonal variation in the numbers and types of animals, particularly birds, present in the vicinity of the oyster farm. Seabirds and nesting wading birds are likely to be present on or

near their nests during the summer months. Eider ducks may be present in very large numbers in summer.

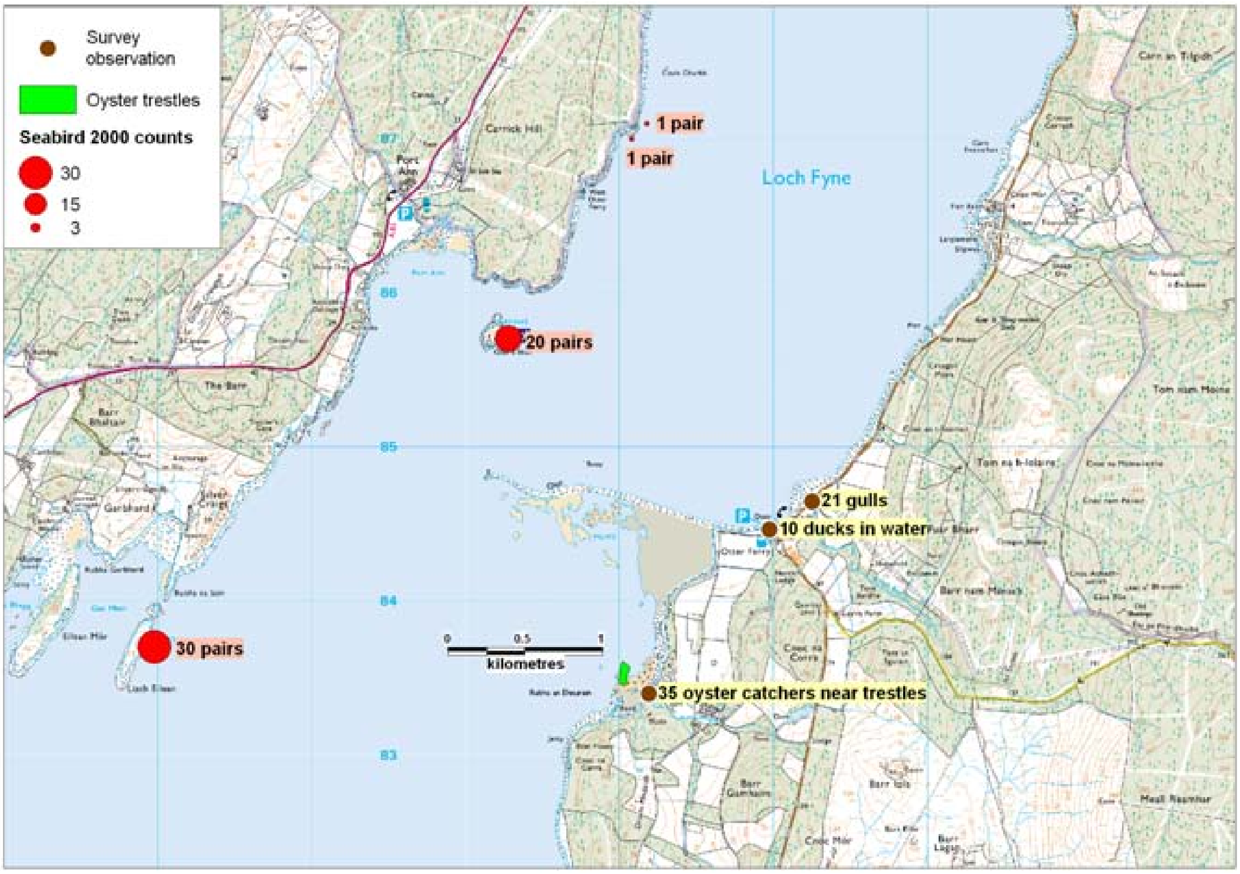


Figure 8.1 Map of wildlife observations at Otter Ferry

9. Meteorological data

The nearest weather station for which a relatively complete data set was available is located at Skipness House, 25 km to the south. Rainfall data was available for 2003-2009 inclusive apart from the months of January and December 2006. The nearest weather station for which wind data is available is Glasgow: Bishopton, 52 km to the east. The production are lies within Loch Fyne, which has a north-south aspect at this point, and the weather station lies in the Clyde valley, which has an east-west aspect. Overall wind patterns are likely to be broadly similar at the two, though local topography is likely to skew these patterns in different ways and conditions at any given time may differ due to the distance between them. This section aims to describe the local rain and wind patterns and how they may affect the bacterial quality of shellfish at Otter Ferry.

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

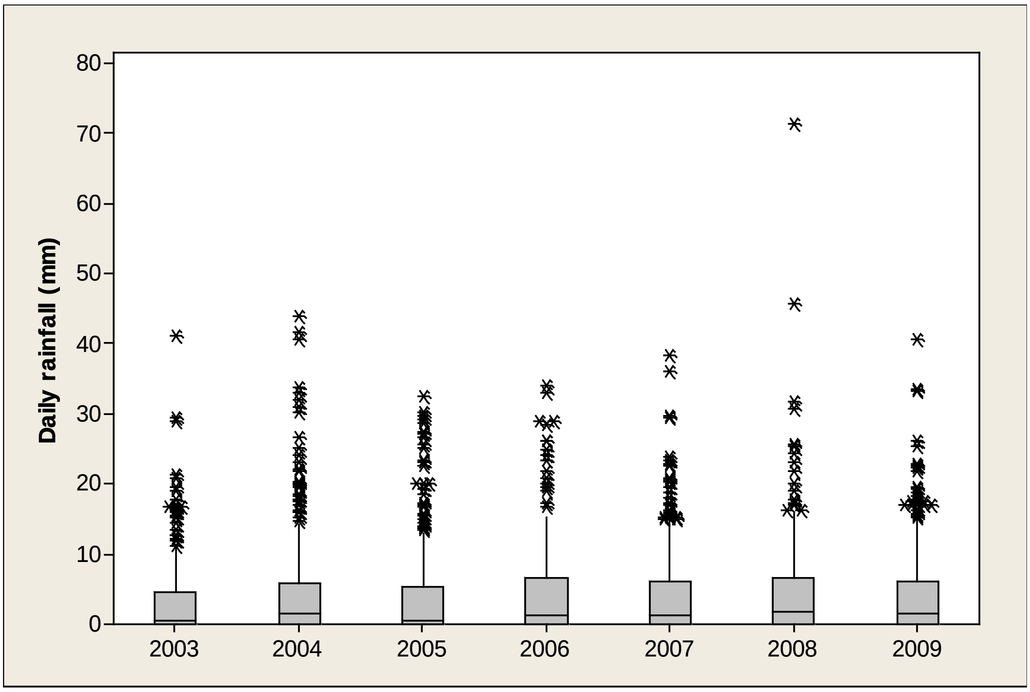


Figure 9.1 Box plot of daily rainfall values by year at Skipness House, 2003-2009

Figure 9.1 shows that rainfall patterns were similar between the years presented here, with 2003 the driest and 2008 the wettest.

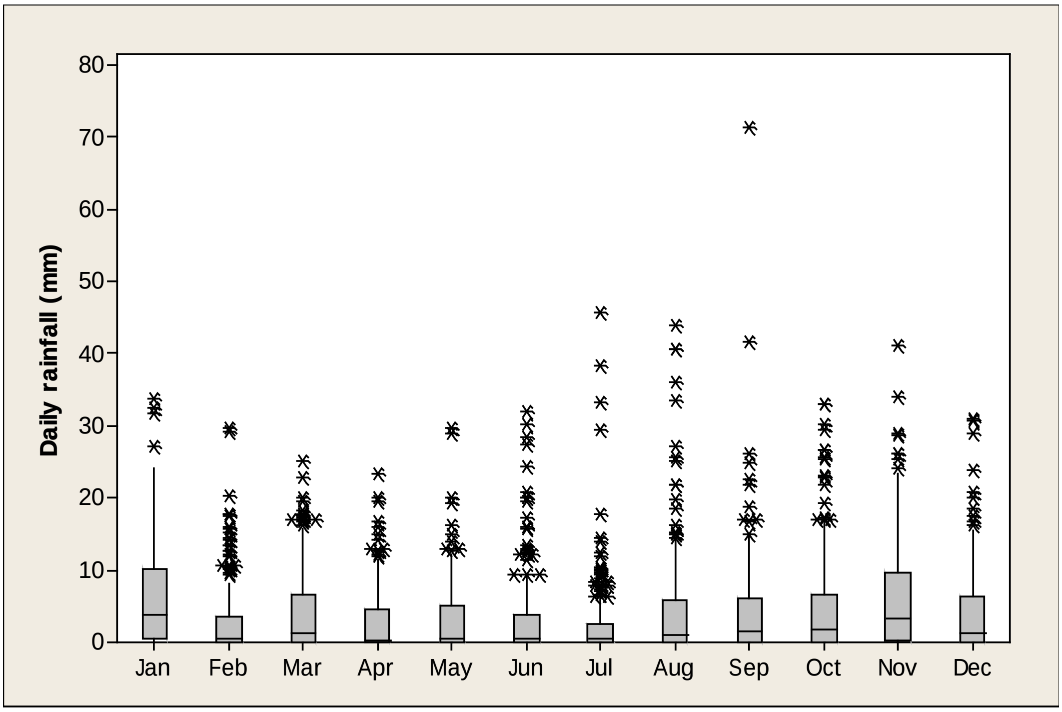


Figure 9.2 Box plot of daily rainfall values by month at Skipness House, 2003-2009

Figure 9.2 shows that daily rainfall was highest in November and January, and lowest in February and July. The most extreme rainfall events occurred during the second half of the year, but events in which over 20mm fell in a day occurred in all months. For the period considered here (2003-2009), 48% of days experienced rainfall less than 1 mm, and 14% 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 dry periods when stock levels are at their highest.

9.2 Wind

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

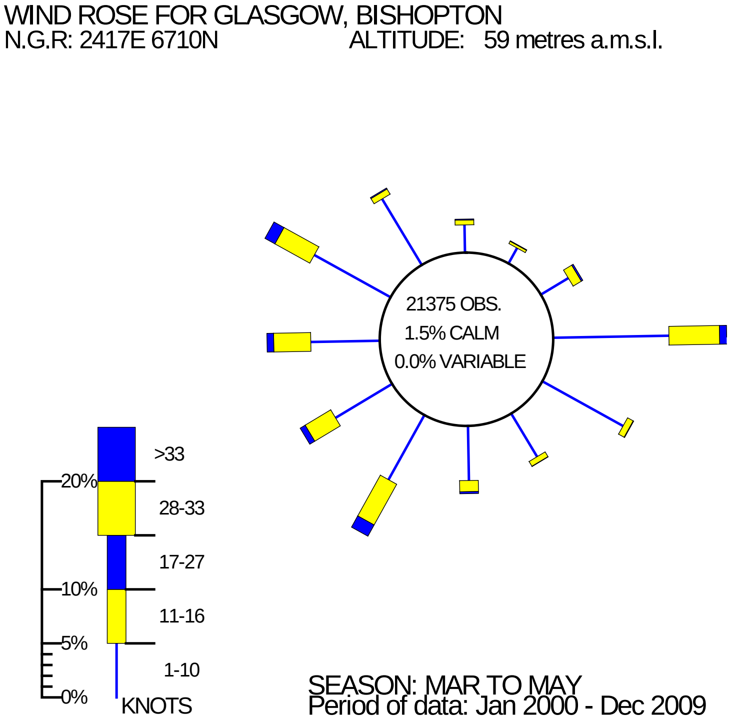


Figure 9.3 Wind rose for Glasgow Bishopton (March to May)

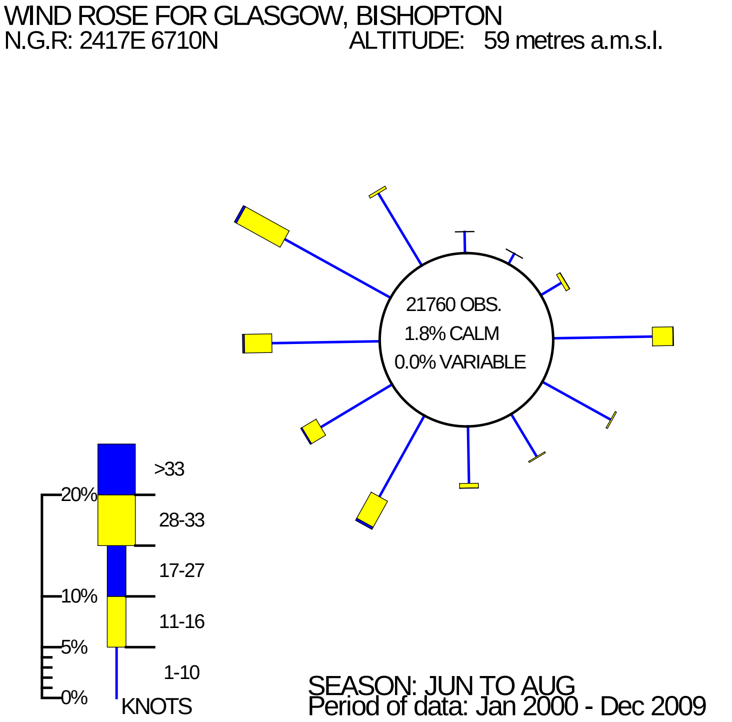


Figure 9.4 Wind rose for Glasgow Bishopton (June to August)

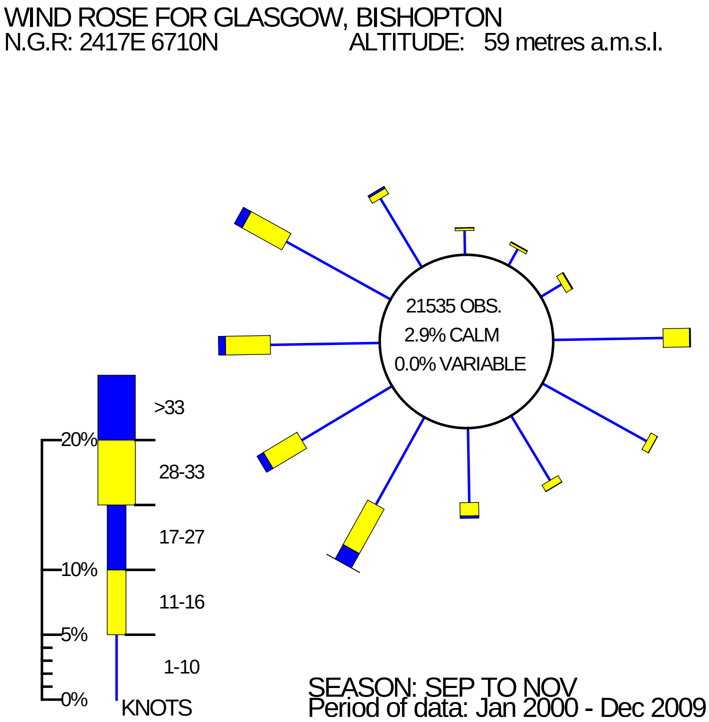


Figure 9.5 Wind rose for Glasgow Bishopton (September to November)

