Scottish Sanitary Survey Project

Sanitary Survey Report

Seil Point

AB 245

May 2008

Cefas

FOOD STANDARDS AGENCY SCOTLAND

Buidheann Inbhe-Bìdhe an Alba

Final Report Distribution – Seil Point

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

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

Table of Contents

Acknowledgements

We are thankful to the following persons and agencies who provided assistance and information used in the following report.

Argyll & Bute Council
Christine McLachlan
SEPA Registry Office Dingwall
Scottish Water
Dr. Alan Lilly, Macaulay Land Research Institute

1. General description

Seil Point Ardencaple is located in the Firth of Lorne. The 1.7km long bay faces north with a maximum water depth of 4 m at LAT (lowest astronomical tide).

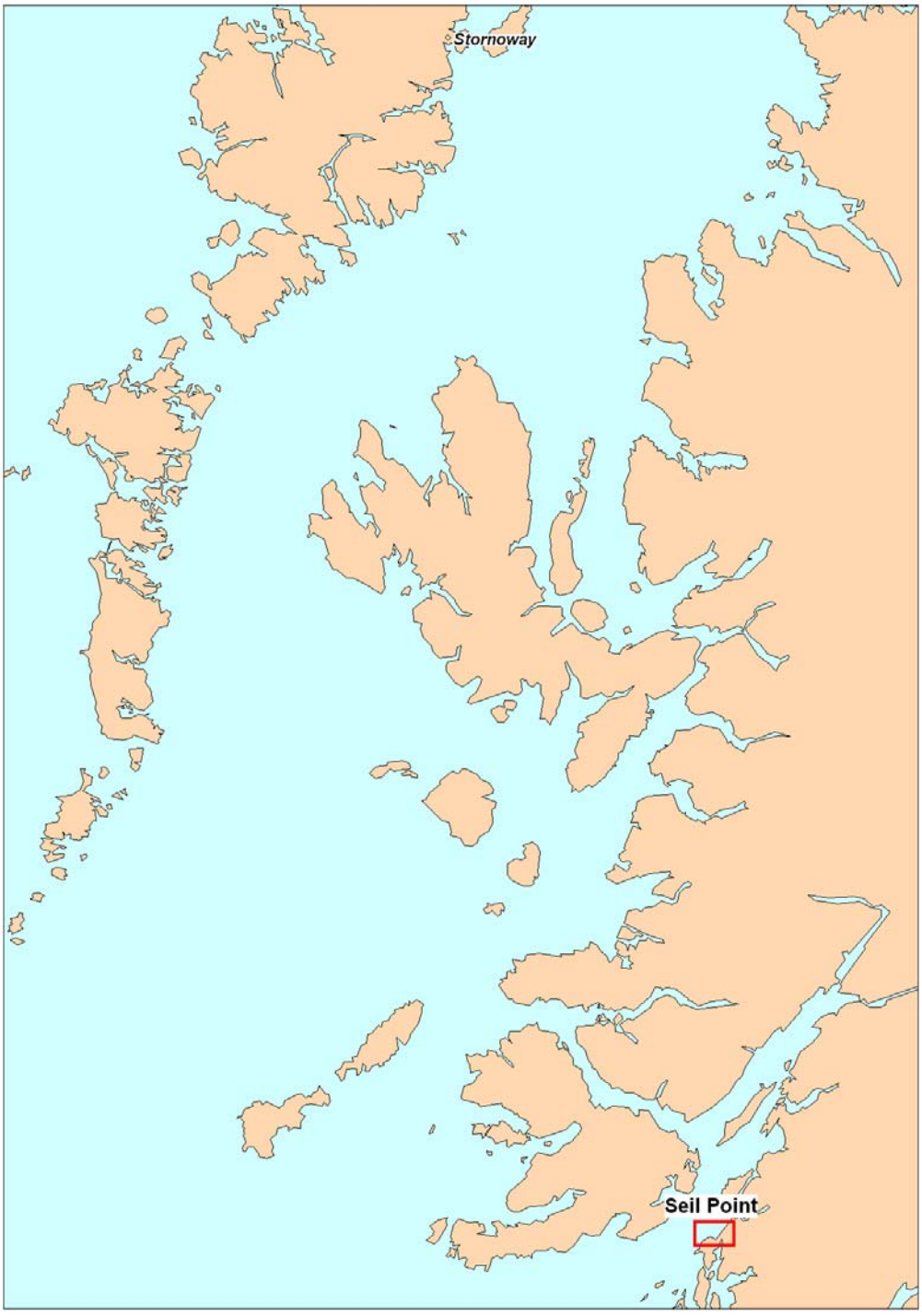

Figure 1.1 Location map for Seil Point

2. Fishery

The fishery at Seil Point is comprised of two trestle grown pacific oyster sites as listed in Table 2.1. Figure 2.1 shows the relative positions of the oyster farms, SEPA designated shellfish growing waters, Food Standards Agency Scotland designated Production Area and the seabed lease areas. The sites are named after the producers. The area of trestles to the west forms part of the Ardencaple: Cyster site. The area of trestles to the east consists of the rest of the Ardencaple: Cyster site on its western half, and the Ardencaple: Cadzow site on its eastern half.

Table 2.1 Seil Point shellfish farms

Site	SIN	Species
Ardencaple - Cyster	AB 245 070 13	Pacific Oysters
Ardencaple - Cadzow	AB 245 069 13	Pacific Oysters

The current production area boundaries are given as the area inside of a line drawn between NM 7644 2033 (Rubha Garbh Airde) and NM 7868 2074 (Eilean nam Beathach). The RMP for the production area is currently located at the Ardencaple Cyster site and lies both within the shellfish farm and seabed lease area. The reported grid reference is NM 772 194.

Both Ardencaple Cyster and Ardencaple Cadzow, farm trestle grown oysters. Stock of a range of sizes was observed, including some of market size. Harvesting is year round, but dependant on weather. Small seed is used (0.07g) and as a consequence take 4 years to grow to a market size.

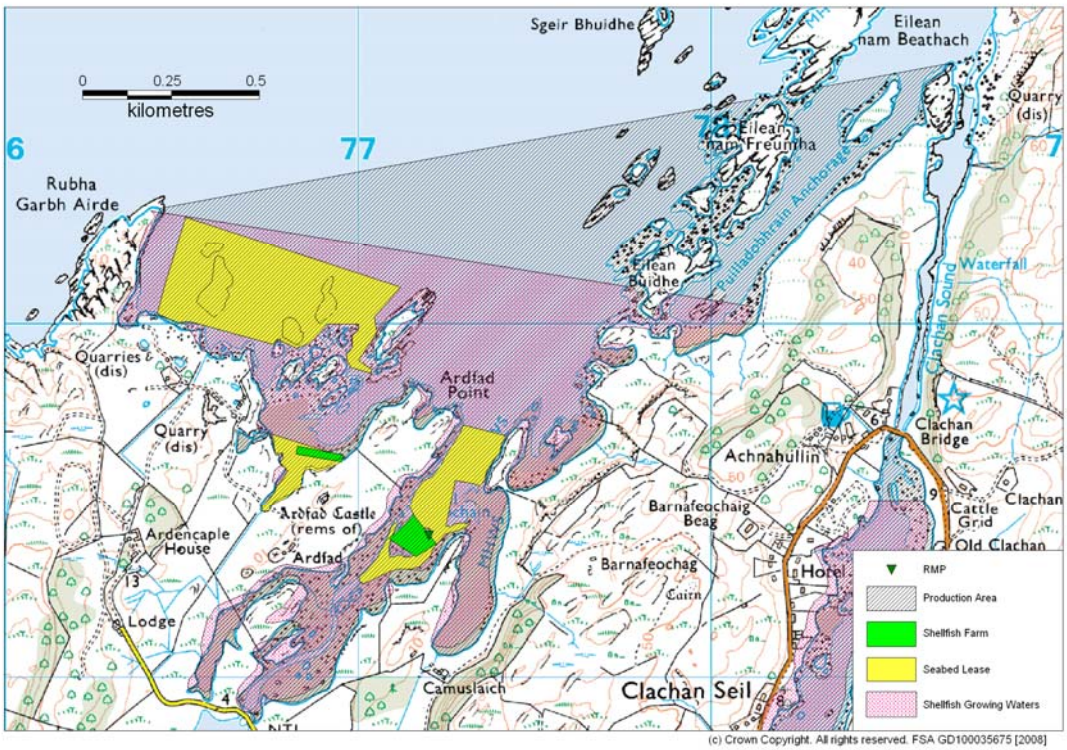

Figure 2.1 Seil Point Fishery

3. Human population

The figure below shows information obtained from the General Register Office for Scotland on the population within the census output in the vicinity of Seil Point.

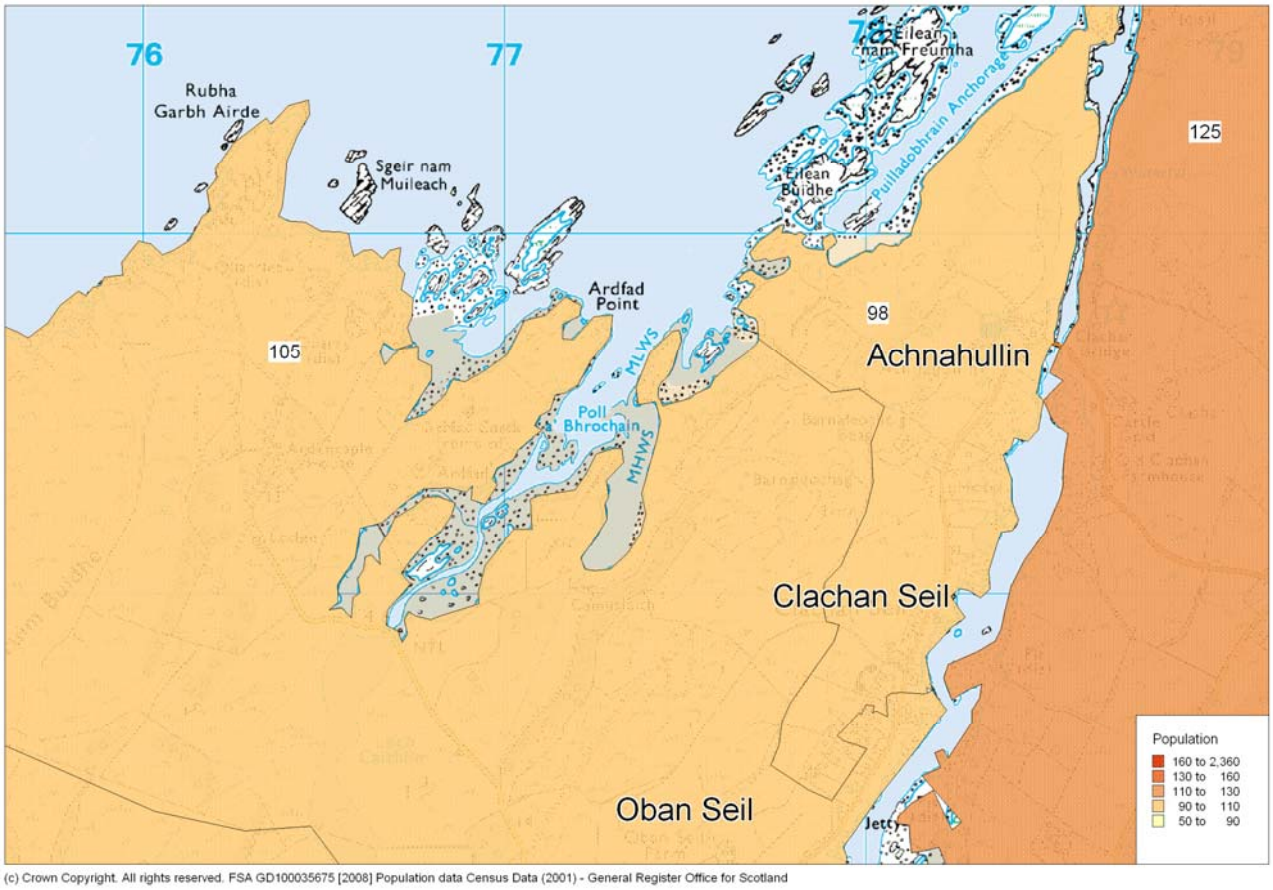

Figure 3.1 Population map for Seil Point

The population for the three census output areas bordering immediately on Seil Point are:

60QD000079	105
60QD000080	98
60QD000081	125

The settlements at Seil Point are concentrated in the central mainland area, covering the census output areas of 60QD000079 and 60QD000080. The settlements include Oban Seil, Clachan Seil and Achnahullin. As these settlements are not located on the coastline that is directly next to the shellfish farm, it is unlikely that there would be any associated faecal pollution from human sources in this area.