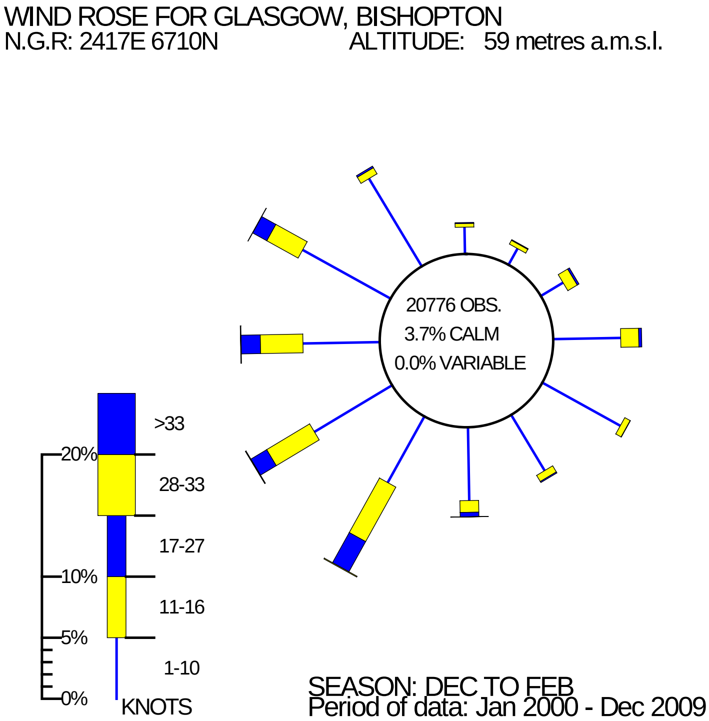


Figure 9.6 Wind rose for Glasgow Bishopton (December to February)

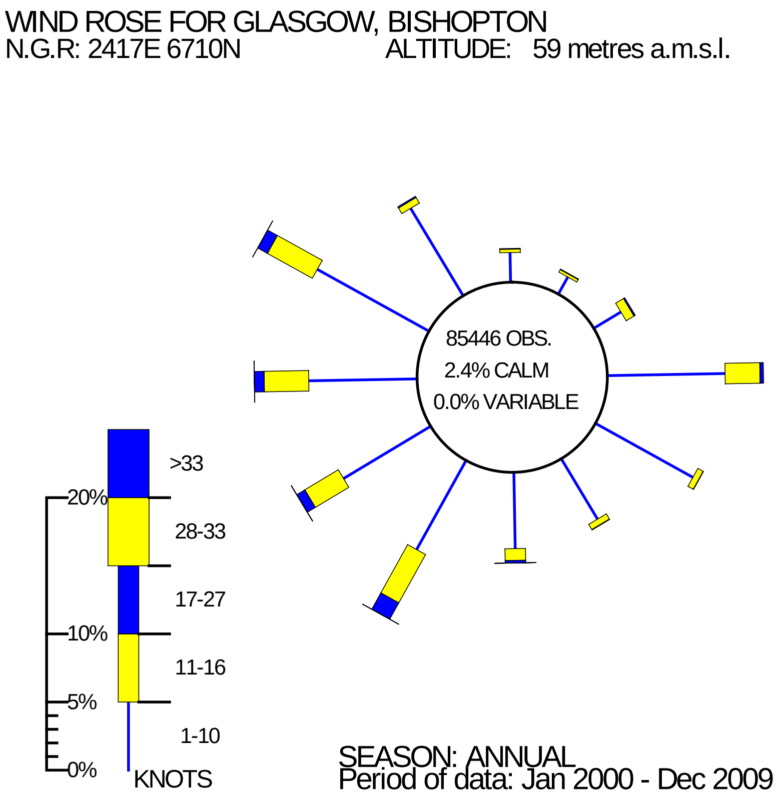


Figure 9.7 Wind rose for Glasgow Bishopton (All year)

The prevailing wind direction at Glasgow Bishopton is from the south west. Overall patterns appear to be skewed along the east west axis. Presumably this is due in part at least to local topography, and wind patterns at otter ferry are likely to align more along the north south axis. There is a higher occurrence of easterly winds during the spring. Winds are generally lightest in the summer and strongest in the winter.

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 may significantly alter the pattern of surface currents at Otter Ferry. 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, in and above the normal high water mark, into the production area. A strong westerly wind will result in increased wave action at Otter Ferry, which may resuspend any organic matter settled in the substrate.

10. Current and historical classification status

Classification records for Pacific oysters produced at Loch Fyne: Otter Ferry were available from 2004.

Table 10.1 Classification history, Otter Ferry Pacific oysters

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2004	A	A	A	A	A	B	B	B	B	A	A	A
2005	B	A	A	A	A	B	B	B	B	B	B	B
2006	A	A	A	A	A	B	B	B	B	B	A	A
2007	A	A	A	A	A	B	B	B	B	B	A	A
2008	A	A	A	A	A	A	B	B	B	B	A	A
2009	A	A	A	A	A	A	B	B	B	A	A	A
2010	A	A	A	A	B	B	B	B	B	B	B	B
2011	A	A	A									

The area has consistently held a seasonal classification, with July-September classified B and February-April classified A in all years.

11. Historical *E. coli* data

11.1 Validation of historical data

All shellfish samples taken Loch Fyne: Otter Ferry from the beginning of 2002 up to the 21st April 2010 were extracted from the database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data.

One Pacific oyster sample had no reported grid reference and so was rejected from the analysis. All other reported sampling locations fell within the production area boundaries. All samples were received by the testing laboratory within two days of collection. Seven Pacific oyster 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 below.

Table 11.1 Summary of historical sampling and results

Sampling Summary		
Production area	Loch Fyne: Otter Ferry	Loch Fyne: Otter Ferry
Site	Balliemore	Balliemore
Species	Pacific oysters	Common mussels
SIN	AB-151-039-13	AB-151-039-08
Location	33 locations	NR 912835
Total no of samples	88	2
No. 2002	4	2
No. 2003	17	0
No. 2004	12	0
No. 2005	11	0
No. 2006	11	0
No. 2007	10	0
No. 2008	10	0
No. 2009	11	0
No. 2010	2	0
Results Summary		
Minimum	10	70
Maximum	5400	500
Median	110	*
Geometric mean	121.2	*
90 percentile	1100	*
95 percentile	1300	*
No. exceeding 230/100g	28 (32%)	*
No. exceeding 1000/100g	10 (11%)	*
No. exceeding 4600/100g	1 (1%)	*

* not calculated for fewer than 5 samples

Only two mussel samples were taken within this period, so sample numbers were insufficient to carry out a more detailed evaluation of results for this species, and the results of these two samples are not considered further in this report.

11.3 Overall geographical pattern of results

From March 2007 sampling officers were equipped with GPS receivers, with which sampling location was recorded with greater accuracy at the time of collection. Results of samples taken before this time are not presented geographically in this report as the accuracy of the sampling location cannot be assured. The majority of these were assigned to the nominal RMP.

Sample results from March 2007 onwards clustered into four geographic groups. These are summarised in Table 11.2. The geometric mean E. coli results for these clusters are thematically mapped in Figure 11.1.

Table 11.2 Clustered results used in geographic analysis

Cluster no.	***Geopraphic centre***	***Number of results***	***Geometric mean* E. coli**	***Sample dates***
1	NR 9195 8331	10	55.6	Apr07-Feb08
2	NR 9199 8340	9	283	Apr09-Mar10
3	NR 9200 8346	9	161	May08-Mar09
4	NR 9204 8349	3	163	Mar-Apr08, Aug09

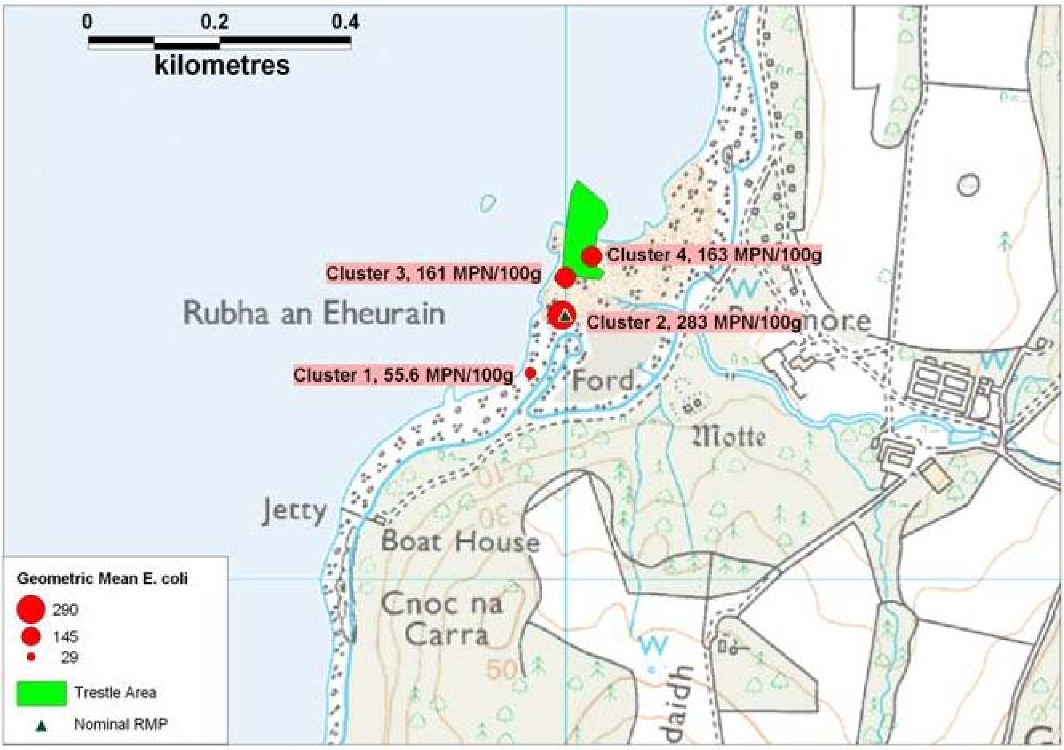


Figure 11.1 Thematic map of *E. coli* results 2007-2010 (Pacific oysters)

Results were lowest at Cluster 1, which lies on shoreline outside a shingle bank south of the main fishery. Cluster 2 coincides roughly with the location of the nominal RMP, where a dedicated trestle has been placed for sampling purposes. The highest geometric mean was obtained for this cluster. Clusters 3 and 4 were very similar. However, as Cluster 4 consisted of only three results it will not be considered in statistical analyses below. It should be noted that sampling at the different point clusters did not coincide in time. Figure 11.2 presents a boxplot of these results for Clusters 1 through 3.

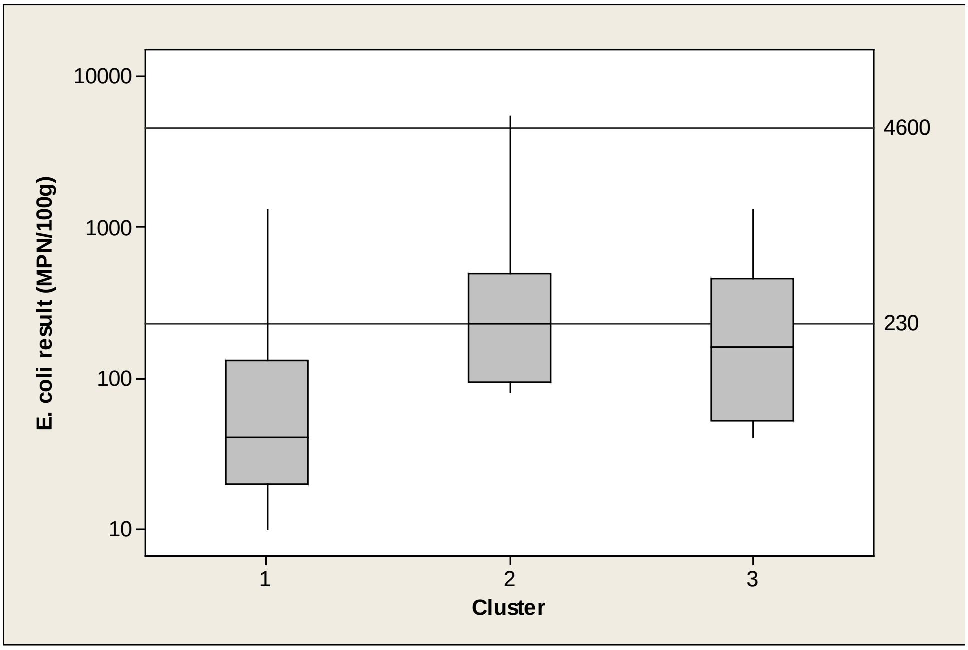


Figure 11.2 Boxplot of *E. coli* results by cluster for Pacific oysters

A significant difference in mean result was found between the three clusters of sampling locations (One-way ANOVA, p=0.038, Appendix 6). A post ANOVA test (Tukeys comparison, Appendix 6) indicates that results for Cluster 2 were significantly higher than those for Cluster 1. No statistically significant difference was found between results for Cluster 2 and Cluster 3.

11.4 Overall temporal pattern of results

Figure 11.3 presents a scatter plot of individual results against date for Loch Fyne: Otter Ferry. The points are 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 lowess 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 lowess 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.

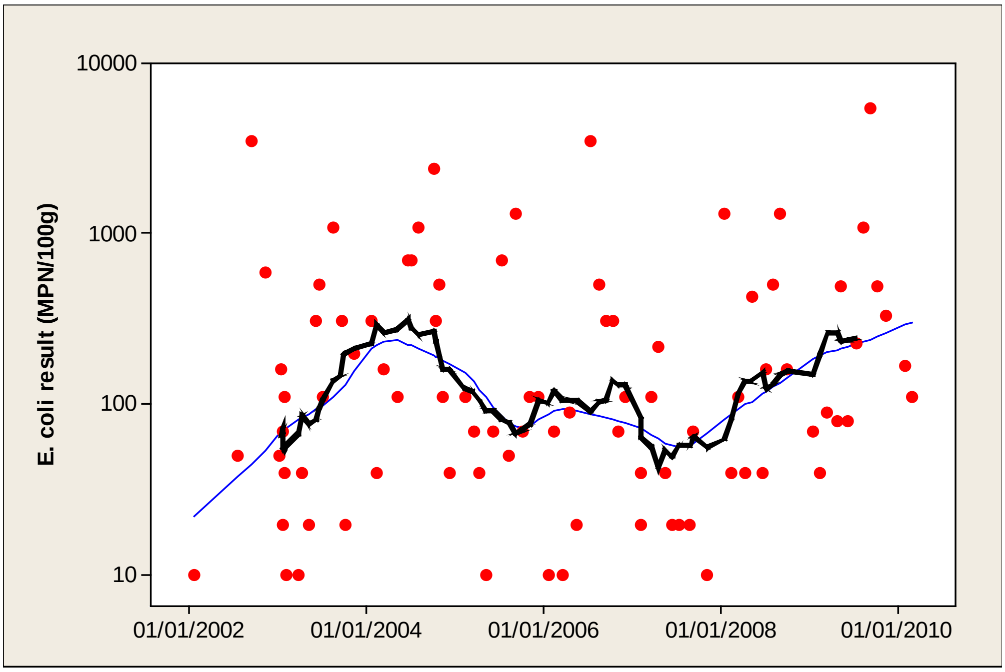


Figure 11.3 Scatterplot of *E. coli* results by date with rolling geometric mean (black line) and loess line (blue line)

Figure 11.3 suggests a deterioration from 2002 to 2004, an improvement from 2004 to 2008, and a deterioration from 2008 onwards. No results of > 230 *E. coli* MPN/100 g were obtained in 2007.

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 11.4 presents a boxplot of *E. coli* result by month.

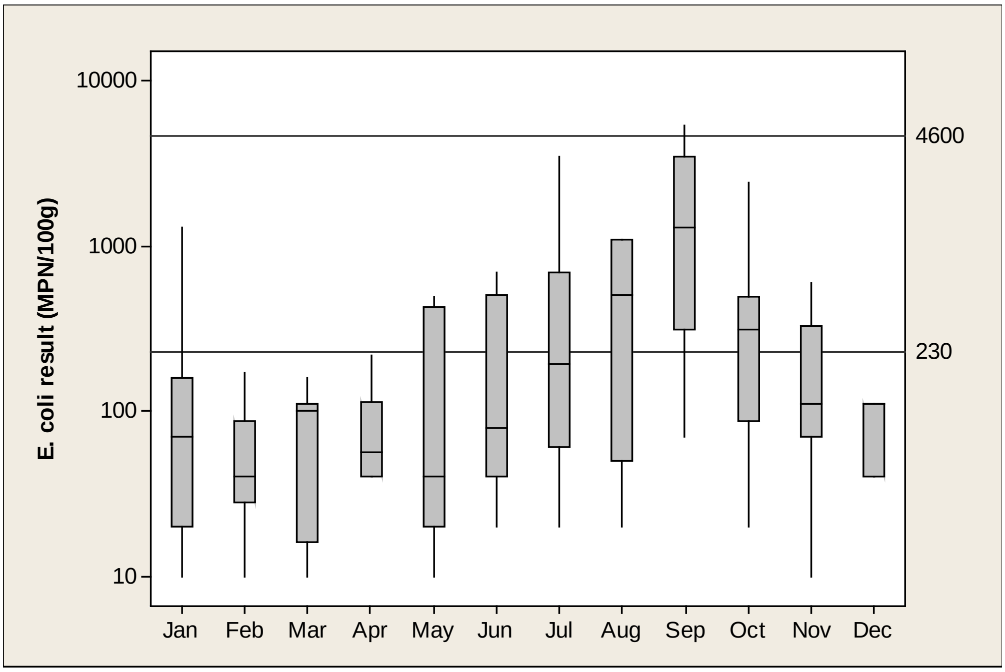


Figure 11.4 Boxplot of results by month

Higher results generally arose between May and November, peaking in September, although one high result was recorded in January. Results were consistently below 230 *E. coli* MPN/100 g during February to April and in December. Six or more samples were taken during all months except December, when only three samples were taken.

For statistical evaluation, seasons were split into spring (March - May), summer (June - August), autumn (September - November) and winter (December - February). Figure 11.4 presents a boxplot of *E. coli* result by season.

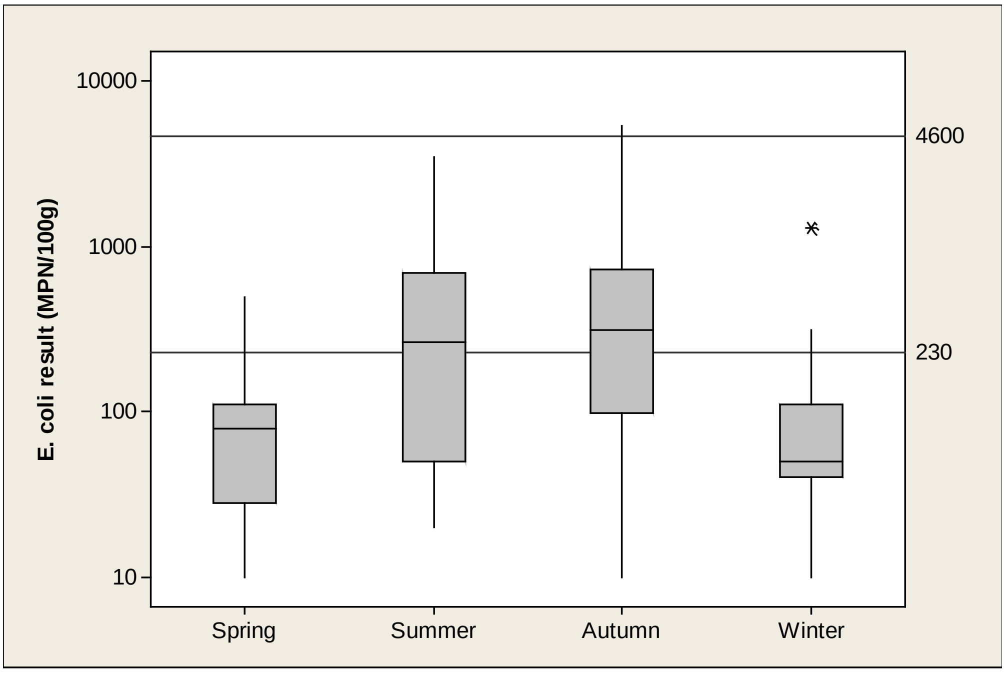


Figure 11.5 Boxplot of result by season

A significant difference was found between results by season (One-way ANOVA, p=0.000, Appendix 6). A post ANOVA test (Tukeys comparison, Appendix 6) indicates that results for the summer and autumn were significantly higher than those in the winter and spring.

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 Skipness House, 25 km to the south 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). The relationship between rainfall during the two-day and seven-day periods prior to sampling and *E. coli* result was investigated. Scatterplots are presented in Figures 11.6 and 11.7 and a Spearman's Rank correlation was carried out between results and rainfall.

Two-day antecedent rainfall

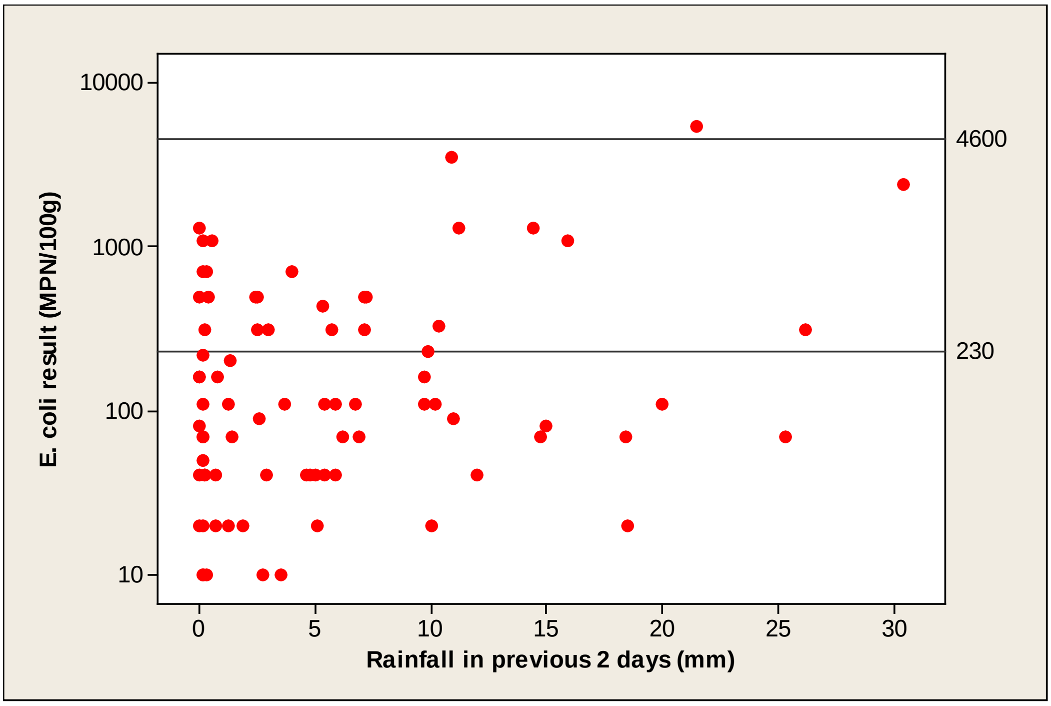


Figure 11.6 Scatterplot of result against rainfall in previous 2 days

No statistically significant correlation was found between *E. coli* result and rainfall in the previous 2 days (Spearman's rank correlation=0.165, p>0.05, Appendix 6). No results <20 *E.coli* MPN/100 g occurred when rainfall totalled

5 mm or more. Results greater than 1000 *E.coli* MPN/100 g occurred even after no rainfall in the 2 days prior to sampling.

Seven-day antecedent rainfall

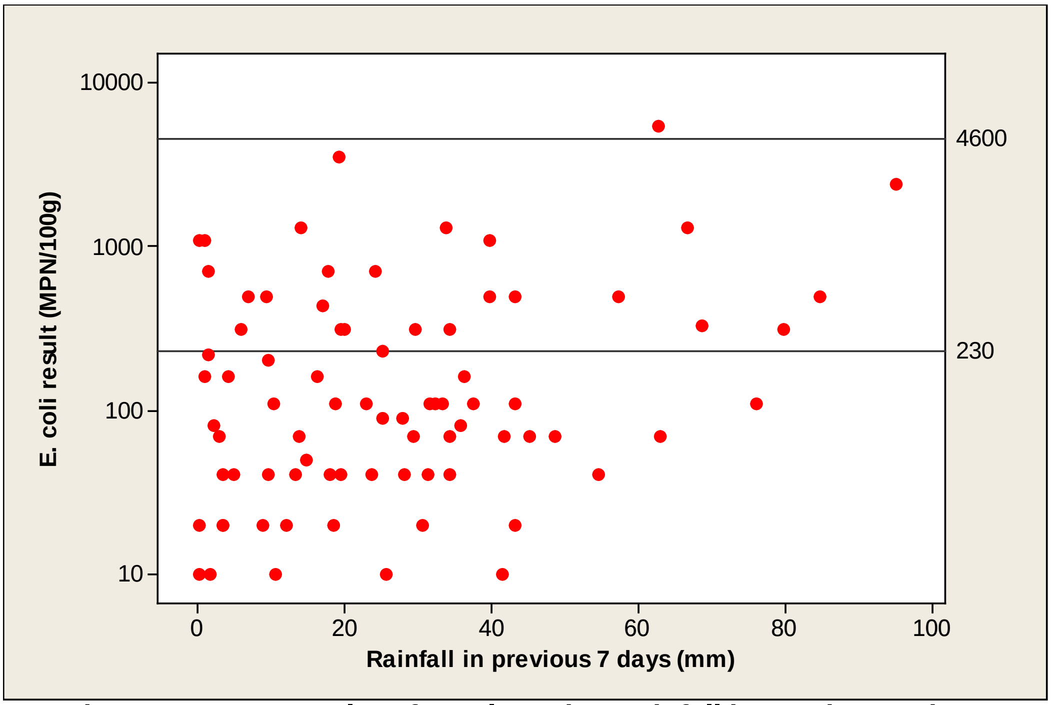


Figure 11.7 Scatterplot of result against rainfall in previous 7 days

A significant positive correlation was found between *E. coli* result and rainfall in the previous 7 days (Spearman's rank correlation= 0.199, $p<0.05$, Appendix 6). No results of <20 or 20 *E.coli* MPN/100 g occurred when rainfall totalled over 45 mm, though results greater than 1000 *E.coli* MPN/100 g occurred at rainfall as low as 0.2 mm.

11.6.2 Analysis of results by tidal height and state

Spring/Neap tidal cycle

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 11.8 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 less 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.

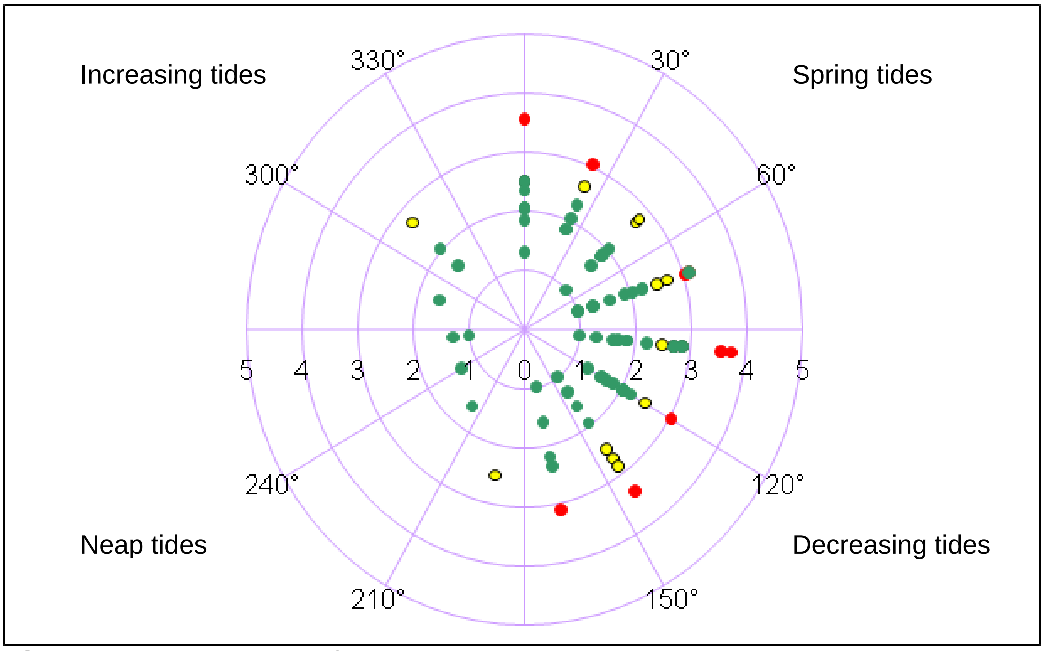


Figure 11.8 Polar plot of $\log_{10}$ *E. coli* results on the spring/neap tidal cycle

No statistically significant correlation was found between *E. coli* results and the spring/neap cycle (circular-linear correlation, r=0.168, p=0.092, Appendix 6). Sampling was heavily targeted towards spring tides.

High/Low tidal cycle

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 11.9 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 less 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.