4. Sewage Discharges

Community septic tanks and sewage discharges were identified by Scottish Water for the area around Seil Point. They are detailed in Table 4.1.

Table 4.1 Discharges identified by Scottish Water

NGR	Discharge name	Discharge Type	Level of Treatment	Consented design PE
NM 7830 1900	Clachan Seil	Continuous	Septic tank	Not stated
NM 7830 1900	Clachan Seil P/S CSO & EO	Intermittent	6mm screen on overflow	Not stated
NM 7820 1880	Clachan Seil EO	Intermittent	6mm mesh screening	Not stated
NM 7820 1880	Clachan Seil CSO	Intermittent	6mm self cleansing screen, storm storage	Not stated
NM 7805 1874	Clachan Upper Seil	Continuous	Septic tank	51

No sanitary or microbiological data were available for these discharges.

No discharge consents were held by SEPA for the area surrounding Seil point.

A sewage pumping station and an inspection cover were recorded during the shoreline survey. Their locations have been included in the mapped discharges in Figure 4.1 and listed in Table 4.2.

Table 4.2 Discharges and septic tanks observed during shoreline survey

No	NGR	Description	Sample No.
1	NM 78147 18853	Clachan Seil Sewage pumping station (outlet pipe not visible). Several other private septic pipes also seen from here.	None
2	NM 78244 19054	Inspection cover in lay by, probably associated with the 2nd Clachan Seil discharge (pipe not seen however).	None

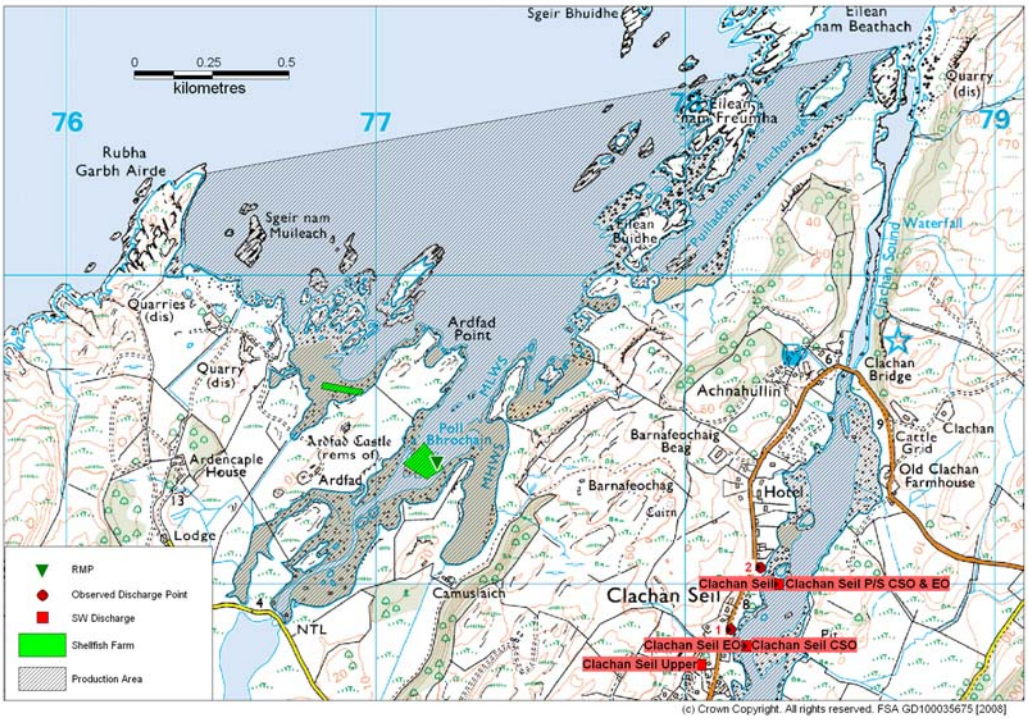

Figure 4.1 Map of discharges at Seil Point

As these discharges are 2 km away from the fishery and there is likely to be little exchange of water from here to the fishery, their impacts are likely to be small.

5. Geology and soils

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 (see the glossary at the end of this section).

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.

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% and can be classified as freely draining soils.

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

Non-calcareous gleys, peaty gleys and humic gleys are generally developed under conditions of intermittent or permanent water logging. In this area, 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 the regions mapped have an average surface % runoff of 44.3%, so it is likely that in this case they would be poorly draining.

Maps were produced using these seven soil type groups and whether they are characteristically freely or poorly draining. The map of component soils and their associated drainage classes for the area around Seil Point can be found in Figure 5.1.

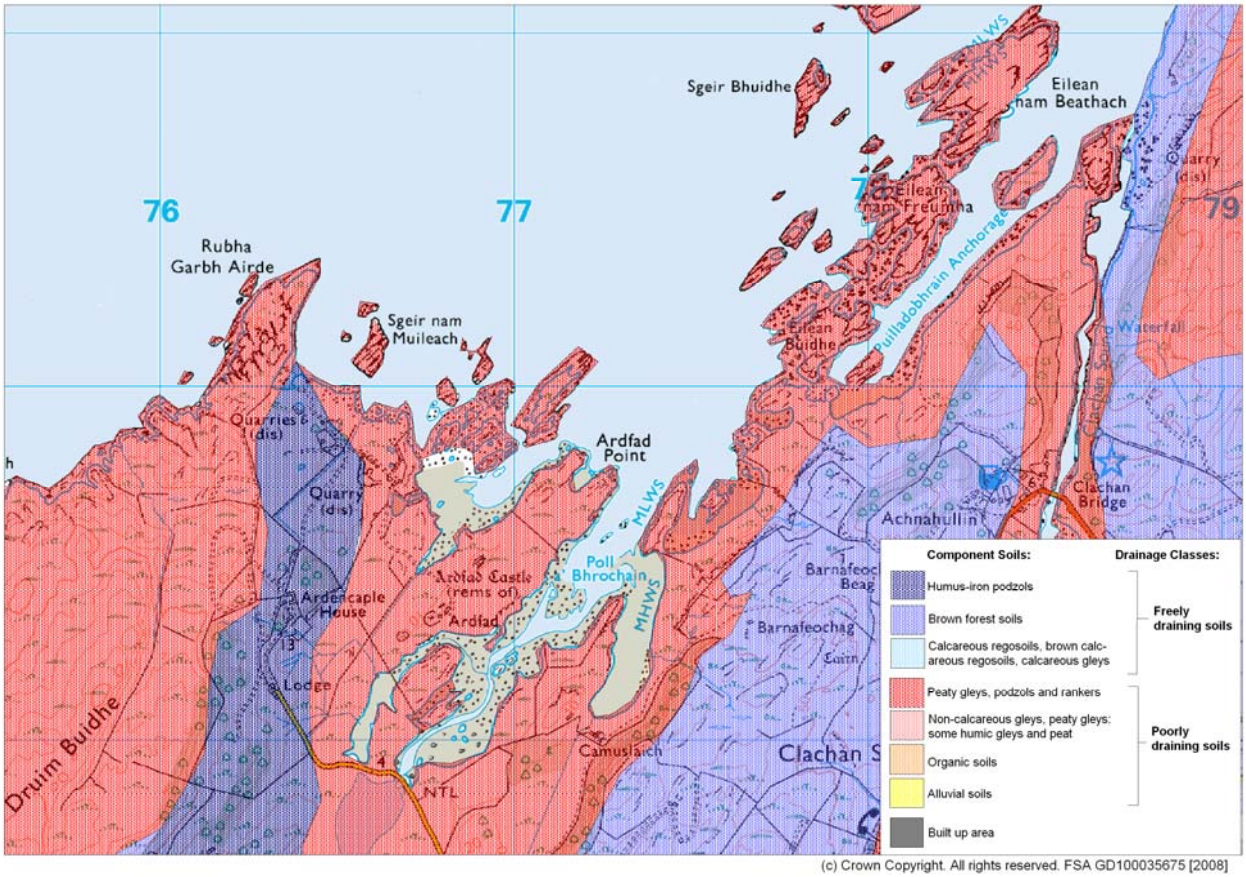

Figure 5.1 Map of component soils and drainage classes at Seil Point

There are three main types of component soils visible in this area. The most dominant is composed primarily of peaty gleys, (peaty) podzols and (peaty) rankers. This soil type dominates much of the coastline of Seil Point. The second dominant component soil is brown forest soil and covers two bands either side of the coastal estuary to the east of Seil Point. The third component soil is humus-iron podzols and occurs in a narrow band on the western side of Seil Point.

Of these soil types, peaty gleys, podzols and rankers are poorly draining, and the other two are more freely draining. Therefore, the potential for runoff contaminated with *E. coli* from animal waste is high along the shoreline adjacent to the Seil Point production area.

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.