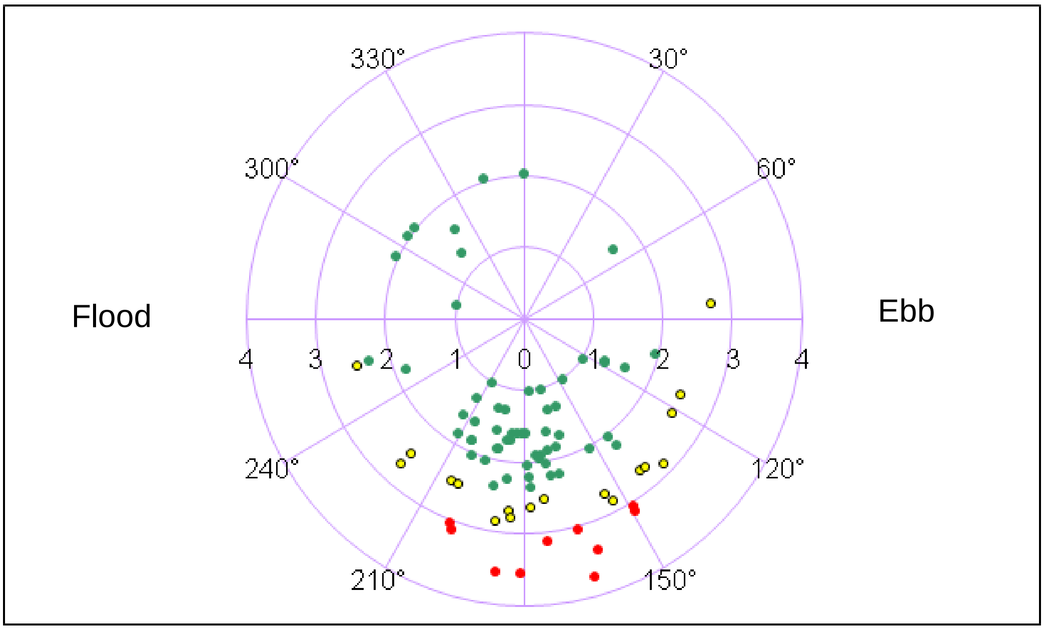


Figure 11.9 Polar plot of $\log_{10}$ *E. coli* results on the high/low tidal cycle

No statistically signficant correlation was found between *E. coli* results and the high/low tidal cycle (circular-linear correlation, r=0.156, p=0.125, Appendix 6). Sampling was heavily targeted towards low water.

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

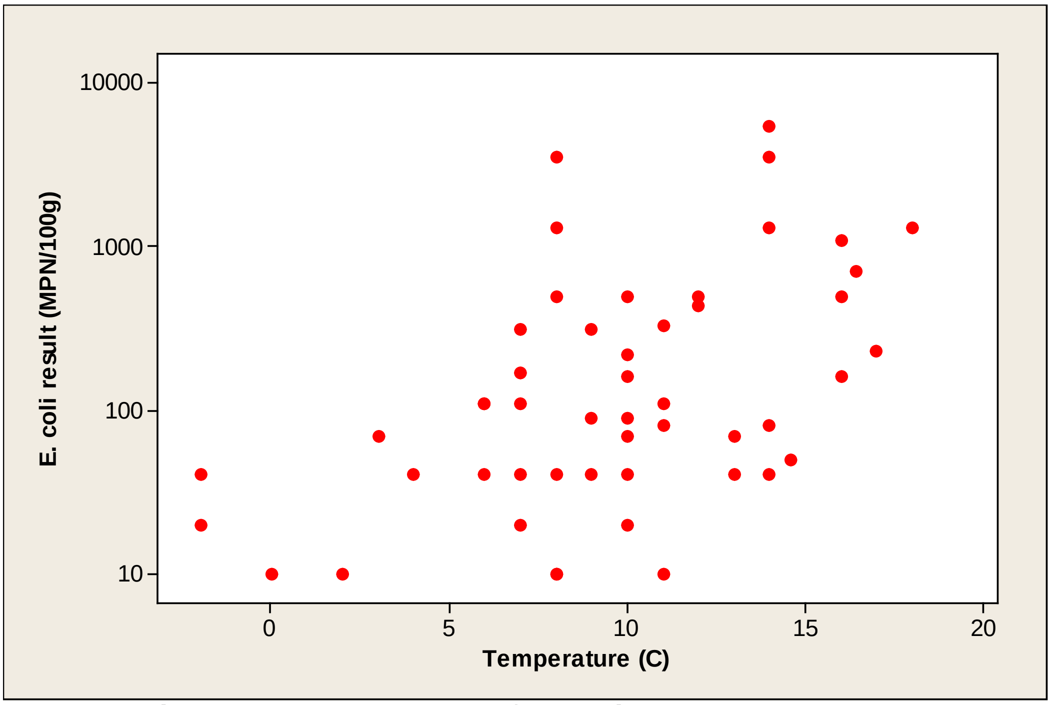


Figure 11.10 Scatterplot of result by water temperature

A positive correlation was found between *E. coli* result and water temperature (Spearman's rank correlation= 0.478, p<0.0005, Appendix 6).

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 11.11 presents a scatter plot of *E. coli* result against salinity.

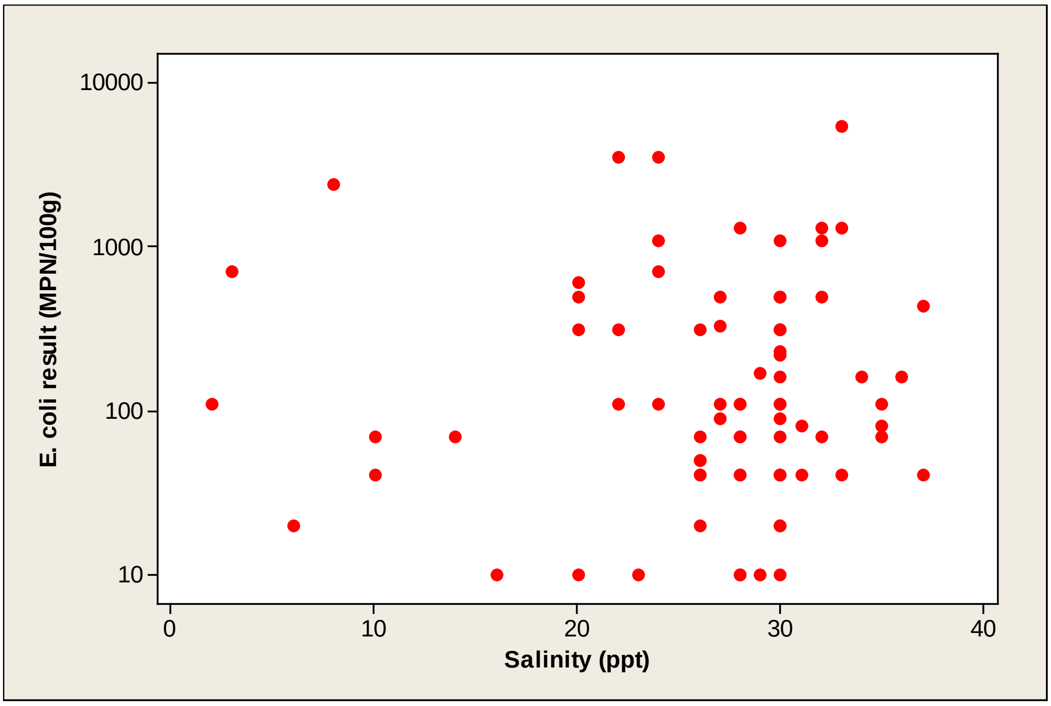


Figure 11.11 Scatterplot of result by salinity

No statistically signficant correlation was found between the *E. coli* result and salinity (Spearman's rank correlation= 0.053, p>0.25, Appendix 6). No results <20 *E. coli* MPN/100 g (10 on the plot) coincided with salinities below 16 ppt, however high results occurred across a range of recorded salinity values.

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

A total of 10 samples gave a result of over 1000 *E. coli* MPN/100g, details of which are presented in Table 11.3.

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

Collection date	*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)
11/09/2002	3500	NR912835	*	*	14	22	Low	Decreasing
13/08/2003	1100	NR920834	0.1	0.2	*	24	Low	Spring
03/08/2004	1100	NR920834	0.5	0.9	*	30	Low	Spring
04/10/2004	2400	NR920834	30.4	95.1	*	8	Low	Decreasing
06/09/2005	1300	NR920834	0	13.9	18	32	Low	Spring
11/07/2006	3500	NR920834	10.9	19.2	8	24	Low	Spring
15/01/2008	1300	NR 91949 83310	11.2	66.7	8	28	Low	Decreasing
02/09/2008	1300	NR 91996 83459	14.4	33.8	14	33	Low	Spring
11/08/2009	1100	NR 92040 83489	15.9	39.7	16	32	Low	Decreasing
08/09/2009	5400	NR 91993 83396	21.5	62.7	14	33	Low	Decreasing

* Data unavailable

Most of these high results arose in August (3) or September (4), with the remainder arising in July (1), October (1) and January (1). Where water temperatures were recorded they were usually relatively high. The samples were taken from a variety of locations, and following a variety of rainfalls, some quite heavy, and at a variety of salinities, some quite low. All were taken around low water on either spring or decreasing tides, but sampling was strongly targeted towards these tidal states.

11.8 Summary and conclusions

Prior to 2007, the vast majority of samples were reported against the nominal RMP. From 2007 onward, sampling locations were recorded accurately using handheld GPS at the time of sampling. Samples for which an accurate grid reference was taken aligned roughly into three clusters along a north-south axis. Results were higher at the north and middle clusters, and were significantly higher at the middle cluster compared to the southerly cluster. The map suggests the mid and north cluster appear more likely to be impacted by a watercourse discharging to the shore. It must be noted that samples were not taken from multiple locations on any given date, therefore the variation in results may be due to the way that sampling location varied over time rather than a true geographic effect.

In terms of overall temporal trends, a deterioration was seen from 2002 to 2004, an improvement from 2004 to 2008, and a deterioration from 2008 onwards. A strong seasonal pattern was found, with results for the summer and autumn significantly higher than those in the winter and spring. A positive correlation was also found between *E. coli* results and water temperature. This may be related to the seasonal effects.

No significant correlation was found between *E. coli* results and rainfall in the previous 2 days, but a weak positive correlation was found with 7 day rainfall. No correlation was found between results and salinity.

No singificant correlation was found between levels of *E. coli* in shellfish and tidal state on either the spring/neap or high/low tidal cycles. Sampling was targeted towards low water on spring tides, so the full range of tidal conditions was not fully represented.

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 this production area as it has held seasonal classifications within the last three years.

12. Designated Shellfish Growing Waters Data

The site considered in this report is contained within a designated Shellfish Growing Water. It was designated in 1998 and has been monitored by SEPA since then. The growing water encompasses a 100 m wide strip along the entire shoreline of Loch Fyne aside from a few stretches around large settlements, and the full extent of this is not shown on Figure 12.1. It is split into three basins and the Ballimore oyster farm is situated in the southern basin. There were historically three separate designated monitoring points, one for each basin. The monitoring point for the south basin was at Whitehouse Bay, 7.1 km to the southwest of the production area.

Monitoring results for faecal coliforms in shore mussels taken at the Whitehouse Bay monitoring point from 1999 to the end of 2007 have been provided by SEPA. These results are presented in Table 12.1. Two monitoring points were given for the data, one of which (NR 864 720) plots 9 km south of Whitehouse Bay in the Loch Fyne: Stonefield production area. It is not clear whether all of the samples came from the sampling point in Whitehouse Bay (NR 8511 8111).

The geometric mean result of all shore mussel samples was 236 faecal coliforms / 100 ml. Results ranged from <20 to 180000 faecal coliforms/100 ml. Results were highest for quarter 3, and lowest for quarter 2, but differences between results by quarter were not significant (One-way ANOVA, p=0.193, Appendix 4). This is a similar seasonal pattern to that observed for the classification samples. Results were markedly worse in 2006 and 2007 than in the previous years, though it is not clear whether this reflected a deterioration over time or a shift in monitoring point.

Levels of faecal coliforms are usually closely correlated to levels of *E. coli*, often at a ratio of approximately 1:1. The ratio depends on a number of factors, such as environmental conditions and the source of contamination and as a consequence the results presented in Table 12.1 are not directly comparable with other shellfish testing results presented in this report. The very high results obtained in the shellfish waters monitoring at Whitehouse Bay in Q4 of 2006 (24000 /100 ml) and Q3 of 2007 (180000 per 100 ml) indicate that the monitoring point at that location is subject to extreme levels of faecal contamination on occasions.

From 2008 onwards, microbiological data obtained under the classification monitoring programme overseen by FSAS were shared with SEPA for use in meeting the monitoring requirements under the shellfish growing water programme. Therefore, these results have already been considered within the analysis in Section 11.

Given the distance between the SGW monitoring point and the Ballimore oyster farm, and the difference in local sources of contamination, results at Whitehouse Bay may not be indicative of conditions at Ballimore.

Table 12.1 SEPA faecal coliform results (faecal coliforms/100ml[1]) for non-commercial shellfish gathered from Whitehouse Bay

	Site	Loch Fyne outer/Whitehouse Bay
	OS Grid Ref.	NR 864 720/NR 85111 81114
1999	Q3	1600
	Q4	
2000	Q1	40
	Q2	
	Q3	20
	Q4	310
2001	Q1	110
	Q2	<20*
	Q3	20
	Q4	
2002	Q1	250
	Q2	40
	Q3	410
	Q4	70
2003	Q1	750
	Q2	
	Q3	250
	Q4	110
2004	Q1	110
	Q2	40
	Q3	2200
	Q4	220
2005	Q1	70
	Q2	2200
	Q3	220
	Q4	265
2006	Q1	<20*
	Q2	20
	Q3	5400
	Q4	24000
2007	Q1	700
	Q2	190
	Q3	180000
	Q4	265

[1] The faecal coliform determined in the Shellfish Waters Directive is expressed per 100 ml, rather than the more usual per 100 g used in shellfish hygiene – in practice, the difference is not important

[2] Assigned a nominal value of 10 for the purpose of calculating the geometric mean

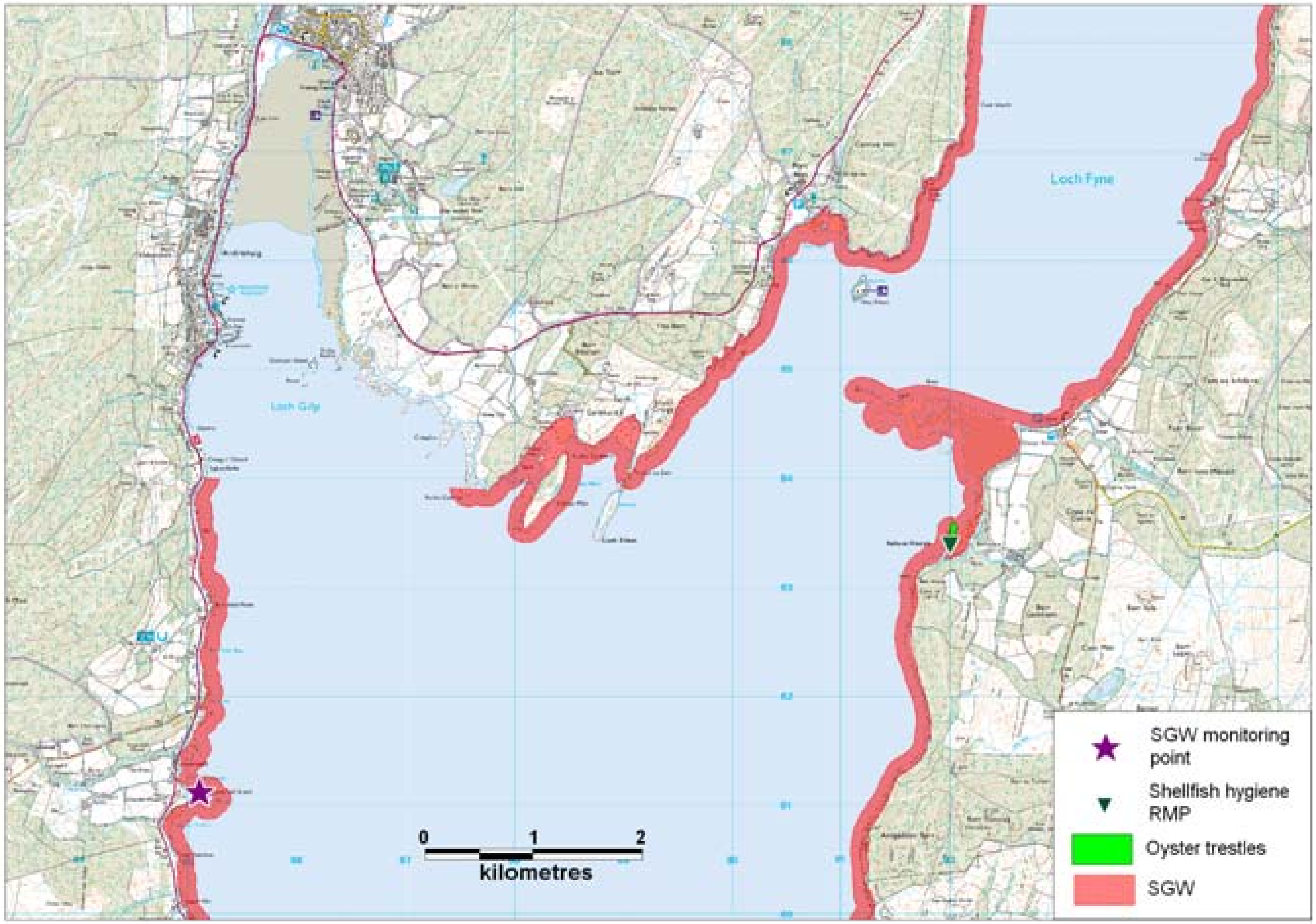


Figure 12.1 Shellfish Growing Water map

13. River Flow

There are no gauging stations on watercourses along the Loch Fyne coastline.

The burns and 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 watercourses were deemed to represent the potentially most significant freshwater inputs into the survey area in the immediate vicinity of the Loch Fyne: Otter Ferry shellfishery. There were rain showers on the day of the survey and it had also rained on the preceding day.

Table 13.1 Stream loadings for Loch Fyne: Otter Ferry

No	Grid Reference	Description	Width (m)	Depth (m)	Flow (m/s)	Flow in m^3/day	*E.coli* (cfu/ 100ml)	Loading (*E.coli* per day)
1	NR 9215 8329	Small stream	0.5	0.05	0.2	493	320	$1.6x10^9$
2	NR 9219 8340	Stream	2.5	0.18	0.083	3230	160[1]	$5.2x10^9$
3	NR 9228 8355	Stream seeping across foreshore	Not measured				160	N/A
4	NR 9325 8465	Kilail Burn	3.5	0.3	0.5	45400	480	$2.2x10^{11}$

Note: [1]Bacteriological sample taken further down the shore in the vicinity of the oyster trestles

Streams 1 and 2 had moderate *E. coli* loadings while Stream 4 had a high *E. coli* loading. Stream 3 could not be measured and sampled due to the nature of the discharge at the shoreline. Streams 1, 2 and 3 all impact directly in the vicinity of the trestles and would be expected to contribute to *E. coli* levels in the oysters. While Kilail Burn had a much higher calculated loading, it is more than 1 km from the fishery and this, together with the nature of the coastline, would limit the potential for this watercourse to significantly affect the water quality at the fishery.

The microbiological loadings from the watercourses would be expected to be lower after periods of dry weather.

Figure 13.1 Map of stream loadings at Otter Ferry

14. Bathymetry and Hydrodynamics

The OS map and Hydrographic Chart for the area are shown in Figures 14.1 and 14.2 respectively.

Figure 14.1 OS map of Otter Ferry

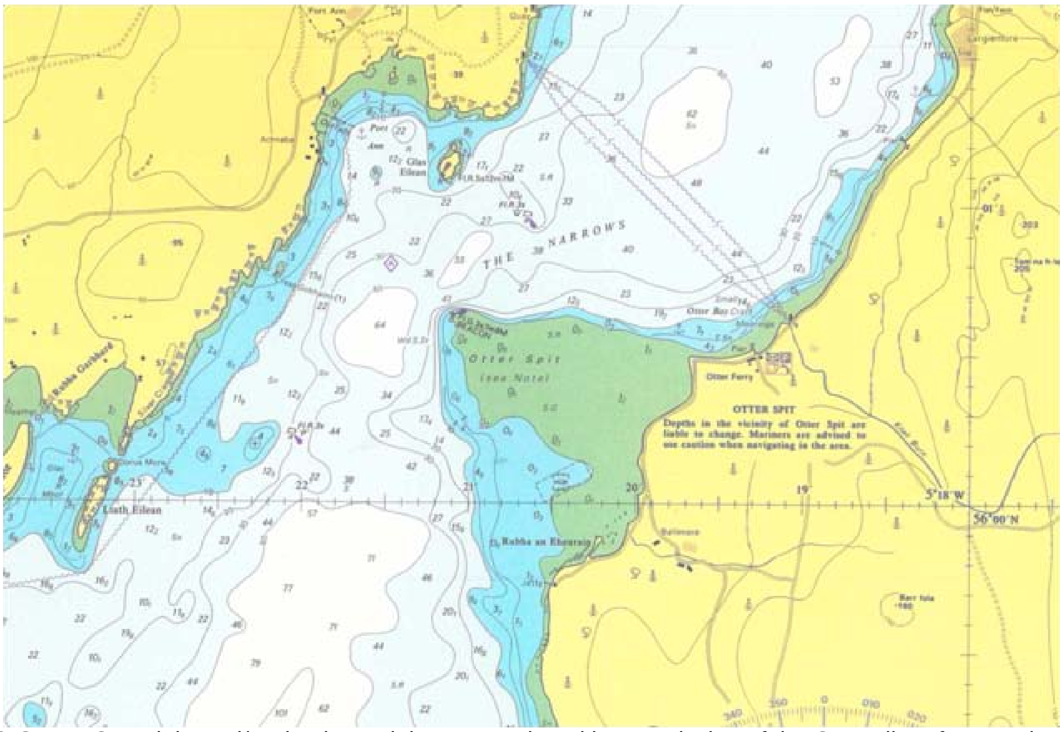


Figure 14.2 Bathymetry at Otter Ferry

Loch Fyne is formed of two main parts (see Figure 1.1). The first, outer part is approximately 20km long, between 4 and 8km wide, ands runs in a north-south direction. The second, inner part is approximately 40 km long, 1 to 2 km wide, and runs roughly south-west to north-east. Otter Ferry lies on the southern shore just inside the inner part. There is a sill in the immediate vicinity of the fishery which runs from the northern side of the loch to otter spit, a large drying area, on the southern side. Immediately to each side of the sill the depths exceed 50 m. However, in the vicinity of the trestles, the seabed is more gently shelving. The trestles themselves are located on the drying area.

14.1 Tidal Curve and Description

The two tidal curves below are for East Loch Tarbert, approximately 16 km SSW of the oyster farm. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 BST on 10/08/10 and the second is for seven days beginning 00.00 BST on 17/08/10. 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.

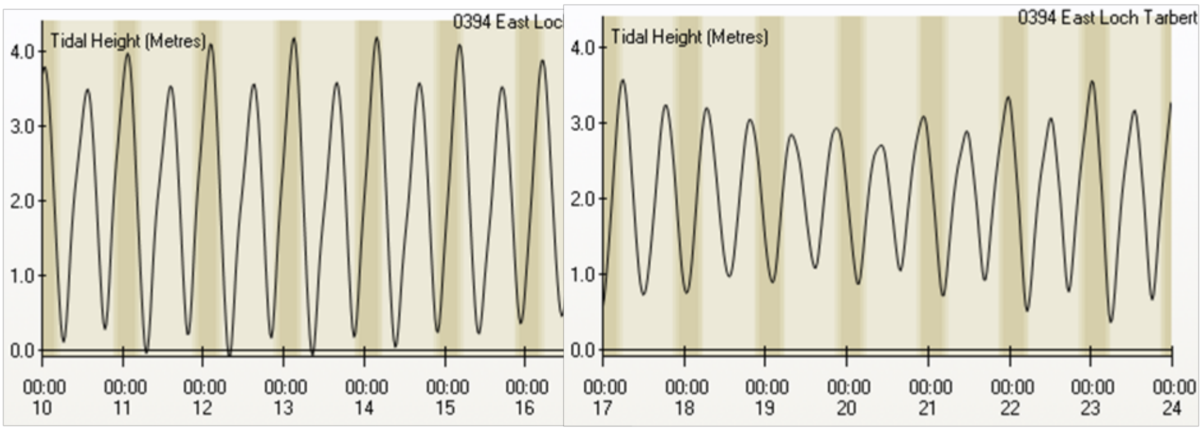


Figure 14.3 Tidal curves for East Loch Tarbert

The following is the summary description for East Loch Tarbert from TotalTide:
0394 East Loch Tarbert is a Secondary Non-Harmonic port.
The tide type is Semi-Diurnal.

HAT	4.2 m
MHWS	3.6 m
MHWN	2.9 m
MSL	2.03 m
MLWN	1.0 m
MLWS	0.3 m
LAT	-0.3 m

Predicted heights are in metres above Chart Datum. The tidal range at spring tide is 3.3 m, and at neap tide 1.9 m, and so tidal ranges in the area are moderate.

14.2 Currents

Tidal stream information was available for a station to the north-west of the fishery. The location of this station, together with the tidal streams for peak flood and ebb tide, are presented in Figures 14.4 and 14.5, and the tidal diamond is presented in Table 14.1. The station is located approximately mid-way between the end of Otter Spit and the opposite shore (see the location of the tidal diamond in Figure 14.2).

Figure 14.4 Spring tidal flows off Otter Ferry

Table 14.1 Tidal streams for station SN040N (56°00.79'N 5°21.47'W) (taken from Totaltide)

Time	Direction	Spring rate (m/s)	Neap rate (m/s)
-06h	023°	0.26	0.15
-05h	038°	0.57	0.36
-04h	043°	0.46	0.26
-03h	041°	0.36	0.21
-02h	038°	0.31	0.21
-01h	035°	0.26	0.15
HW		0.00	0.00
+01h	215°	0.21	0.10
+02h	219°	0.41	0.26
+03h	219°	0.57	0.36
+04h	213°	0.57	0.36
+05h	222°	0.36	0.21
+06h		0.00	0.00

In the vicinity of the station, the currents therefore flow parallel to the shore for much of the tidal cycle. It is likely that this movement will be markedly modified within the area of the fishery, partly due to the presence of the drying area and partly due to the presence of the gravel spit at the north-eastern end. During much of the flood tide, the currents will flow around Otter Spit and so contamination originating south of the fishery will tend to be taken offshore. On the ebb tide, contaminants will flow over the spit until it becomes exposed. However, the bulk of the flow will increasingly be diverted around the spit as the depth decreases.

Edwards and Sharples (1991) give the current speeds at sill 1 as 37 cm/s (i.e. 0.37 m/s). This location equates to the station for which the data is presented above.

SEPA provided current meter data for one location in the vicinity of Otter Ferry. The location is shown in Figure 14.6 and the survey period is given in Table 14.1.

Table 14.2 Current meter survey period

Location	NGR	Survey period
Ardgaddan	NR 9079 8084[1]	28/11/1996 – 13/12/1996

Note: [1]Position estimated from a plan provided to Cefas

Plots of the current direction and speed at this location are shown in Figure 14.7. No wind data was available for comparison. The plots show that the predominant current direction at Ardgaddan lies north-south. The proportion of zero current speed readings increases towards the sea bed. Mean current speeds were between 5 (near-bottom) and 9 (near-surface) cm/s (0.05 to 0.09 m/s; 0.1 to 0.18 knots). Maximum recorded speeds were between 18 (near-bottom) and 28 (near-surface) cm/s (0.18 to 0.28 m/s; 0.36 to 0.56 knots).

At the maximum spring tide speed of 0.57 m/s given for the tidal station, the maximum distance travelled by contaminants over a flood or ebb tide would be more than 8 km, ignoring dilution and dispersion. The distance would be less on neap tides.

Figure 14.5 Current meter location near Otter Ferry

14.3 Conclusions

Given the location of the oyster trestles on the drying area, and the restricted depths outside of this, contaminants from nearby sources will be subject to limited dilution. Contaminants from sources away from the trestles will tend to be diverted around the site at most states of tide due to the presence of Otter Spit. Contamination arising from the shore adjacent to the trestles will be taken across the site as the tide ebbs.

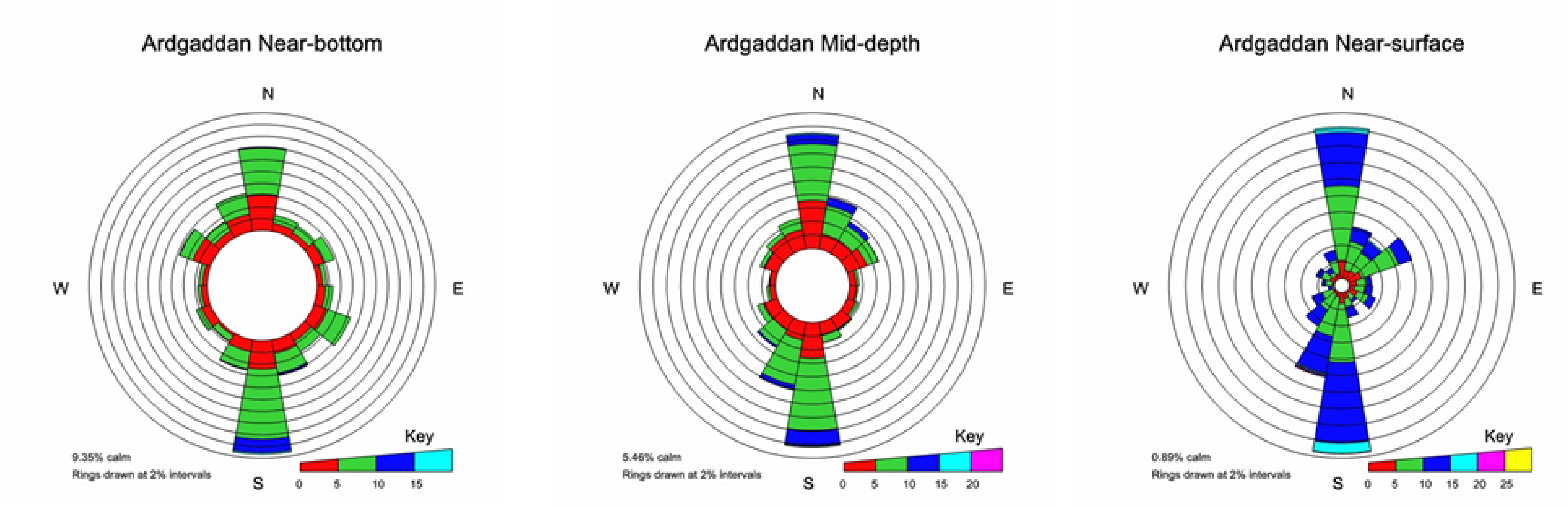


Figure 14.6 Current plots

Currents measured in cm/s. As per convention, currents are plotted against the direction towards 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. The blank areas at the centres of the plots represent the proportion of zero readings (i.e. when no current flow was recorded).