6. Land cover

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

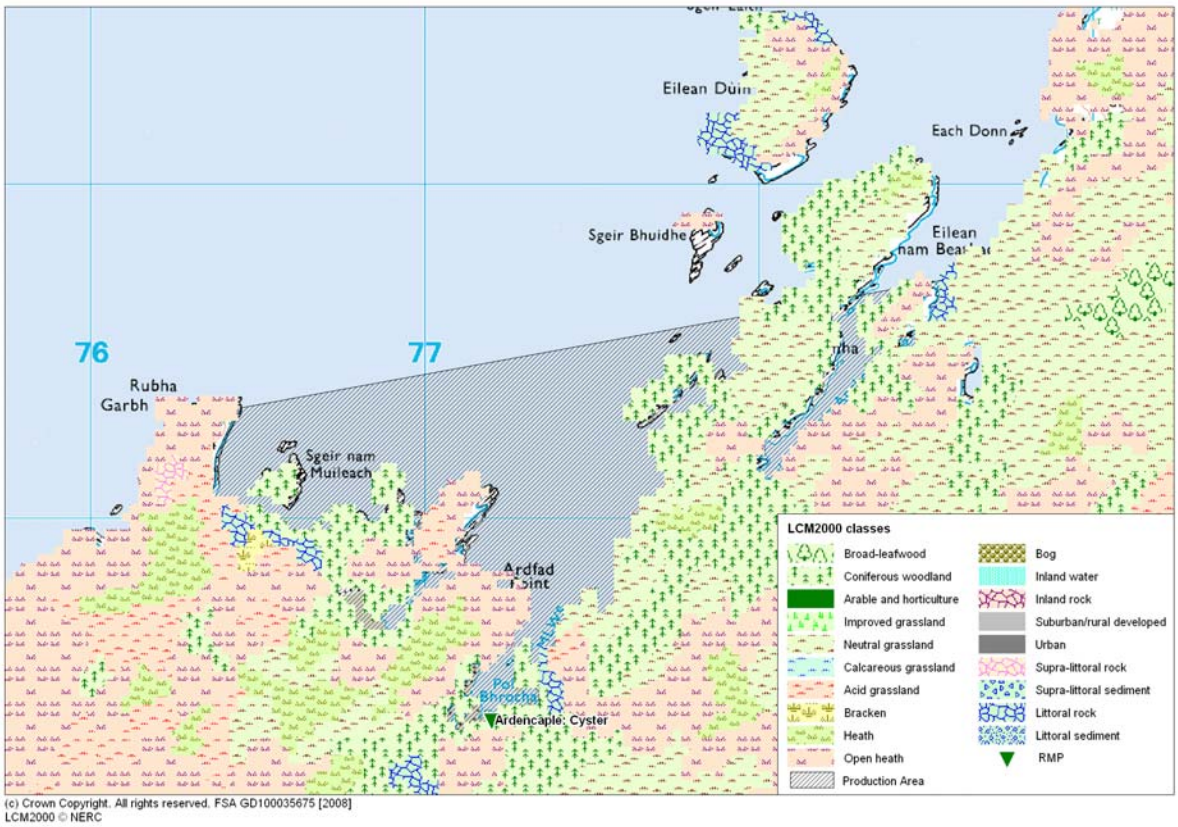

Figure 6.1 LCM2000 class data map for Seil Point

The land cover surrounding the production area of Seil Point is very mixed. The land on the eastern side of Seil Point is composed of patches of coniferous woodland, neutral grassland, open heath, heath and some broad-leaf woodland. The western side of Seil Point covers the land types just mentioned with additional areas of acid grassland, bracken, littoral rock and supra-littoral rock.

The faecal coliform contribution would be expected to be highest from developed areas (approx 1.2 – 2.8×10^9 cfu km^{-2} hr^{-1}), with intermediate contributions from the improved grassland (approximately 8.3×10^8 cfu km^{-2} hr^{-1}) and lowest from the other land cover types (approximately 2.5×10^8 cfu km^{-2} hr^{-1}) (Kay *et al*. 2008). The contributions from all land cover types would be expected to increase significantly after marked rainfall events, this being expected to be highest, at more than 100-fold, for the improved grassland.

As there are no developed areas or improved grassland shown in Figure 6.1, all land cover types present fall into the category contributing the lowest levels of faecal coliforms.

7. Farm Animals

Regulation (EC) No. 854/2004 requires the competent authority to:

(a) make an inventory of the sources of pollution of human or animal origin likely to be a source of contamination for the production area;
(b) examine the quantities of organic pollutants which are released during the different periods of the year, according to the seasonal variations of both human and animal populations in the catchment area, rainfall readings, waste-water treatment, etc.

With regard to potential sources of pollution of animal origin, agricultural census data to parish level was requested from the Scottish Government. The request was declined on the grounds of confidentiality because the parishes in most cases contained only a small number of farms making it possible to determine specific data for individual farms. The only significant source of information was therefore the shoreline survey (see Appendix) which only relates to the time of the site visit on 13-14 August, 2007.

At the time of the shoreline survey there were no livestock visible around the Seil Point area. However, evidence of livestock presence was found on the shoreline adjacent to the production area. The Ardencaple gamekeeper advised that some parts of the shoreline are closed to stock from June to September to protect breeding birds. The shoreline was not fenced off and so would be accessible to stock. A cattle shed and dung heap were located on the shore of Loch Caithlim at the head of the larger (eastern) bay in which oysters are cultivated. Further, sweepings from the livestock shed were reported dumped on the shoreline here from time to time.

It can therefore be concluded that livestock impact is likely to be higher outside the bird breeding season. As well as diffuse inputs from livestock, the cattle shed and associated dung heap may constitute a significant point source. Rainfall associated runoff from the dung heap could affect the fishery at any time of year.

8. Wildlife

8.1 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*). Scotland hosts significant populations of both species.

The amount 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).

Common seals 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.

There are three common seal colonies close to Seil Point. In the north is Loch Linnhe, with an estimated count of 158 in 2000 and Loch Creran with an estimated count of 67 (Sea Mammal Research Unit, 2000). Within the immediate vicinity of Seil Point is the Firth of Lorne, which had a higher estimated count of 527 in 2000 (Sea Mammal Research Unit, 2000). It must be noted that these figures are likely to have changed as a result of the year (2000) the data was collected. Due to not being able to specify the exact location of the haul out sites the impact that they could potentially have on the shellfish farm is unpredictable.

Seven seals were observed in the production area during the course of the shoreline survey, indicating that they do frequent the area in relatively high numbers at times.

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.

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).

Seals will forage widely for food and it is likely that seals will feed near the oyster farms at some point in time. The population is relatively small in relation to the size of the area concerned and is highly mobile therefore it is likely that any impact will be limited in time and area and unpredictable.

8.2 Cetaceans

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

Table 8.1 Cetacean sightings in 2007 – Western Scotland.

Common name	**Scientific name**	**No. sighted***
Minke whale	*Balaenoptera acutorostrata*	28
Killer whale	*Orcinus orca*	183
Long finned pilot whale	*Globicephala melas*	14
Bottlenose dolphin	*Tursiops truncatus*	369
Risso's dolphin	*Grampus griseus*	145
Common dolphin	*Delphinus delphis*	6
Harbour porpoise	*Phocoena phocoena*	>500

*Numbers sighted are based on rough estimates based on reports received from various observers and whale watch groups. Source: Hebridean Whale and Dolphin Trust.

Within the vicinity of Seil Point, it is likely that cetaceans may be present from time to time, especially the smaller species. Their presence, however, is likely to be unpredictable and so will not be taken into account with regard to establishing the sampling plan for the Seil Point production area.

8.3 Birds

A number of seabird species are known to breed in Argyll & Bute and the most significant of these are described in table 8.2.

Table 8.2 Breeding seabirds of Argyll & Bute

Common name	Species	Population	Common name	Species	Population
European Shag	*Phalacrocorax aristotelis*	3341	Great Cormorant	*Phalacrocorax carbo*	231*
Black-headed Gull	*Larus ridibundus*	586	Common Gull	*Larus canus*	2683
Lesser Black-backed Gull	*Larus fuscus*	3235	Herring Gull	*Larus argentatus*	15370
Great Black-backed Gull	*Larus marinus*	1736	Black-legged Kittiwake	*Rissa tridactyla*	8976
Common Tern	*Sterna hirundo*	1362	Arctic Tern	*Sterna paradisaea*	1823
Common Guillemot	*Uria aalge*	42697	Black Guillemot	*Cepphus grille*	3046
Razorbill	*Alca torda*	9056	Atlantic Puffin	*Fratercula arctica*	2597*

*Population number based on Apparently Occupied Sites, Territories, Nests or Burrows. These may equate to more than one adult.

Of these, only the cormorants and gulls are likely to be breeding in the area of Seil Point in appreciable numbers. Distribution of nesting sites near the harvesting areas is not known. Though nesting occurs in early summer, these birds are likely to be present in the area throughout the year. Impact to the fisheries is likely to be very localised where birds rest on oyster trestles.

Wading birds are present on the intertidal areas of the loch, though information on numbers and specific locations was not available at the time this report was written. There are no RSPB reserves at Seil Point.

8.4 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. The land adjacent to the production area is a mixture of coniferous forest and unimproved grassland. While no population data were available for this area, it can be presumed that they host populations of deer. The DCS did not have information on deer in this specific area.

Deer, like cattle and other ruminants, shed *E. coli*, *Salmonella* and other potentially pathogenic bacteria via their faeces and it is likely that some of the indicator organisms detected in the streams feeding into the production area will be of deer origin.

8.5 Other

The European Otter (*Lutra lutra*) is present around Scotland with some areas hosting populations of international significance. Coastal otters, such as those likely to be found near Seil Point, 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 10m 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. While otters are known to occur in the general area, it is unlikely to be home to a substantial population due to their large home range size.

Waterfowl (ducks and geese) are present in Argyll & Bute at various times of the year.

8.6 Summary

Of all species, common seals are likely to be most significant, with their presence within the production area in relatively large numbers (7) confirmed on the shoreline survey. Overall, Wildlife impacts to the fisheries at Seil Point are likely to be localised and unpredictable and will therefore not be explicitly taken into account in determining the sampling plan. However, the effect of such contamination should be detected intermittently during regular monitoring based on the plan.

9. Meteorological data

The nearest weather station is located at Kimelford, approximately 8 km to the south east of the production area. Rainfall data was supplied for the period 1/1/2003 to 31/10/2006 (total daily rainfall in mm). For this period of 1400 days, total daily rainfall was not recorded on 91 days. Wind data was not recorded at this station. It is likely that rainfall experienced at Kimelford is very similar to that experienced at the production area due to their close proximity.

The nearest major weather station is located at Tiree, approximately 90 km to the WNW of the production area. Rainfall data was recorded on all but 11 days from 1/1/2003 to 31/12/2006. Wind direction was recorded at 3 hourly intervals for the majority of the period 1/1/2003 to 31/12/2006. It is likely that the rainfall and wind patterns at Tiree are broadly similar to those at Seil Point, but are liable to differ on any given day. Local topography may also affect wind strength and direction.

This section aims to describe the local rain and wind patterns and how they may affect the bacterial quality of shellfish within the Seil Point production area.

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).

9.1.1 Rainfall at Kimelford

Due to the high number of days rainfall data which were not recorded, it is not appropriate to present monthly or annual totals. Instead, box and whisker plots summarising the distribution of individual daily rainfall values by month and by year are presented in Figures 9.1 and 9.2. The grey box represents the middle 50% of the observations, with the median at the midline. The whiskers extend to the largest or smallest observations up to 1.5 times the box height above or below the box. Individual observations falling outside the box and whiskers are represented by the symbol *.