15. Shoreline Survey Overview

The shoreline survey was undertaken on 11 August 2010 under cloudy conditions with showers during the survey and some rain on the previous day.

Pacific oysters are grown on trestles on the intertidal shore adjacent Balliore Estate. Pacific oyster seed is purchased in and placed at the western end of trestles where they are below water for a greater proportion of the tidal cycle. As the oysters grow, they are moved to shallower trestles for hardening off. A few trestles are kept higher on the beach for access during poor tides. Oysters are harvested year-round according to demand and the harvester has depuration facilities north of the fishery at Otter Ferry.

The septic tank discharge from the main house at Ballimore estate discharges via a pipe through the seawall east of the trestles. A sample collected from the discharge from this pipe contained 74000 *E.coli* cfu/100 ml, which which was consistent with a treated sewage discharge (Appendix 5). Further cottages, most occupied permanently, were located along the shore north from the estate house. The harvester reported these are connected to 4-5 septic tanks, two of which were observed. Both had discharge pipes exiting the seaward side of the tanks and leading into the ground at the foreshore. No pipes were found across the shoreline. The total population on the estate was estimated by the harvester to be roughly 80 people.

At Otter Ferry, there was a further septic tank for the public house. Foul water was found discharging across the beach north of the quay, with sewage fungus clearly observable on the shore.

Roughly 1000 sheep are kept on the estate and grazed on fields around the area. They are brought into barns during the winter. Bedding from the barns is scraped up and spread on the fields after the sheep are put back out in spring. A small number of cattle are also kept (<10) further uphill from the estate, though these were not directly observed. Sheep were seen on pasture north of the fishery. All pastures were fenced and no sheep droppings were observed on the shoreline.

Six yachts were seen on moorings north of the spit at Otter Ferry.

Much of the land along the shoreline is wooded and there was some evidence of recent logging activity along the B8000 north of Otter Ferry.

A stream flows through the estate and then splits into a number of channels as it crosses the foreshore at the fishery. A sample was taken where it was found to be flowing past the trestles and this was found to have 160 *E. coli* cfu/100 ml indicating low levels of contamination at the time. The largest watercourse in the area was north of Otter Ferry, and water sample taken from it had 480 *E. coli* cfu/100 ml, indicating moderate levels of faecal contamination. Shellfish samples taken from the north and south sides of the trestles showed similar levels of contamination (130 and 170 *E. coli* MPN/100 g).

Small numbers of ducks and oystercatchers were observed, as well as a few gulls. Large numbers of pheasants were present along the roads on the estate. No other wild animals were seen.

The most significant findings from the shoreline survey are summarised in Figure 15.1.

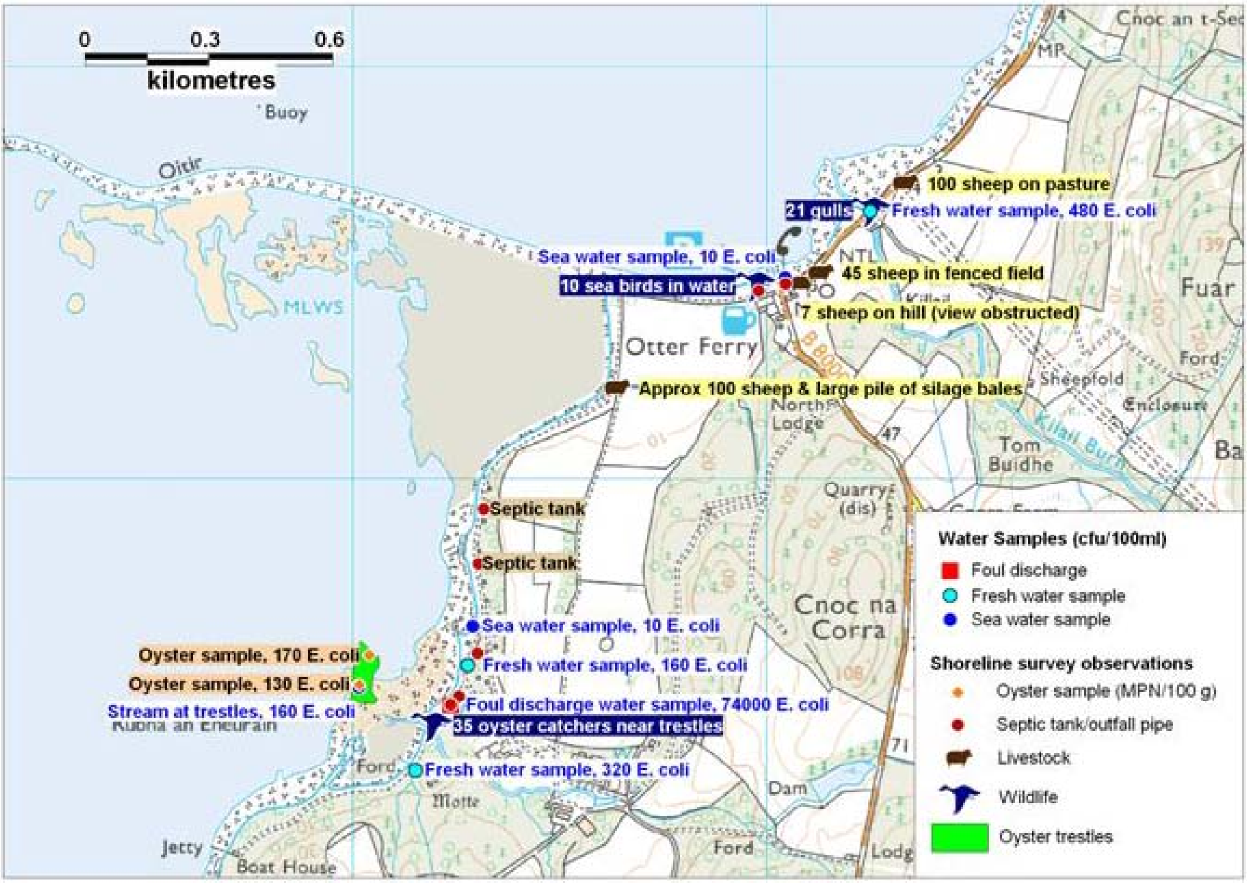


Figure 15.1 Summary of shoreline survey findings for Otter Ferry

16. Overall Assessment

Human sewage impacts

The closest sources of human sewage to the fishery are located on the Ballimore Estate and include the main estate house and cottages lining the road northward along the shore toward Otter Ferry. The full time population of the estate was estimated to be 80 and this could increase by a relatively small number when the holiday accomodation is let.

The septic tank for the main house discharges to the shoreline west of the southern end of the trestles. When sampled during the shoreline survey, the effluent was confirmed to have a substantial faecal content ($7.4x10^4$ *E. coli* cfu/100 ml), which is lower than what would be expected for septic tank effluent (roughly $7x10^6$). This may have been due to dilution with less contaminated washwater or rain, but the cause is not clear. The tank discharges 178 m from the nearest trestle, however the flow observed at the time of survey was very small (10 ml/sec).

The locations of two of the further 4-5 septic tanks thought to be present along the shore north of the estate house were confirmed during the shoreline survey. Discharge pipes were buried under the shore and presumed to discharge below MLWS. A further pipe was identified that was likely to link to a septic tank, though the tank itself was not located. If this is presumed to be discharging to the loch below MLWS west of the pipe, then it could potentially discharge within 100 m of the oyster trestles. The majority of the population on the estate live in cottages served by these tanks, though it is not known whether some discharge to soakaway instead of to the shoreline.

Sewage discharges are also present at Otter Ferry. Although the only discharge consent on file for Otter Ferry relates to trade effluent from the oyster depuration shed, a septic tank was identified near a restaurant and foul water with sewage fungus was seen on the shore north of the quay. The discharge from the depuration centre may also contain *E. coli* and faecal pathogens. A small number of moorings are maintained here, with 6 yachts observed on the day of survey. These would be expected to discharge waste overboard and would affect water quality north of Otter Spit.

The septic tank discharge at Blue Rocks Cottage, on the west shore of Loch Fyne, lies less than 3 km northwest of the oyster trestles. It is a small discharge (PE 46) and as it lies across the loch and a significant depth of water, it is unlikely to significantly affect water quality at Ballimore.

Although no discharge consents were provided for the holiday village at Largiemore, it is of a sufficient size to have a discharge similar to that of Blue Rocks Cottage during the high season in summer. Although further from the fishery than Blue Rocks Cottage, it lies along the east shore and depending on movement of contaminants and weather conditions, could potentially add to background levels of contamination at the fishery.

Sewage discharged from the combined population at Ballimore would be more likely to compromise water quality at the fishery than discharges from further afield. The extent of the impact is highly dependent upon the size and location of each of the discharges. Discharges from the main house tank would impact most highly at the southern end of the trestles. Discharges from the other tanks along the shore would affect the northern end of the trestles most, particularly as stock there is underwater for more of the tidal cycle.

Samples taken quarterly for norovirus testing were positive in the winter quarter for both genogroups tested (Appendix 9), which is consistent with the impact of human sewage on the oyster farm.

Agricultural impacts

Relatively large numbers of sheep (~1000) and a small number of cattle are kept on the Ballimore estate. Animals are housed in barns during winter and grazed on pastures around the estate during the rest of the year. The pasture areas are for the most part separated from the shoreline by areas of woodland and animals are kept fenced. Farmyard waste is likely to impact the fishery via the stream running past the barns on the estate. This stream discharges into the trestles, and when the barns are occupied in winter it is likely to carry significant loadings of faecal waste from runoff of hardstanding areas.

Livestock bedding from the barns in spread on the pastures when the animals are turned out after winter, and runoff from these would increase faecal loadings in local streams. Soils in the area are freely draining, therefore the potential for direct runoff is reduced somewhat. For the most part, streams discharging near the fishery pass through woodland or between field boundaries, thereby reducing the opportunity for direct contamination from livestock accessing watercourses.

In general, sheep numbers would be expected to be highest during the late spring and summer months, when lambs are present and lower after September or October when they are sent to market.

Wildlife impacts

Wildlife impacts to the fishery are most likely to be from birds and deer. A significant number of gulls and wading birds were observed during the shoreline survey, and previous reports of large flocks of eider ducks (>900) at Otter Ferry confirm that the numbers of birds on or near the water in the area can be substantial. Modest numbers of seabirds breed in the area according to Seabird 2000 counts, those most of these nest on offshore islands. Seabirds, wading birds and waterfowl are more likely to directly deposit faecal bacteria to the waters of the fishery. Gulls and wading birds are likely to deposit droppings on the sands in the area as they feed at low tide. However, these impacts are unpredictable in terms of both timing and exact location.

Large numbers of pheasants were seen along roads on the estate, and these are likey to contribute to diffuse loadings to watercourses in the area.

The wooded areas are likely to harbour significant numbers of deer. Though no counts were available, deer are likely to contribute to diffuse loadings to watercourses in the area particularly as these mostly run through wooded areas.

Seasonal variation

A modest increase in human population is likely on the Ballimore estate as holiday accomodation is let out. High season in this case is likely to extend to the autumn hunting seasons as well as the traditional summer holiday months of July and August.

Daily rainfall has tended to be higher from August to January and lower in the intervening months with peak rainfall being higher from July to September and November.

Higher *E. coli* monitoring results generally arose between May and November, peaking in September, although one high result was recorded in January. Results were consistently below 230 *E. coli* MPN/100 g during February to April and in December.

Seasonal variation is likely in human, livestock and wildlife populations in the area with generally higher numbers expected to be present from May to October.

Rivers and streams

Three streams were found to impact most directly on the oyster trestles. All were found to contain relatively low levels of faecal contamination, with *E. coli* concentrations of 160-320 cfu/100 ml. The highest concentration was found in the small stream discharging to the south end of the bay. This stream drains a small area of mostly woodland, though one branch of it appears to originate in a pasture area (based on the OS 1:25000 map). The stream that passes through the estate fans out across the shoreline and through the trestles. A water sample from this flow adjacent to the trestles contained 160 cfu/100 ml.

The Kilail Burn, which discharges at Otter Ferry, is likely to carry faecal contamination from grazing pastures to the north of the fishery and was found to contribute the largest loading of all the streams. However, as Otter Spit lies between this stream and the fishery, it is less likely that this source will significantly impact water quality at the oyster farm. However, it is likely to affect water quality north of Otter Spit, which could affect inlet water to the depuration facility.

Meteorology, hydrology, and movement of contaminants

Tidal flows are generally up and down the loch offshore. Contamination arising from the shoreline adjacent to the fishery is likely to be subject to limited dilution before being carried across the oyster trestles on the outgoing tide.
Water flows across Otter Spit at high tide, which would allow contaminants arising from the vicinity of Otter Ferry to flow across toward the fishery as the tide begins to fall. However, the presence of Otter Spit will cause contaminants from sources further north of the fishery to divert away from the oyster farm at most states of tide. Therefore, sources most local to the fishery are likely to have the greatest impact on water quality there.

Temporal and geographical patterns of sampling results

Higher results were found at the location of trestle established at the sampling point, which is situated higher up the shoreline and farther south than the main block of trestles. These were significantly higher than results reported from a point south of the main embayment at Ballimore. However, no statistically significant difference was found between samples obtained from the monitoring point trestle and the southern end of the main block of trestles. The same number of results exceeded 230 *E. coli* MPN/100 g at both locations, however the highest result obtained for the site came from location the monitoring trestle (5400 *E. coli* MPN/100 g). Likewise, there was very little difference between samples taken at the eastern and western sides of the trestle area.

A deterioration in results since late 2007 was apparent, though this was mostly due to a decrease in the number of low results. No results greater than 230 *E. coli* MPN/100 g were obtained during 2007, during which time the sampling point was located south of the current fishery, outside the embayment at Ballimore.

A statistically significant positive correlation was found between *E. coli* monitoring results and rainfall in the 7 days prior to sampling, though not in the 2 days prior to sampling. The correlation was due to a decrease in the coincidence of low results and higher rainfall values. However, results greater than 1000 E. coli MPN/100 g were recorded at very low rainfall values of <1 mm in the 7 days prior to sampling. Therefore, rainfall was a poor predictor of high results at this site.

Analysis of monitoring results by spring/neap and high/low tidal cycles did not yeild any statistically significant correlations. Most samples were taken at low water springs.

A statistically significant positive correlation between water temperature and *E. coli* monitoring result was found. However, it is not clear whether the higher water temperatures naturally found during the late summer months result in greater update of contaminants by the oysters or whether this merely coincides with other factors.

It should be noted that all sources of contamination to waters immediately north of Otter Spit (including septic tanks, yachts and Kilail Burn) are likely to impair water quality in the immediate vicinity and therefore would be expected to affect inlet water quality at the depuration facility.

Conclusions

Faecal contamination arising from both septic tank discharges and diffuse sources on the shoreline adjacent to the fishery are expected to have the greatest impact on the bacteriological quality of the oysters grown there. Whilst some contamination may reach the fishery from sources further to the north, these are expected to be substantially diluted before reaching the oyster trestles however may contribute to background levels of contamination, particularly during summer.

Comparison of sampling results from points at the RMP and on the fishery showed no statistically significant difference between the two, with the highest result overall occurring at the RMP. However, as the two locations were not sampled on the same dates, it is not clear whether this was purely due to location. Both the RMP location and the southern end of the oyster trestles would be affected by faecal contamination carried via the two streams at the southern end of the embayment and the septic tank discharge from the estate house. Although the northerneastern extent of the trestles may be more impacted by discharges from other septic tanks on the estate, as well as any contaminants carried from Otter Ferry at high tide, the farm practice of placing only juvenile stock at this location and harvesting from trestles further south and in shallower water will limit the potential risk should that location be more contaminated.

17. Recommendations

Production area

It is recommended that the production area boundaries be amended to the area bounded by lines drawn between NR 9100 8400 to NR 9231 8400 to NR 9100 8300 to NR 9167 8300 and between NR 9201 8337 to NR 9225 8350 extending to MHWS. These boundaries exclude areas nearer significant sources of faecal contamination. It is specifically curtailed at the southeastern boundary to exclude areas nearest the mouths of the two streams south of the oyster trestles and the discharge from the estate house septic tank.

RMP

The currently established monitoring point at NR 9199 8340 represents the area of highest historical monitoring results and lies near the same sources of contamination as the oyster farm. It is therefore recommended that this be retained as the RMP for the production area.

Frequency

Given the seasonal variation in both classification and sampling results observed to date, it is recommended that monthly monitoring be maintained.

Tolerance

As a fixed sampling trestle is situated at the RMP location, a 10 m tolerance is recommended to allow for variation in GPS readings.

Locations of the recommended production area boundaries and RMP relative to the recorded fishery are shown mapped in Figure 17.1.

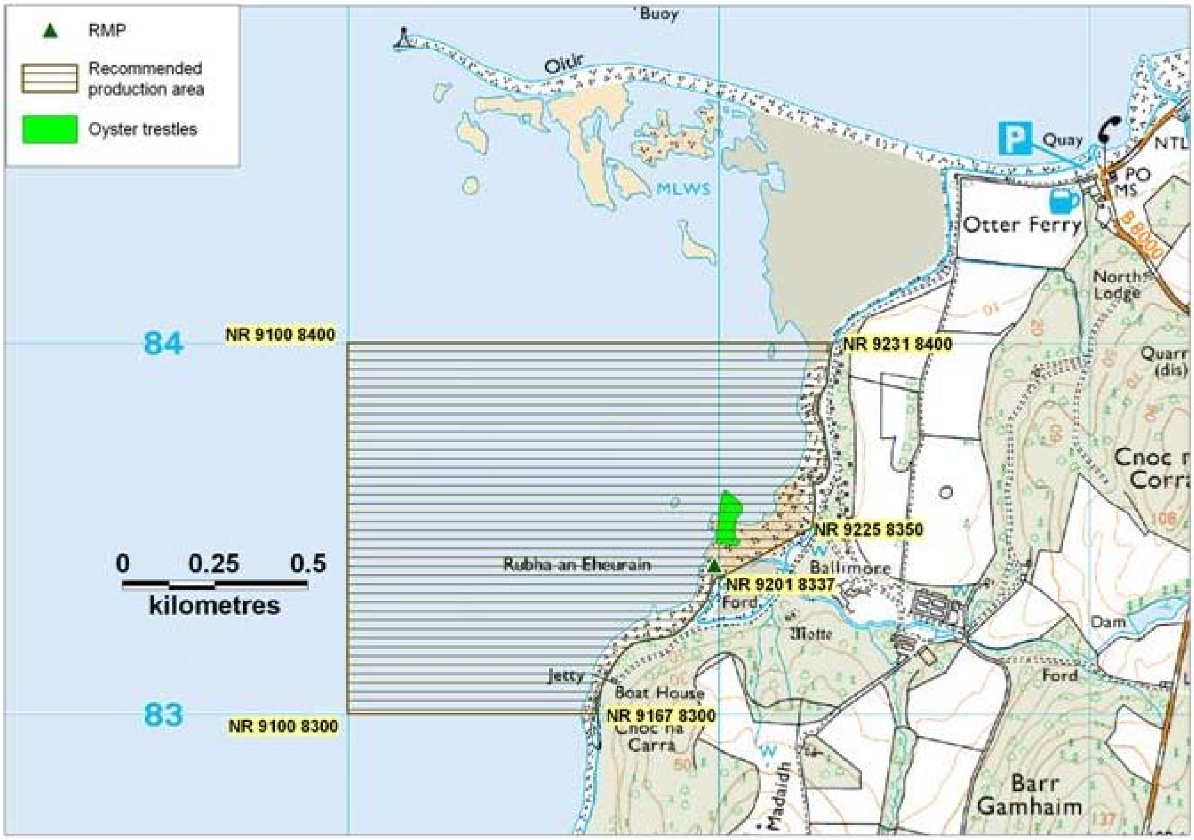


Figure 17.1 Map of recommendations at Loch Fyne: Otter Ferry

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9. **Norovirus Testing Summary**

Sampling Plan for Loch Fyne: Otter Ferry

PRODUCTION AREA	Loch Fyne: Otter Ferry
SITE NAME	Ballimore
SIN	AB 151 039
SPECIES	Pacific oyster
TYPE OF FISHERY	Trestle aquaculture
NGR OF RMP	NR 9199 8340
EAST	191990
NORTH	683400
TOLERANCE (M)	10
DEPTH (M)	not applicable
METHOD OF SAMPLING	Hand
FREQUENCY OF SAMPLING	Monthly
LOCAL AUTHORITY	Argyll & Bute Council
AUTHORISED SAMPLER(S)	Christine McLachlan William MacQuarrie Ewan McDougall Donald Campbell
LOCAL AUTHORITY LIAISON OFFICER	Christine McLachlan

Table of Proposed Boundaries and RMPs

PRODUCTION AREA	**Loch Fyne: Otter Ferry**
SPECIES	**Pacific oyster**
SIN	**AB 151 039**
EXISTING BOUNDARY	**Area bounded by lines drawn between NR 9100 8400 and NR 9231 8400 and NR 9100 8300 and NR 9167 8300, extending to MHWS**
EXISTING RMP	**NR 920 834**
RECOMMENDED BOUNDARY	**Area bounded by lines drawn between NR 9100 8400 to NR 9231 8400 to NR 9100 8300 to NR 9167 8300 and between NR 9201 8337 to NR 9225 8350 extending to MHWS**
RECOMMENDED RMP	**NR 9199 8340**
COMMENTS	Exclude areas nearest mouths of two streams and septic tank discharge, restate RMP to 10 m accuracy.

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 x 10^4 CFU (colony forming units) *E. coli* per gram dry weight of faeces (Lisle *et al* 2004).

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

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

Cetaceans

As mammals, whales and dolphins would be expected to have resident populations of *E. coli* and other faecal indicator bacteria in the gut. Little is known about the concentration of indicator bacteria in whale or dolphin faeces, in large part because the animals are widely dispersed and sample collection difficult.

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

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

Birds

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

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

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

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

Deer

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

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

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

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

Other

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

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

References:

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

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

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

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

Tables of Typical Faecal Bacteria Concentrations

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

Indicator organism	Base-flow conditions				High-flow conditions			
Treatment levels and specific types: Faecal coliforms	n^c	Geometric mean	Lower 95% CI	Upper 95% CI	n^c	Geometric mean	Lower 95% CI	Upper 95% CI
Untreated	252	$1.7 \times 10^{7*}$ (+)	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		

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

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

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

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

Statistical Data

All *E. coli* data was log transformed prior to statistical tests.

Section 11.3 One way ANOVA comparison of results by sampling for which sampling location was recorded by GPS by cluster

```
Source   DF      SS     MS     F      P
Cluster   2   2.467  1.234  3.73  0.038
Error    25   8.275  0.331
Total    27  10.742

S = 0.5753   R-Sq = 22.97%   R-Sq(adj) = 16.81%


                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level    N    Mean   StDev  ------+---------+---------+---------+---
1       10  1.7450  0.6250  (---------*--------)
2        9  2.4523  0.5685                   (---------*---------)
3        9  2.2065  0.5212             (---------*---------)
                           ------+---------+---------+---------+---
                                1.60      2.00      2.40      2.80

Pooled StDev = 0.5753


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

Individual confidence level = 98.02%


Cluster = 1 subtracted from:

Cluster    Lower  Center   Upper  -----+---------+---------+---------+----
2         0.0494  0.7073  1.3653                  (----------*----------)
3        -0.1965  0.4614  1.1194              (----------*----------)
                                  -----+---------+---------+---------+----
                                     -0.60      0.00      0.60      1.20


Cluster = 2 subtracted from:

Cluster    Lower   Center   Upper  -----+---------+---------+---------+----
3        -0.9209  -0.2459  0.4292  (----------*----------)
                                   -----+---------+---------+---------+----
                                      -0.60      0.00      0.60      1.20
```

Section 11.5 One way ANOVA comparison of *E. coli* results by season

```
Source  DF      SS     MS     F      P
Season   3   8.274  2.758  7.92  0.000
Error   84  29.248  0.348
Total   87  37.522

S = 0.5901   R-Sq = 22.05%   R-Sq(adj) = 19.27%


                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level   N    Mean   StDev  ---------+---------+---------+---------+
```

```
1      21  1.7954  0.4905  (--------*-------)
2      22  2.3205  0.6634                   (-------*--------)
3      22  2.4527  0.6819                       (--------*-------)
4      23  1.7676  0.4969  (-------*-------)
                           ---------+---------+---------+---------+
                                 1.80      2.10      2.40      2.70

Pooled StDev = 0.5901


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

Individual confidence level = 98.97%


Season = 1 subtracted from:

Season    Lower   Center   Upper  ---------+---------+---------+---------+
2        0.0528   0.5251  0.9974                    (-------*-------)
3        0.1851   0.6574  1.1296                      (-------*-------)
4       -0.4950  -0.0278  0.4394           (-------*------)
                                  ---------+---------+---------+---------+
                                        -0.60      0.00      0.60      1.20


Season = 2 subtracted from:

Season    Lower   Center    Upper  ---------+---------+---------+---------+
3       -0.3345   0.1323   0.5990               (-------*-------)
4       -1.0145  -0.5529  -0.0913    (-------*------)
                                   ---------+---------+---------+---------+
                                         -0.60      0.00      0.60      1.20


Season = 3 subtracted from:

Season    Lower   Center    Upper  ---------+---------+---------+---------+
4       -1.1468  -0.6852  -0.2235  (-------*------)
                                   ---------+---------+---------+---------+
                                         -0.60      0.00      0.60      1.20
```

Section 11.6.1 Spearman's rank correlation for *E. coli* result and 2 day rainfall

```
Pearson correlation of ranked 2 day rain and ranked e coli for rain = 0.165
```
n=79, p>0.05

Section 11.6.1 Spearman's rank correlation for *E. coli* result and 7 day rainfall

```
Pearson correlation of ranked 7 day rain and ranked e coli for rain = 0.199
n=79, p<0.05
```

Section 11.6.2 Circular linear correlation for *E. coli* result and tidal state on the spring/neap cycle

CIRCULAR-LINEAR CORRELATION
Analysis begun: 21 May 2010 11:38:37

Variables (& observations)	r	p
Angles & Linear (88)	0.168	0.092

Section 11.6.2 Circular linear correlation for *E. coli* result and tidal state on the high/low cycle

CIRCULAR-LINEAR CORRELATION
Analysis begun: 11 June 2010 14:24:47

Variables (& observations)	r	p
Angles & Linear (88)	0.156	0.125

Section 11.6.3 Spearman's rank correlation for *E. coli* result and water temperature

```
Pearson correlation of ranked temperature and ranked E coli for temperature
=
     0.478
```
n=50, p<0.0005

Section 11.6.5 Spearman's rank correlation for *E. coli* result and salinity

```
Pearson correlation of ranked salinity and ranked e coli for salinity =
0.053
```
n=78, p>0.25

Section 12 ANOVA comparison of SEPA results by quarter

```
Source   DF      SS     MS     F      P
Quarter   3   4.448  1.483  1.69  0.193
Error    26  22.758  0.875
Total    29  27.206

S = 0.9356   R-Sq = 16.35%   R-Sq(adj) = 6.70%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level  N    Mean   StDev  -----+---------+---------+---------+----
Q1     8  2.0810  0.6292       (---------*--------)
Q2     6  1.8544  0.8435  (----------*----------)
Q3     9  2.8322  1.2372                 (--------*---------)
Q4     7  2.5639  0.8349            (----------*---------)
                          -----+---------+---------+---------+----
                             1.40      2.10      2.80      3.50

Pooled StDev = 0.9356
```

Hydrographic Methods

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

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

<u>Background processes</u>

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

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

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

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

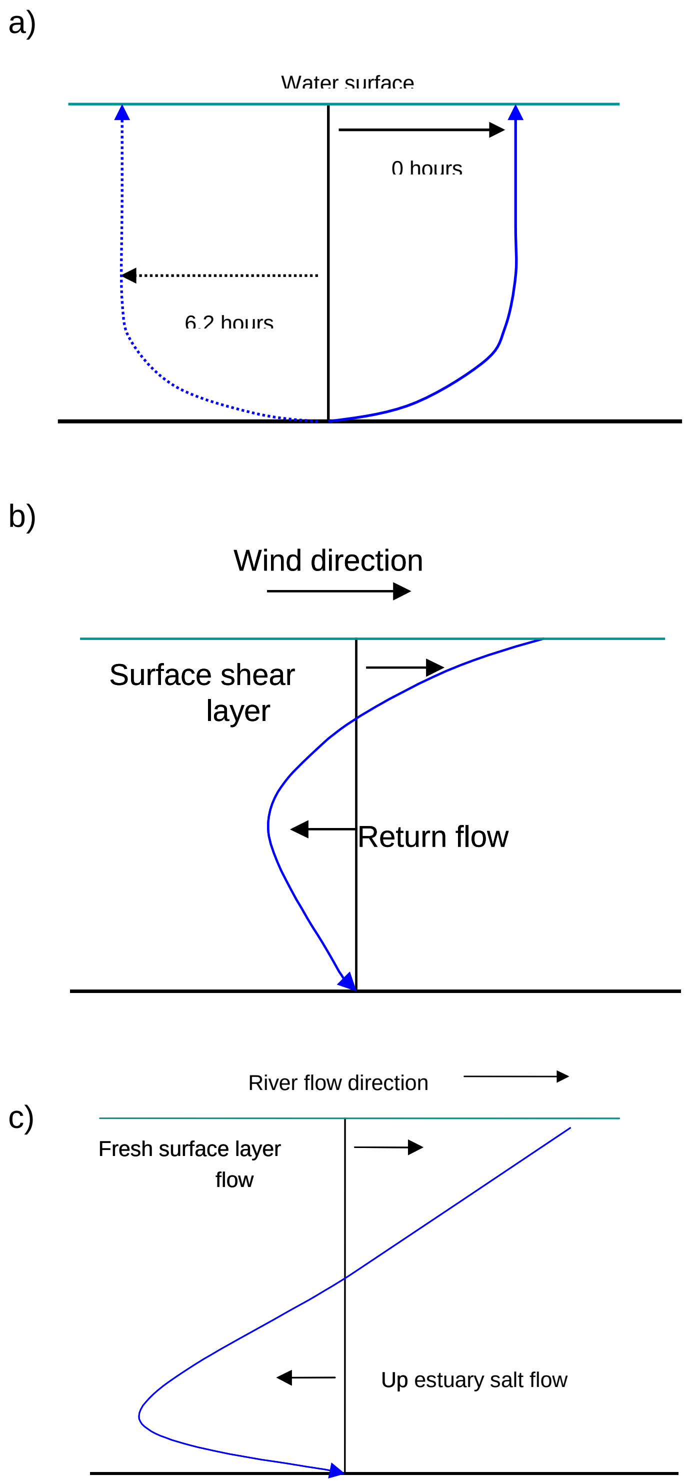

Figure 1. Typical vertical profiles for water currents. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction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