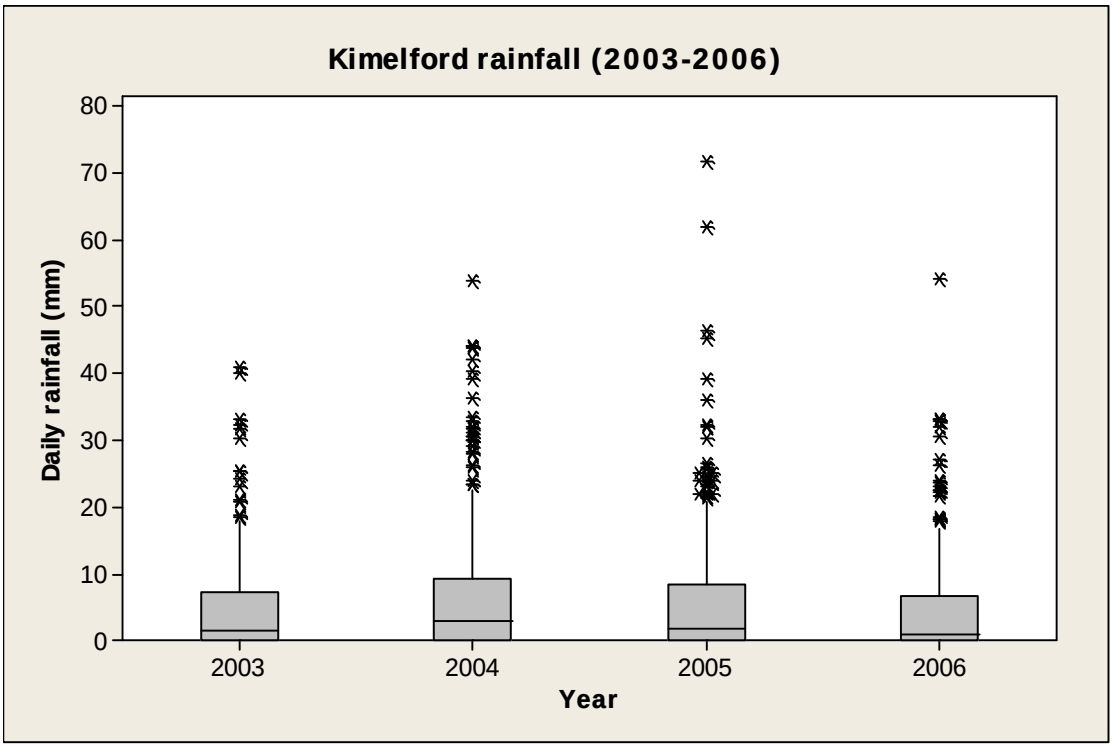

Figure 9.1 Boxplot of daily rainfall at Kimelford by year (no data for November 2004, September 2006 and October 2006)

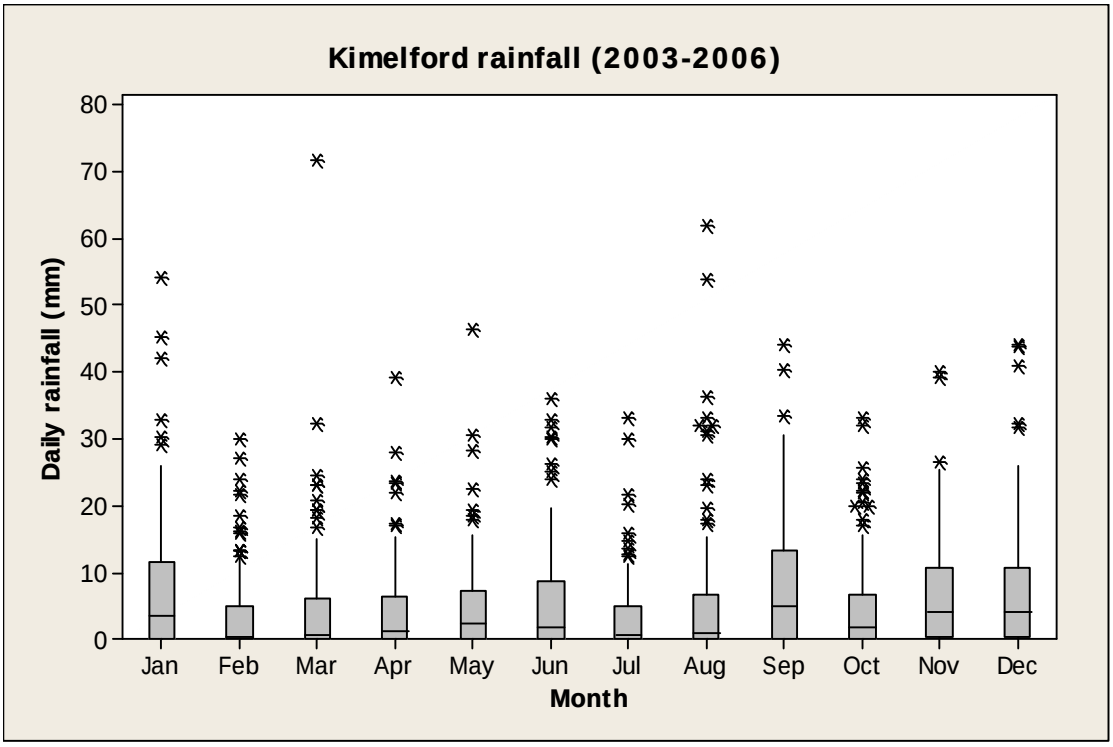

Figure 9.2 Boxplot of daily rainfall at Kimelford by month (no data for November 2004, September 2006 and October 2006)

Higher median daily rainfall was recorded at Kimelford in September, November, December and January.

9.1.2 Rainfall at Tiree

As the rainfall records from Tiree are more complete, total annual rainfall and mean monthly rainfall can be calculated, and are presented in Figures 9.3 and 9.4. Boxplots of daily rainfall values by year and by month are presented in Figures 9.5 and 9.6 to allow their comparison with the pattern of rainfall at Kimelford.

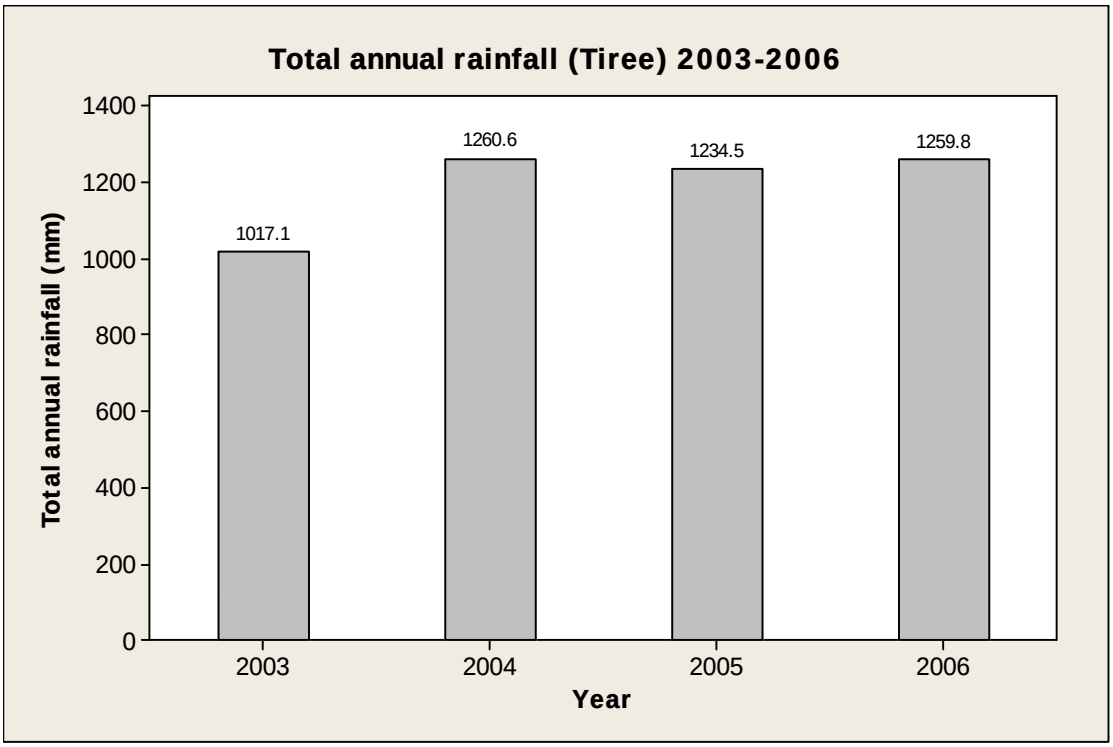

Figure 9.3 Total annual rainfall at Tiree 2003-2006 (no records for 11 days in 2006).

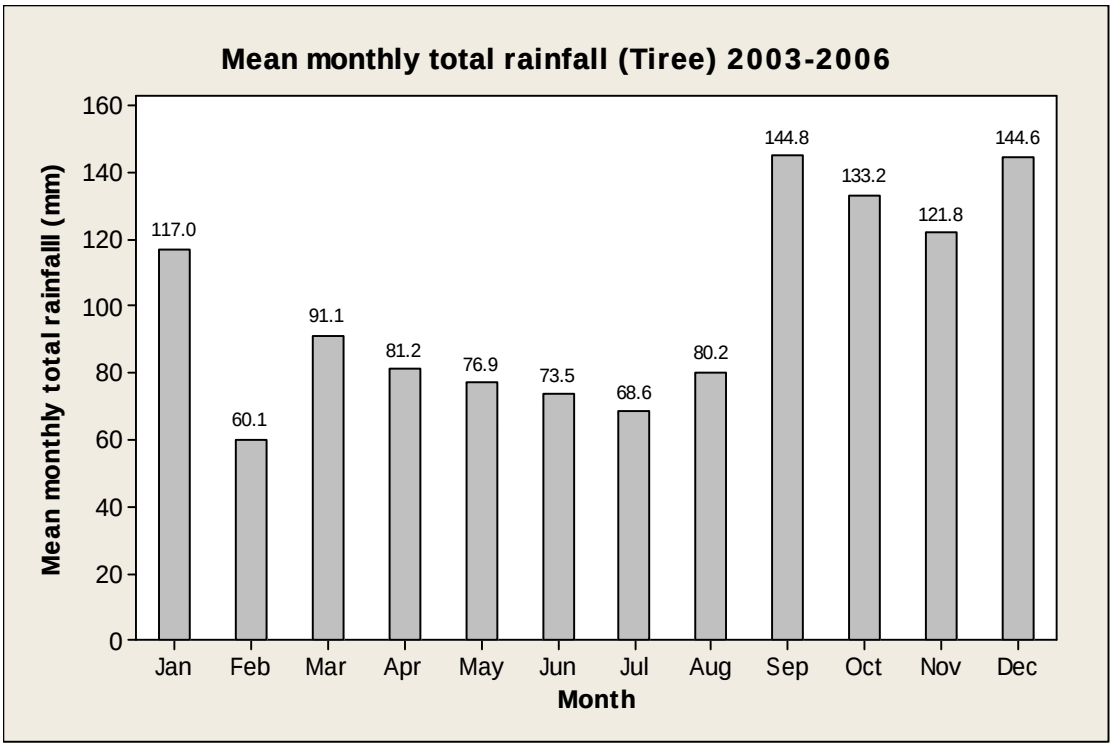

Figure 9.4 Mean total monthly rainfall at Tiree 2003-2006 (no records for 6 days in August 2006 and 5 days in October 2006).