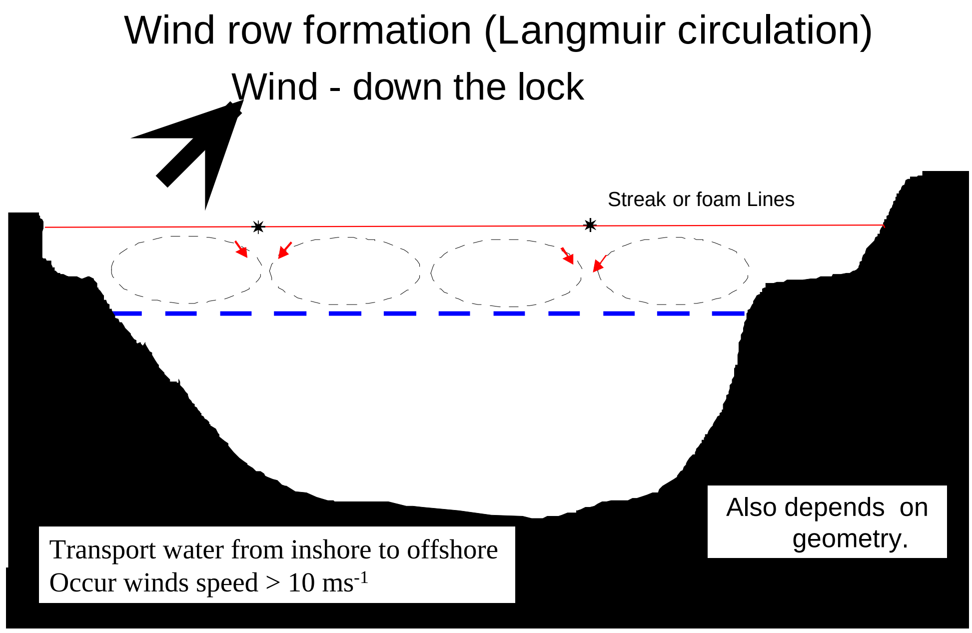

Figure 2. Schematic of wind driven ‘wind row’ currents. The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

<u>Non-modelling Assessment</u>

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

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

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

The catalogue of Scottish Sea Loch produced by the SMBA is used to quantify sills, volume fluxes and likely flow velocities. Because the flow is so constrained by the rapidly varying bathymetry, care has to be used in the extrapolation of direct measurements of current flow. Mean flow velocities can be estimated at the sills by using estimates of the sill area and the volume change through a tidal cycle. This in turn can be used to estimate the maximum distance travelled in a tidal cycle in the sill area. Away from the sill area, tidal velocities are general low and transport events are dominated by wind or density effects. Sea Lochs generally have a surface layer of fresher water; the extent of this depends on freshwater input, sill depth and quantity of mixing.

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

References

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

Glossary

The following technical terms may appear in the hydrographic assessment.

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

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

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

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

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

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

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

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

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

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

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

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

Shoreline Survey Report

Prod. area:	Loch Fyne: Otter Ferry
Site name:	Ballimore (AB 151 039 13)
Species:	Pacific oyster
Harvester:	Tristan Van Lynden
Local Authority:	Argyll & Bute
Status:	Existing
Date Surveyed:	10-12 August 2010
Surveyed by:	Michelle Price-Hayward, William McQuarrie
Existing RMP:	NR 920 834
Area Surveyed:	Otter Ferry to south of the production area boundary

Weather observations

Cloudy, rain showers. 16ºC, winds calm early, increasing to NW F4 later in morning. Rain previous day.

Fishery

Pacific oysters are grown on trestles on the intertidal zone as shown in Figure 1. Pacific oyster seed is purchased in and is placed at the western end of trestles where they are below water for a greater proportion of the tidal cycle. As the animals grow, they are moved to shallower trestles for hardening off. A few trestles are kept higher on the beach for access during poor tides.

Oysters are harvested year-round according to demand. The harvester has depuration facilities north of the fishery at Otter Ferry.

Sewage/Faecal Sources

Septic tank discharge from the main house at Ballimore estate discharges via a pipe through the seawall east of the trestles. Further cottages in year-round occupation along the shore north of the trestles are connected to 4-5 septic tanks. Two of these were located during the survey. Both had discharge pipes exiting the seaward side of the tanks that led into the ground at the foreshore. No pipes were found on the shoreline. The total population on the estate was estimated to be roughly 80 people.

Further sewage discharges were observed at Otter Ferry. There was a septic tank for the public house and foul water was found discharging across the beach north of the quay, with sewage fungus clearly observable on the shore.

The harvester reported that roughly 1000 sheep were kept on the estate and that these were grazed on fields around the area and brought into barns during the winter. Bedding from the barns is then scraped up and spread on the fields after the sheep are put back out in spring. A small number of cattle are also kept (<10) further uphill from the estate, though these were not directly observed. Sheep were seen on pasture north of the fishery and would normally be moved around the pastures to graze. All pastures were fenced and no sheep droppings were observed on the shoreline.

Seasonal Population
A small number of holiday homes were present amongst the cottages on the estate. There are a small number of moorings north of the spit at Otter Ferry for visiting yachts, which were in use at the time of survey. Access to the area is via a lengthy single track road, and there is little in the way of accommodation in the immediate vicinity of the fishery.

Boats/Shipping
A small number of yachts (6) and a few dinghies were observed at Otter Ferry during the survey. No other boats were observed.

Land Use
Much of the land along the shoreline is wooded. Areas of pasture were present north of the estate and along the road north of Otter Ferry. These were used for grazing sheep. There was some evidence of recent logging activity along the B8000 north of Otter Ferry.

Watercourses
A stream was found to flow through the estate and then split into a number of channels as it crossed the foreshore at the fishery. Further small streams were present along the shore, though these were not flowing sufficiently to sample or measure accurately. The largest watercourse in the area was north of Otter Ferry. This burn is tidal for the lower portion of its course, with seaweed growing on both banks.

Wildlife/Birds
Pheasants were observed along the tracks on the estate. Small numbers of ducks and oystercatchers were observed, as well as a few gulls. A fox dropping was found on the shoreline. No other wild animals were seen.

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

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

Figure 1. Map of shoreline survey observations

Table 1. Shoreline Observations

No.	Date	Time (GMT)	NGR	East	North	Associated photograph	Description
1	11/08/2010	06:28:44	NR 92018 83495	192018	683495		Stream crossing shoreline
2	11/08/2010	06:31:10	NR 92016 83501	192016	683501	Figure 4	Sample LFOF10-001, oyster sample plus norovirus sample
3	11/08/2010	06:40:43	NR 92014 83497	192014	683497		Water sample (22 ppt) LFOF10-003
4	11/08/2010	06:46:43	NR 92040 83572	192040	683572		LFOF10-002, oyster sample
5	11/08/2010	06:52:58	NR 92000 83441	192000	683441		Stream crossing shoreline
6	11/08/2010	06:54:05	NR 91998 83402	191998	683402		RMP
7	11/08/2010	07:02:48	NR 92117 83523	192117	683523		Stream crossing shoreline
8	11/08/2010	07:56:37	NR 92256 83473	192256	683473	Figure 5	Pipe exiting wall, water seeping down wall, insufficient flow for sample
9	11/08/2010	08:00:01	NR 92237 83452	192237	683452	Figure 6	Pipe, 15cm diameter, flowing 100ml=10sec. Water sample LFOF10-004, foul discharge from estate house
10	11/08/2010	08:07:07	NR 92191 83400	192191	683400		Stream, 0.18mx2.5m, flow 2m=24sec. Sample taken at trestles (see 3 above). 35 oyster catchers near trestles
11	11/08/2010	08:15:39	NR 92151 83293	192151	683293		Small stream, 0.05mx.5m flow 1m=5sec. Sample LFOF10-005
12	11/08/2010	08:25:03	NR 91994 83254	191994	683254	Figure 7	Small stream, flow too shallow to measure or sample accurately
13	11/08/2010	08:30:20	NR 91909 83222	191909	683222		Outfall pipe - no evidence of recent use, nothing apparent on shore above pipe
14	11/08/2010	08:37:18	NR 91724 83136	191724	683136		Fox dropping on shore
15	11/08/2010	08:38:37	NR 91716 83095	191716	683095		Boat house
16	11/08/2010	08:45:44	NR 91688 82915	191688	682915		Southern extent of shoreline walk
17	11/08/2010	09:06:00	NR 92265 83486	192265	683486		2 yachts observed passing light at end of Otter Spit
18	11/08/2010	09:09:59	NR 92277 83548	192277	683548		Stream seeping across rocks and foreshore. Water sample LF10-006
19	11/08/2010	09:20:11	NR 92301 83577	192301	683577		Possible septic pipe running across ditch toward shore. No outlet found on shore side
20	11/08/2010	09:23:19	NR 92301 83636	192301	683636		Stream, very shallow across shingle. Algae on rocks, faint odour
21	11/08/2010	09:29:51	NR 92289 83644	192289	683644		Water sample LFOF10-007, seawater offshore of stream
22	11/08/2010	09:32:53	NR 92304 83695	192304	683695		Water seep across shoreline, algae
23	11/08/2010	09:39:56	NR 92304 83795	192304	683795	Figure 8,9	Septic tank with outlet pipe next to tree. End of pipe disappears underground
24	11/08/2010	09:46:26	NR 92310 83893	192310	683893		House. Corrugated drainage pipe (dry) visible to south
25	11/08/2010	09:47:53	NR 92316 83927	192316	683927	Figure 10,11	Septic tank with discharge pipe angling down bank and then under shore. Presumed vent pipe angled upward
26	11/08/2010	09:50:34	NR 92329 83974	192329	683974		House
27	11/08/2010	09:56:42	NR 92640 84218	192640	684218		Dry stream bed, field with roughly 100 sheep and large pile of silage bales
28	11/08/2010	10:05:50	NR 92649 84451	192649	684451		Old boathouse at Otter Spit, corner of pasture (no sheep on at the time)
29	11/08/2010	10:12:39	NR 92973 84468	192973	684468	Figure 12	10 ducks floating near end of pontoon, 3 boats on mooring (6 photographed earlier in day)

No.	Date	Time (GMT)	NGR	East	North	Associated photograph	Description
30	11/08/2010	10:13:42	NR 92981 84457	192981	684457		Septic tank. Oystercatcher Restaurant.
31	11/08/2010	10:15:50	NR 93047 84474	193047	684474	Figure 13	Puddle on shore, smells of septic waste. Sewage fungus growth on shore.
32	11/08/2010	10:18:20	NR 93045 84490	193045	684490		Water sample LFOF10-008
33	11/08/2010	10:22:12	NR 93089 84472	193089	684472		Home, sheep on hill behind. Seven visible but view obstructed.
34	11/08/2010	10:23:37	NR 93131 84498	193131	684498		45 sheep in fenced field
35	11/08/2010	10:28:52	NR 93251 84650	193251	684650		21 gulls. Burn, 0.3mx3.5m, flow 2m=4sec. Water sample LFOF10-009
36	11/08/2010	12:26:39	NR 93280 84582	193280	684582		Stream at Otter Ferry, 0.2mx5m, flow 0.17m/s.
37	11/08/2010	12:41:12	NR 92703 83193	192703	683193		Stream at farm, 0.08mx2.5m, flow 0.102m/s
38	11/08/2010	13:07:02	NR 93336 84716	193336	684716		Power substation with farm and pasture behind. >100 sheep on pasture
39	11/08/2010	13:09:48	NR 93658 85057	193658	685057		North end of pasture area
40	11/08/2010	13:11:12	NR 93797 85406	193797	685406		Recently logged hillside

Photographs referenced in the table can be found attached as Figures 4-13.

Sampling

Water and shellfish samples were collected at sites marked on the map. Where indicated in Table 1, salinity was recorded in the field using a refractometer. Samples were transferred to a Biotherm 25 box with ice packs and shipped to Glasgow Scientific Services on 11 August for *E. coli* analysis. Samples were received by the laboratory on 13 August. The sample temperature on arrival was 7.5C, which was within the recommended temperature range of 2-8C. The National Reference Laboratory (NRL) undertook a study on the effect of temperature and time of storage on levels of *E. coli* in shellfish and found no significant effect with up to 48 hours' storage at temperatures $\leq$10ºC. These results have been included in Tables 2 and 3.

Seawater samples were tested for salinity by the laboratory and results reported in mg Cloride per litre. These results have been converted to parts per thousand (ppt), and are shown in Table 2.

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (cfu/100ml)	Salinity (ppt)
1	11/08/2010	LFOF10-003	NR 92014 83497	Brackish	160	22
2	11/08/2010	LFOF10-004	NR 92237 83452	Foul discharge	74000	
3	11/08/2010	LFOF10-005	NR 92151 83293	Freshwater	320	
4	11/08/2010	LFOF10-006	NR 92277 83548	Freshwater	160	
5	11/08/2010	LFOF10-007	NR 92289 83644	Seawater	10	29
6	11/08/2010	LFOF10-008	NR 93045 84490	Seawater	10	35
7	11/08/2010	LFOF10-009	NR 93251 84650	Freshwater	480	

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (MPN/100g)
1	11/08/2010	LFOF10-001	NR 92016 83501	Pacific oyster	130
2	11/08/2010	LFOF10-002	NR 92040 83572	Pacific oyster	170

Figure 2. Water sample results map

Figure 3. Shellfish sample results map

Photographs

Figure 4. Oyster farm at Otter Ferry

Figure 5. Drainage pipe in seawall

Figure 6. Discharge pipe

Figure 7. Small stream

Figure 8. Septic tank with outlet pipe

Figure 9. Discharge pipe for tank above

Figure 10. Septic tank 2

Figure 11. Discharge pipe for tank 2

Figure 12. Yachts moored at Otter Ferry.

Figure 13. Sewage fungus in discharge at shoreline

Norovirus Testing Summary

Loch Fyne: Otter Ferry

Oyster samples taken from the oyster farm at Ballimore were submitted for Norovirus analysis quarterly from August 2010. The result for the May 2011 sample was not yet available at the time of reporting.

Results are tabulated below.

Ref No.	Date collected	NGR	GI	GII
10/366	11/08/2010	NR 9202 8350	Not detected	Positive-lod
10/506	09/11/2010	NR 9200 8340	Positive-lod	Positive
11/388	22/02/2011	NR 9200 8344	Positive	Positive
11/1088	03/05/2011	NR 9200 8340	Positive-lod	Not detected