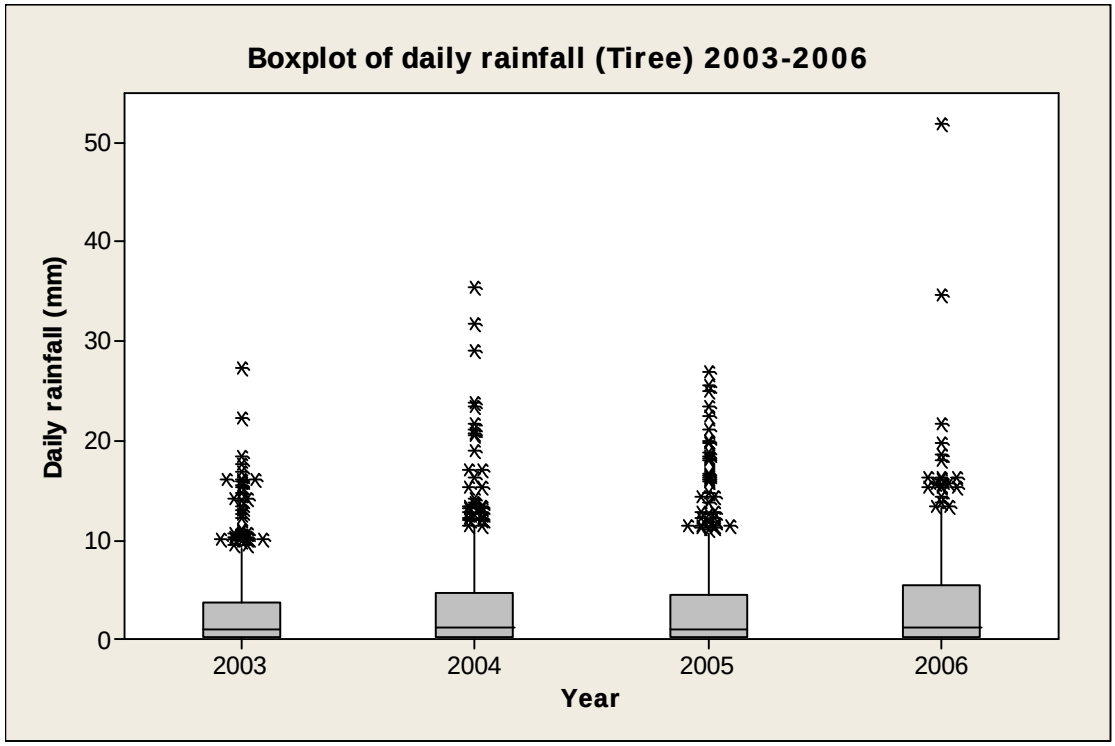

Figure 9.5 Boxplot of daily rainfall at Tiree by year

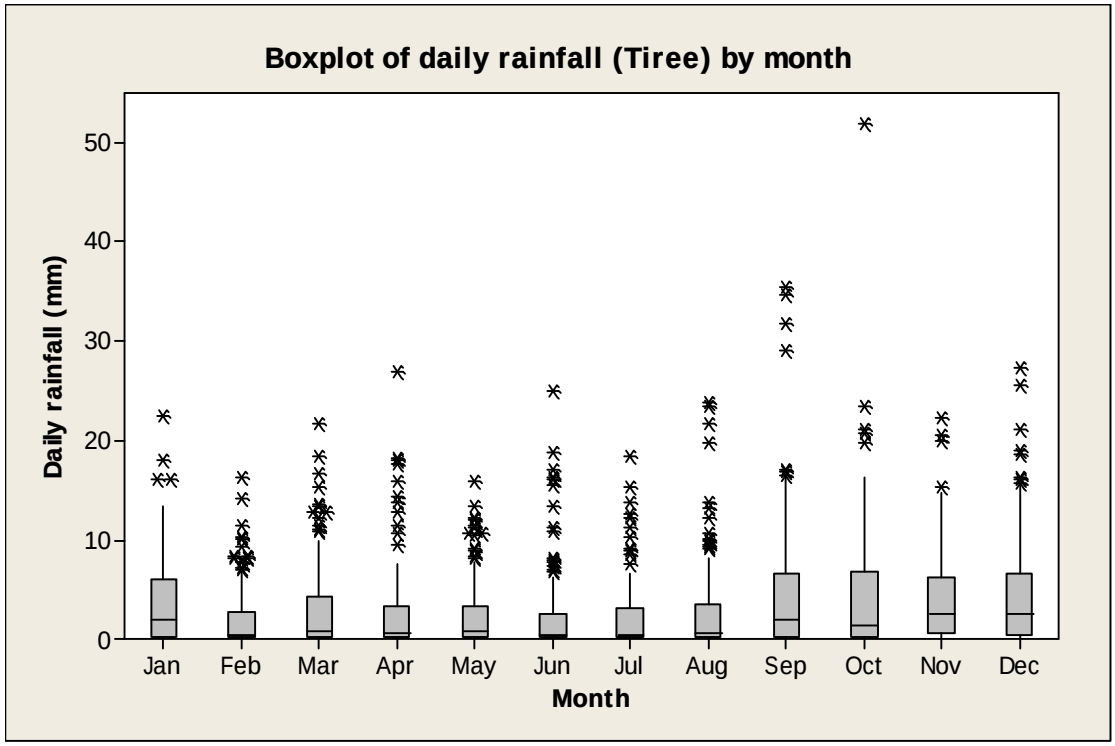

Figure 9.6 Boxplot of daily rainfall at Tiree by month

The wettest months were September, October, November, December and January. For the period considered here (2003-2006), only 13.3% of days experienced no rainfall. 50.7% of days experienced rainfall of 1mm or less. 2003 was the driest year, and 2004 was the wettest year.

A comparison of Tiree rainfall data with Scotland average rainfall data for the period of 1970-2000 is presented in Table 9.1 (Data from Met office website © Crown copyright). This indicates that rainfall in Tiree was lower than the average for the whole of Scotland for every month of the year, but there were fewer dry days in Tiree during the autumn and winter.

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

Month	Scotland rainfall (mm)	Tiree rainfall (mm)	Scotland - days of rainfall >= 1mm	Tiree - days of rainfall >= 1mm
Jan	170.5	142.5	18.6	20.1
Feb	123.4	98.2	14.8	15.8
Mar	138.5	104.5	17.3	18.1
Apr	86.2	67.1	13	11.6
May	79	54.1	12.2	10.8
Jun	85.1	61.5	12.7	11.2
Jul	92.1	77.5	13.3	13.6
Aug	107.4	98.7	14.1	14.0
Sep	139.7	118.6	15.9	16.5
Oct	162.6	142.7	17.7	18.8
Nov	165.9	136.6	17.9	19.7
Dec	169.6	134.5	18.2	20.4
Whole year	1520.1	1236.4	185.8	190.6

It can therefore be expected that levels of rainfall dependant faecal contamination entering the production area from these sources will be higher during the autumn and winter months. It is possible that faecal matter can build up on pastures during the drier summer months when stock levels are at their highest, leading to more significant faecal contamination of runoff at the onset of the wetter weather in the autumn.

9.2 Wind

Wind data collected at the Tiree weather station is summarised by season and presented in figures 9.7 to 9.11.

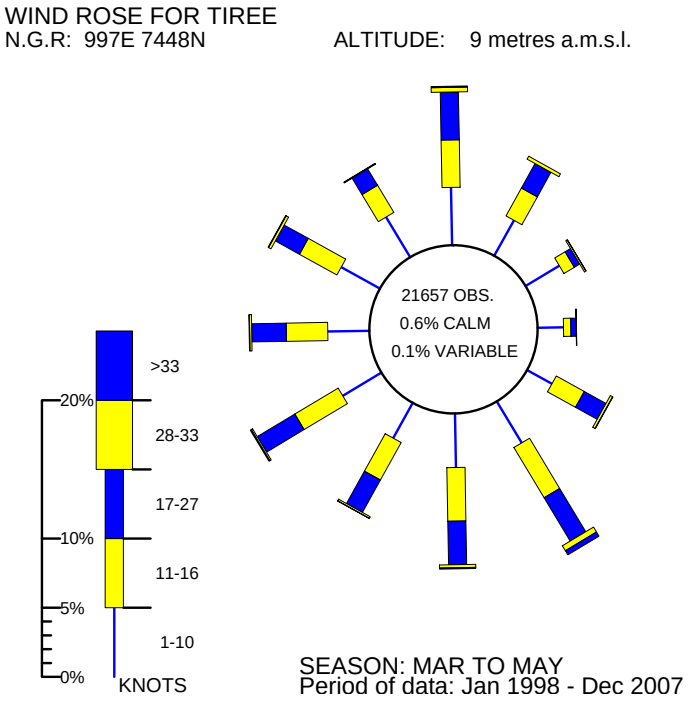

Figure 9.7 Wind rose for Tiree (March to May)

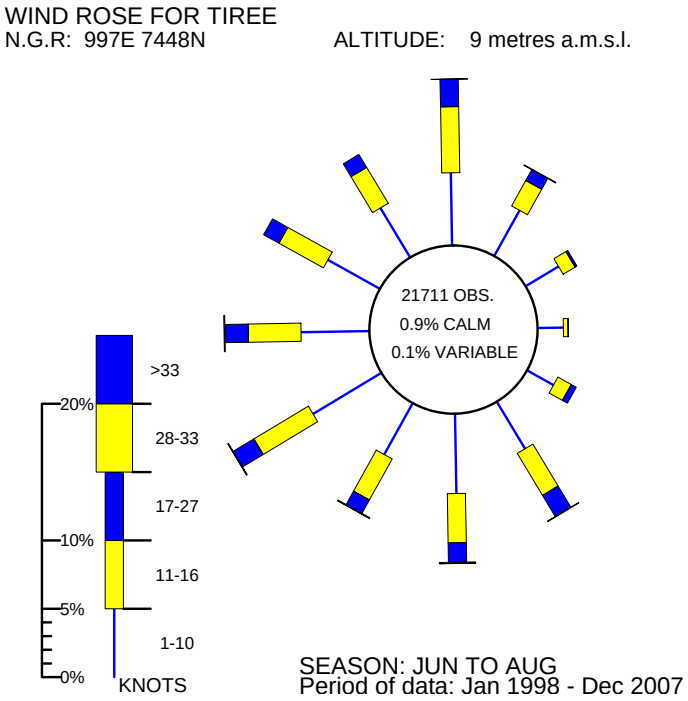

Figure 9.8 Wind rose for Tiree (June to August)

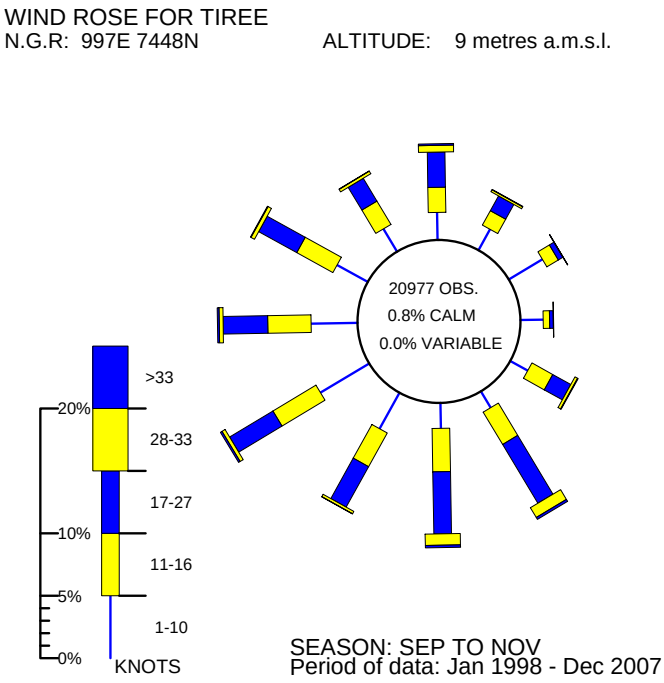

Figure 9.9 Wind rose for Tiree (September to November)

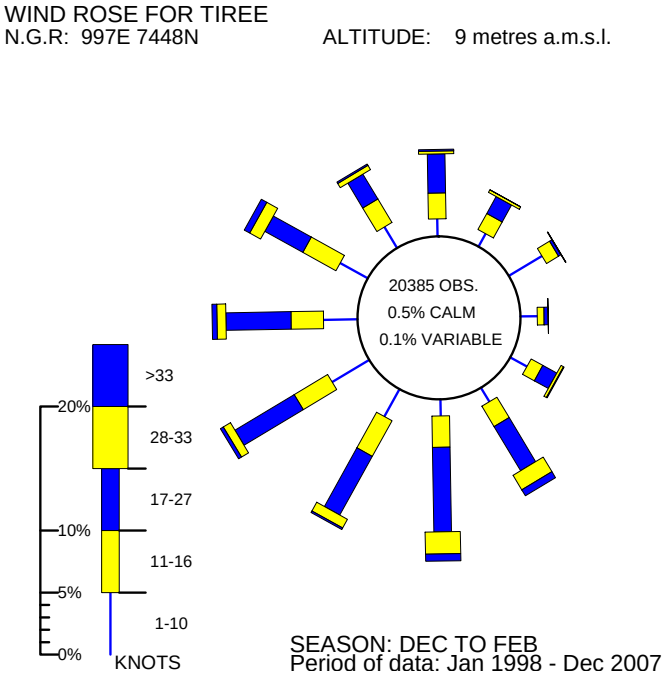

Figure 9.10 Wind rose for Tiree (December to February)

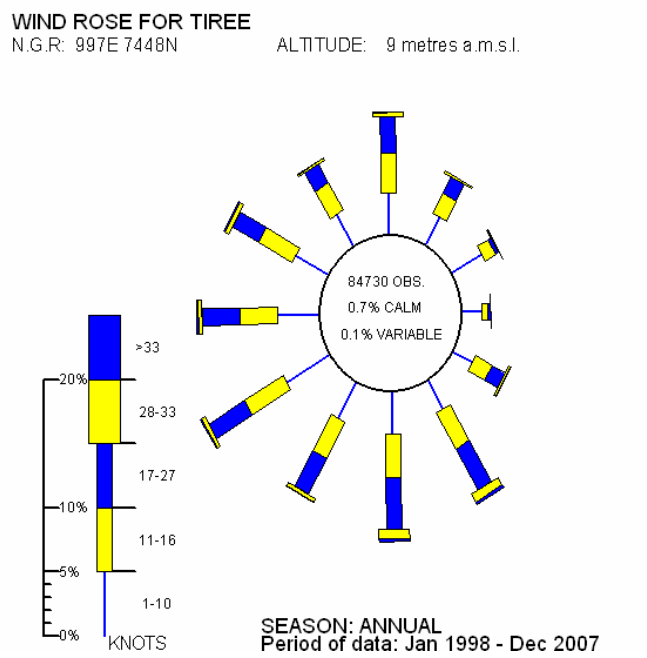

Figure 9.11 Wind rose for Tiree (All year)

The prevailing wind direction at Tiree is from the south and west, but wind direction often changes markedly from day to day with the passage of weather systems. Winds are 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. 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.

Seil Point is located on the north coast of Seil Island. The production sites are in small bays which face north east into the Firth of Lorn, but are partially sheltered by small rocky islands around their mouth as well as by the surrounding land. The Firth of Lorn has a southwest to northeast aspect.

Circulation of water in the bays where the oyster farms are located is therefore most likely to be affected by north easterly winds to which they will be more exposed than from winds from other directions. On a larger scale, circulation in the Firth of Lorn itself will be most affected by south westerly and north easterly winds. The bays in which the Seil Point oyster farms are located exchange a high proportion of their water on each tidal cycle, so tidally driven circulation is likely to be more important for the movement and dispersal of contamination of local origin. On a larger scale, winds may alter the circulation of water within the Firth of Lorn in such a way to assist the transport of contamination from further afield, but the region is sparsely populated and there are no major point sources nearby.

10. Current and historical classification status

The area was provisionally classified in 2001, not classified in 2002, and given a full classification in 2003. The classification history is presented in Table 10.1. Currently, the area is classified as a year seasonal A/B. A map of the current production area is presented in Figure 10.1.

Table 10.1 Classification history

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001*	A	A	A	A	A	A	A	A	A	A	A	A
2002**	-	-	-	-	-	-	-	-	-	-	-	-
2003	A	A	A	A	B	B	B	B	B	B	B	A
2004	A	A	A	B	B	B	B	B	B	B	B	A
2005	A	A	A	B	B	B	B	B	B	B	B	A
2006	A	A	A	B	B	B	B	B	B	B	B	A
2007	A	A	A	B	B	B	B	B	B	B	B	A

* provisional classification in 2001
** not classified in 2002

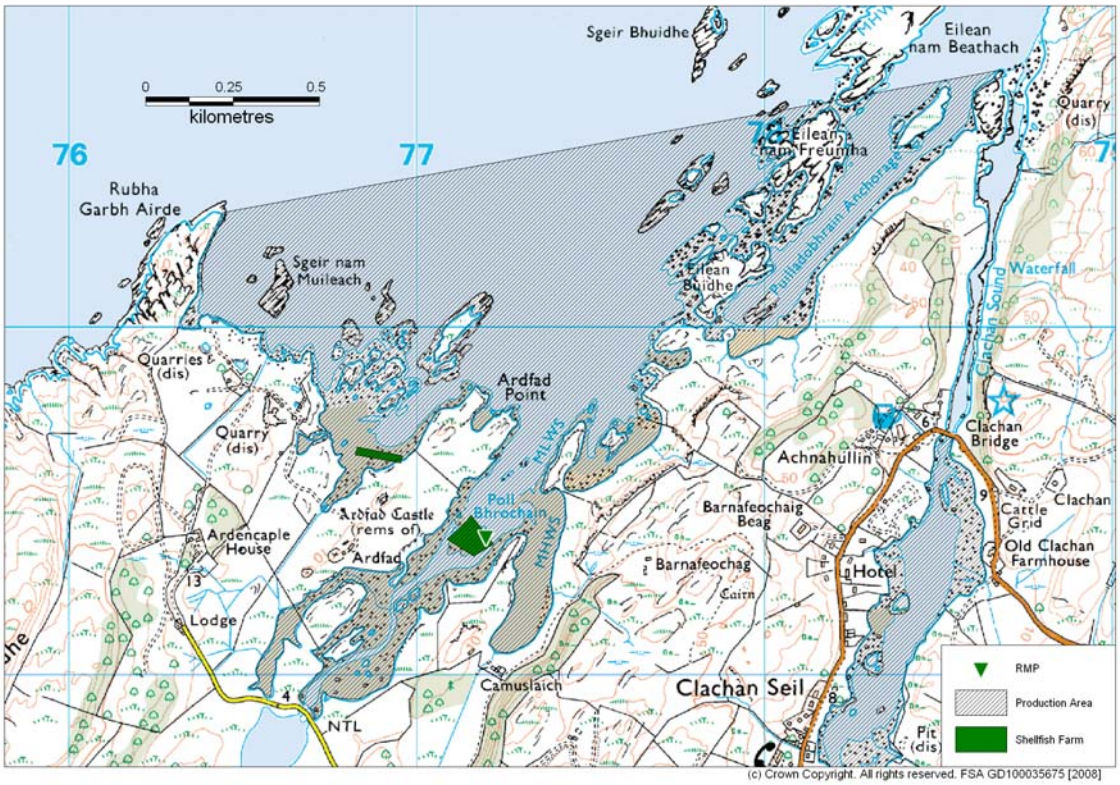

Figure 10.1 Map of Seil point production area

Two producers operate within this production area, after which the sites are named. The area of trestles to the west forms part of the Ardencaple: Cyster site. The area of trestles to the east consists of the rest of the Ardencaple: Cyster site on its western half, and the Ardencaple: Cadzow site on its eastern half.

11. Historical *E. coli* data

11.1 Validation of historical data

All oyster samples taken from Seil Point up to the end of 2006 were extracted from the database and validated according to the criteria described in the standard operating procedure for validation of historical *E. coli* data. Nine samples were rejected on the basis of geographical discrepancies (their reported sampling location fell over 100m outside the production area). Eight samples had the result reported as <20, and were assigned a nominal value of 10, and in the one instance the result was reported as >18000, it was assigned a nominal value of 36000 for statistical assessment and graphical presentation. All *E. coli* results are reported in most probable number per 100g of shellfish flesh and intervalvular fluid.

11.2 Summary of microbiological results by sites

Samples were taken from three locations, all reported as being collected from the eastern bay. Two of these three locations fall outside of the actual farm (as measured on the shoreline survey) and the Crown Estates lease. A summary of sampling and results is presented in Table 11.1, and a map presenting the geometric mean result by year is presented in Figure 11.1. None of the reported sampling locations coincided with the western set of trestles.

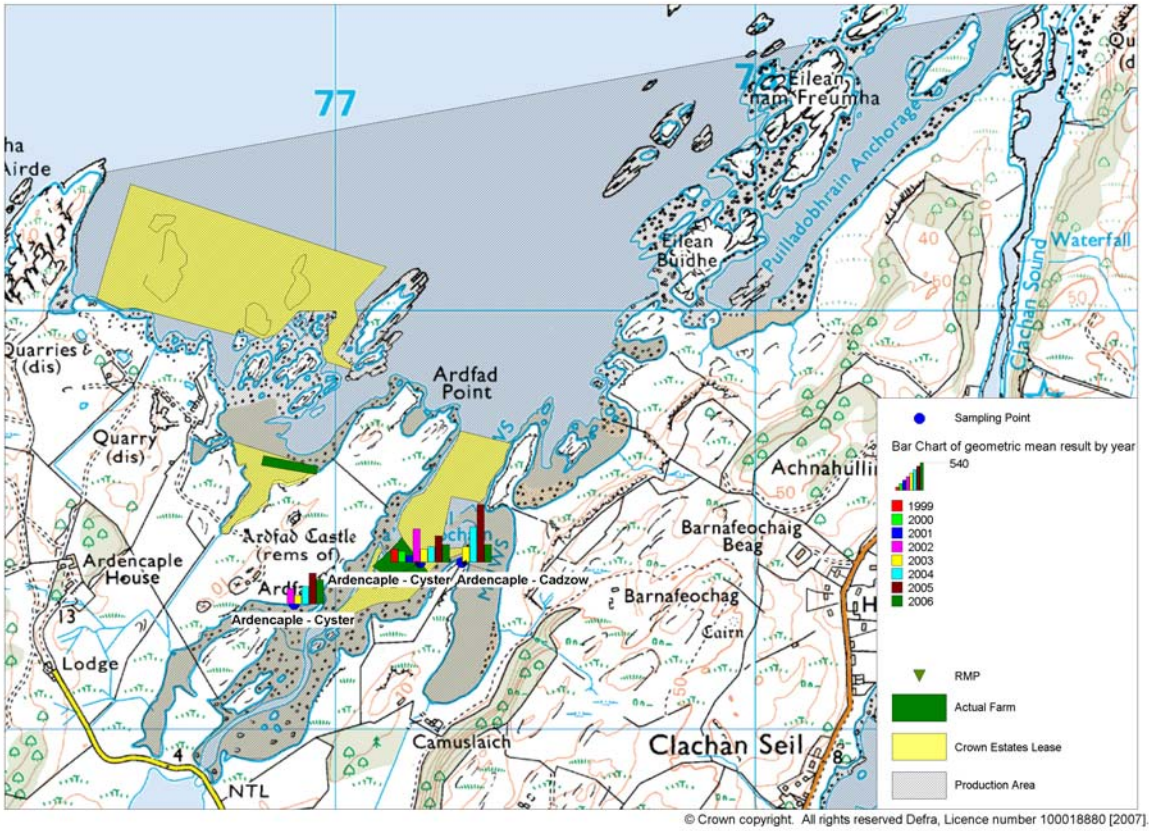

Figure 11.1 Map showing sampling location and geometric mean result by year

Table 11.1 Summary of results from Seil Point

Sampling summary				
Production area	Seil Point	Seil Point	Seil Point	Seil Point
Site	Ardencaple - Cyster	Ardencaple - Cyster	Ardencaple - Cadzow	All (2)
Species	Pacific oysters	Pacific oysters	Pacific oysters	Pacific oysters
SIN	AB 245 070 13	AB 245 070 13	AB 245 069 13	AB 245
Location	NM769193	NM772194	NM773194	NM769193, NM772194, NM773194
Location of RMP	NM772194	NM772194	None	NM772194
Total no of samples	54	55	42	151
No. 1999	0	3	0	3
No. 2000	0	3	0	3
No. 2001	0	1	0	1
No. 2002	12	6	0	18
No. 2003	12	12	11	35
No. 2004	11	11	11	33
No. 2005	10	10	10	30
No. 2006	9	9	10	28
Results Summary (*E. coli* mpn/100g)				
Minimum	<20	<20	<20	<20
Maximum	5400	>18000	16000	>18000
Median	160	110	220	220
Geometric mean	162	165	247	183
90 percentile	2190	750	1700	1700
95 percentile	5400	1630	5220	5400
No. exceeding 230/100g	18 (33%)	22 (40%)	20 (48%)	60 (40%)
No. exceeding 1000/100g	11 (20%)	4 (7%)	7 (17%)	22 (15%)
No. exceeding 4600/100g	5 (9%)	2 (4%)	3 (7%)	10 (7%)
No. exceeding 18000/100g	0 (0%)	1 (2%)	0 (0%)	1 (1%)

No significant difference was found between results obtained from the three sampling locations was found (One-way ANOVA, p=0.402, Appendix 4), so no firm conclusions regarding setting the RMP can be drawn from this data.

11.3 Temporal pattern of results

Figures 11.2 and 11.3 present scatter plots of individual results against date for all samples taken from Seil Point. Both are fitted with trend lines to help highlight any apparent underlying trends or cycles. Figure 11.2 is fitted with a line indicating the geometric mean of the previous 5 samples, the current sample and the following 6 samples. Figure 11.3 is fitted with a loess smoother, a regression based smoother line calculated by the Minitab statistical software. Figure 11.4 presents the geometric mean of results by month (+ 2 times the standard error).

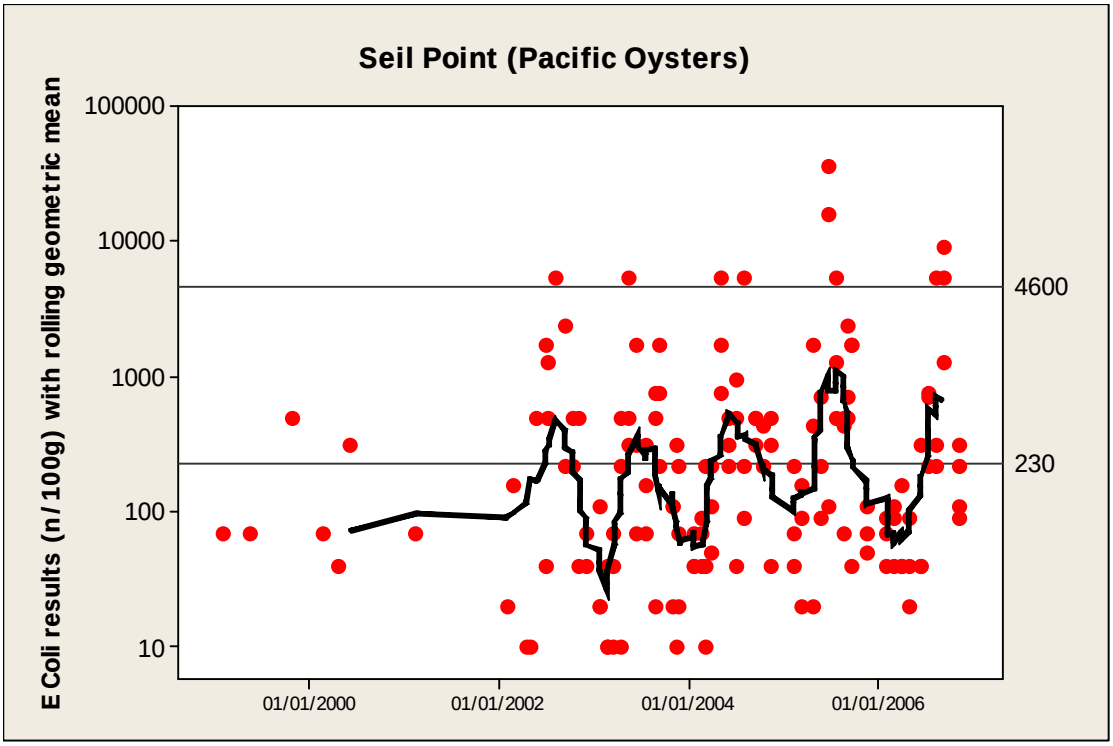

Figure 11.2 - Scatterplot of results by date with rolling geometric mean

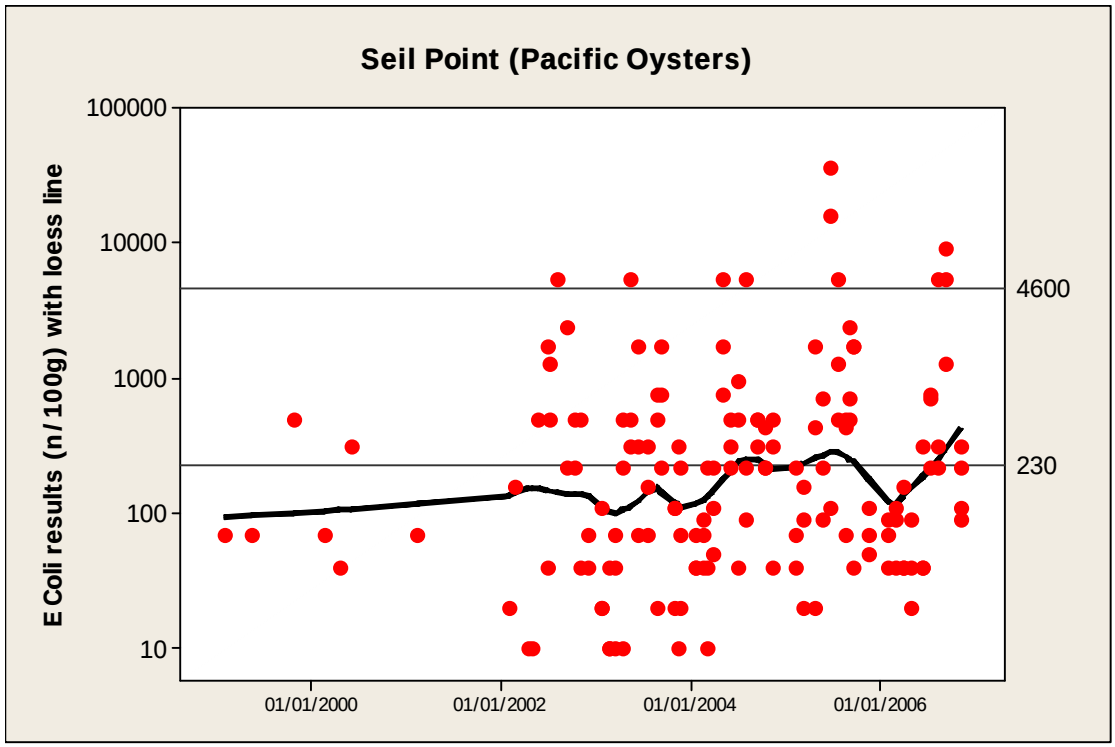

Figure 11.3 - Scatterplot of results by date with loess smoother

Figures 11.2 and 11.3 suggest seasonal fluctuations in levels of contamination, with peaks in the summer.

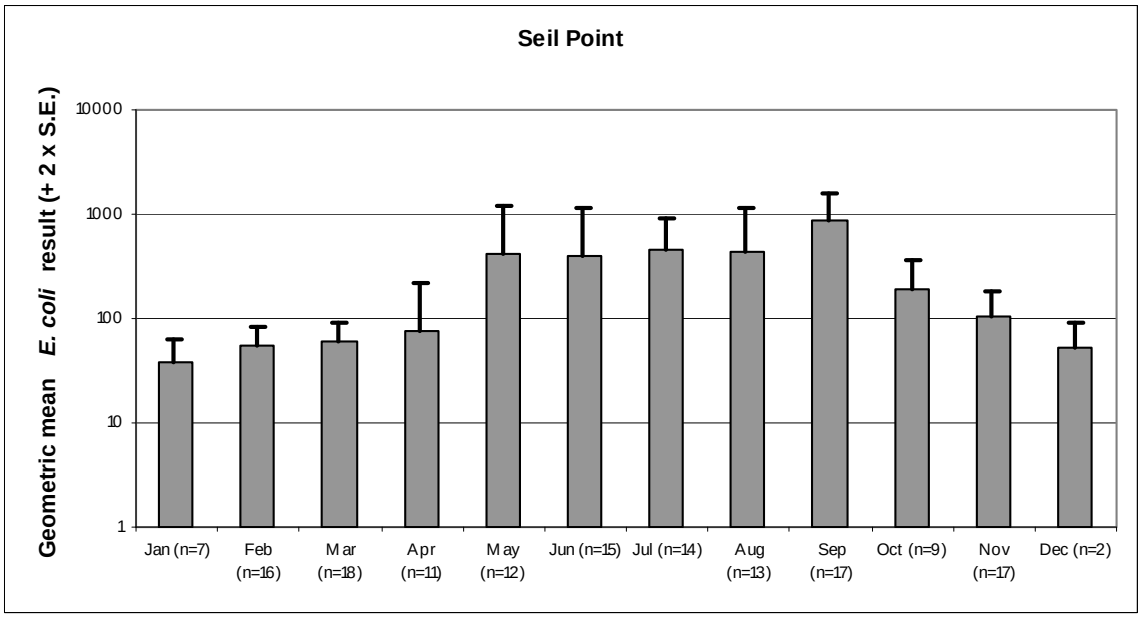

Figure 11.4 - Geometric mean result by month

Highest mean results occurred in the period from May to September.

11.4 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. This analysis considers the 151 samples taken from Seil Point from 1999 to the end of 2006.

11.4.1 Analysis of results by season

Although not strictly an environmental variable in the same way as rainfall for example, season dictates not only weather patterns, but livestock numbers and movements, presence of wild animals and patterns of human occupation. Seasons were split into spring (March - May), summer (June - August), autumn (September - November) and winter (December - February).

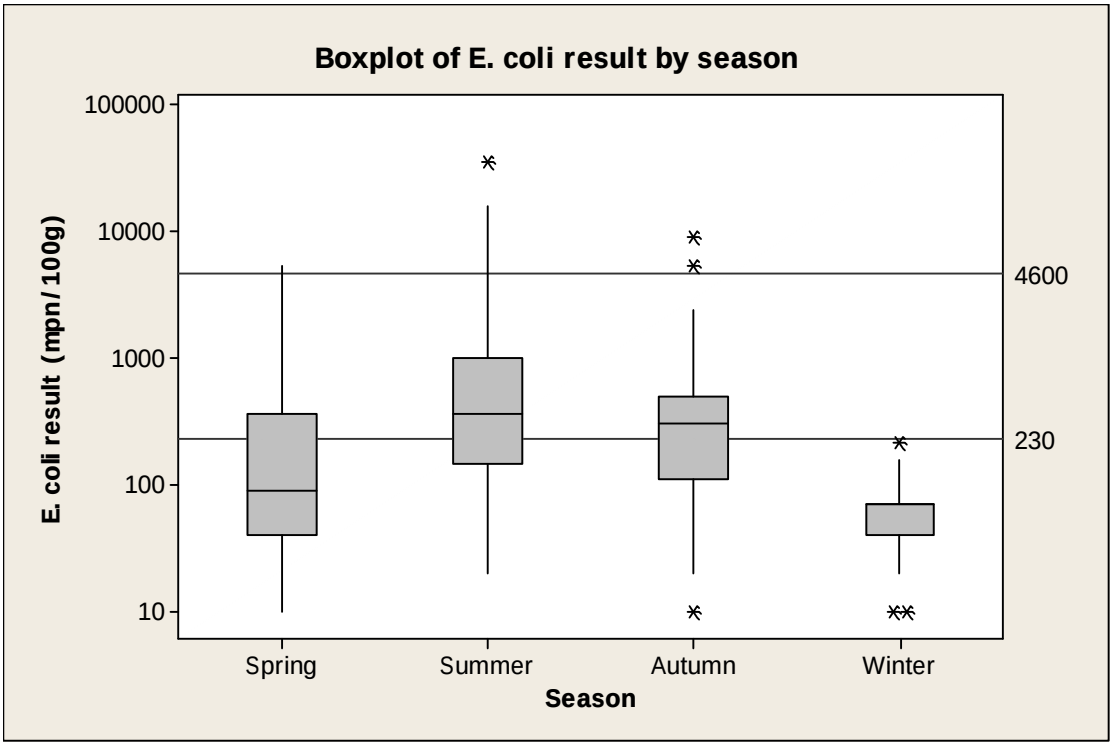

Figure 11.5 Boxplot of result by season

A strong seasonal effect was observed (One-way ANOVA, p=0.000, Appendix 4). A post ANOVA test (Tukeys comparison, Appendix 4) indicated that results were significantly higher in the summer and autumn compared to the winter and spring.

11.4.2 Analysis of results by recent rainfall

The nearest weather station is located at Kimelford, approximately 8 km to the south east of the production area. Rainfall records were available for the period 1/1/2003 to 31/10/2006 (total daily rainfall in mm), although total daily rainfall was not recorded on 91 days of this period.

The coefficient of determination was calculated for *E. coli* results and rainfall in the previous 2 days at Kimelford. Figure 11.6 presents a scatterplot of *E. coli* result and rainfall. Figure 11.8 presents a boxplot of results by rainfall quartile (quartile 1 = 0 to 0.5 mm, quartile 2 = 0.5 to 6.49 mm, quartile 3 = 6.49 to 16.19 mm, quartile 4 = more than 16.19 mm).

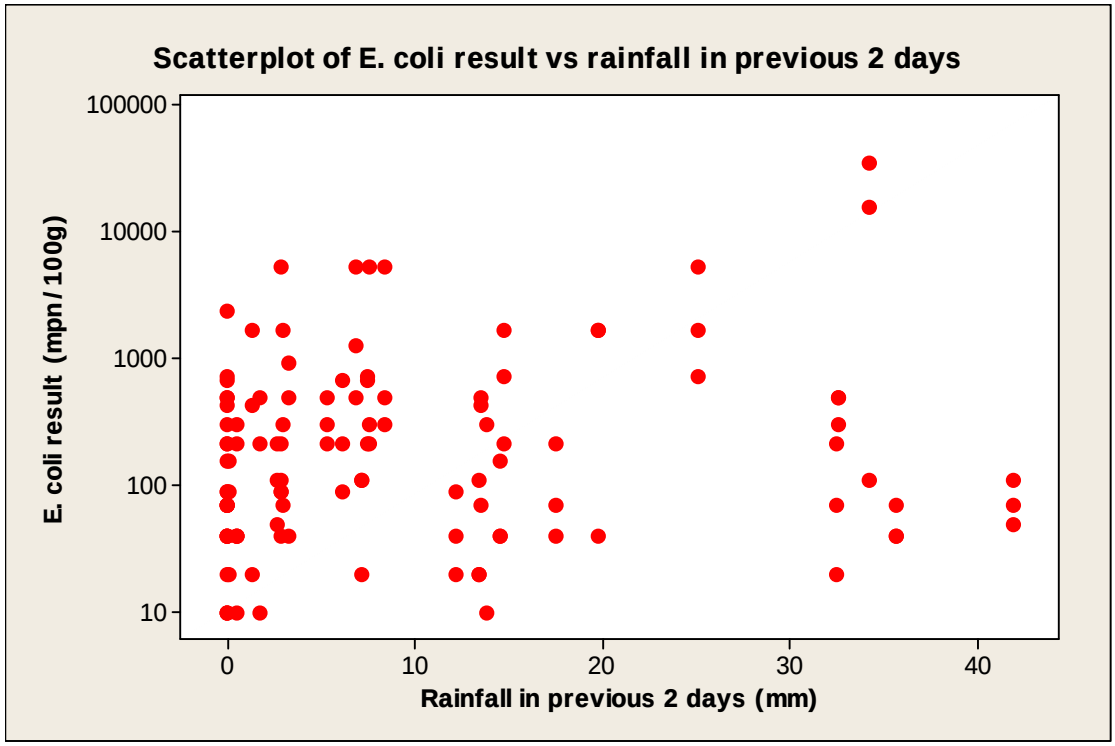

Figure 11.6 Scatterplot of result against rainfall in previous 2 days

The coefficient of determination indicates that there was no relationship between the *E. coli* result and the rainfall in the previous two days (Adjusted R-sq=0.8%, p=0.171, Appendix 4).

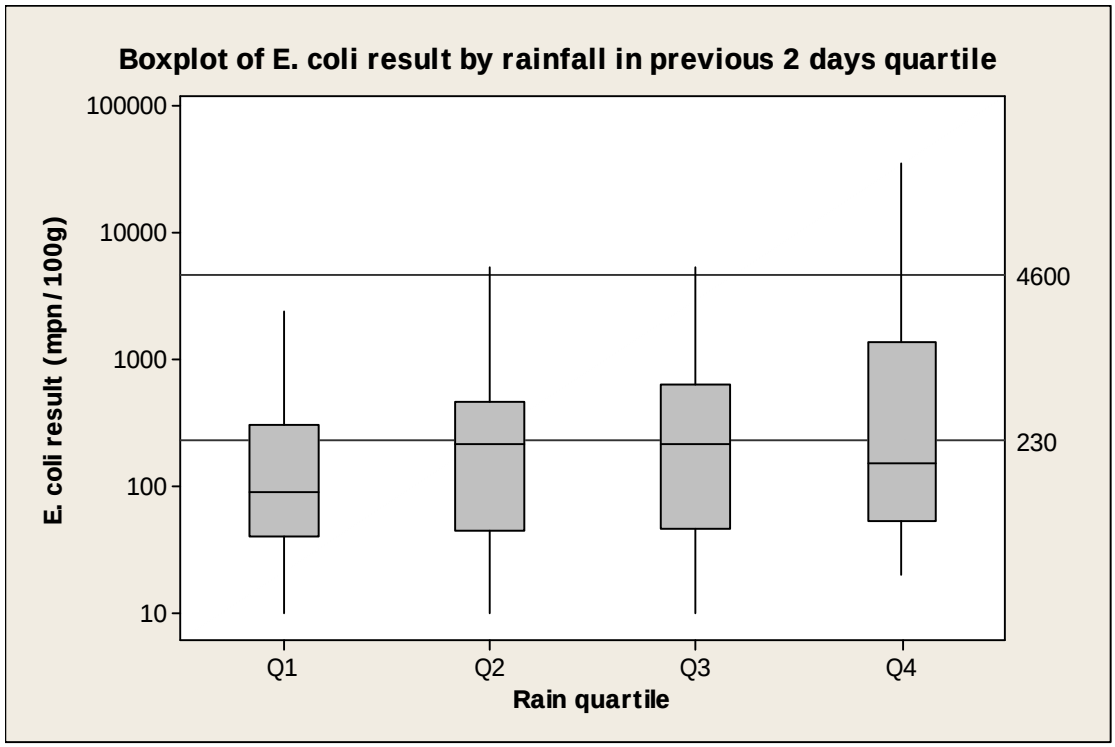

Figure 11.7 Boxplot of result by rainfall in previous 2 days quartile

No significant difference was found between the results for each rain quartile (One way ANOVA, p=0.152, Appendix 4).

As the effects of heavy rain may take differing amounts of time to be reflected in shellfish sample results in different systems, the relationship between rainfall in the previous 7 days and sample results for Seil Point was investigated in an identical manner to the above. Interquartile ranges for 7 days rainfall were as follows; quartile 1 = 0 to 14.09 mm; quartile 2 = 14.09 to 34.0 mm; quartile 3 = 34.0 to 57.2 mm; quartile 4 = more than 57.2 mm.

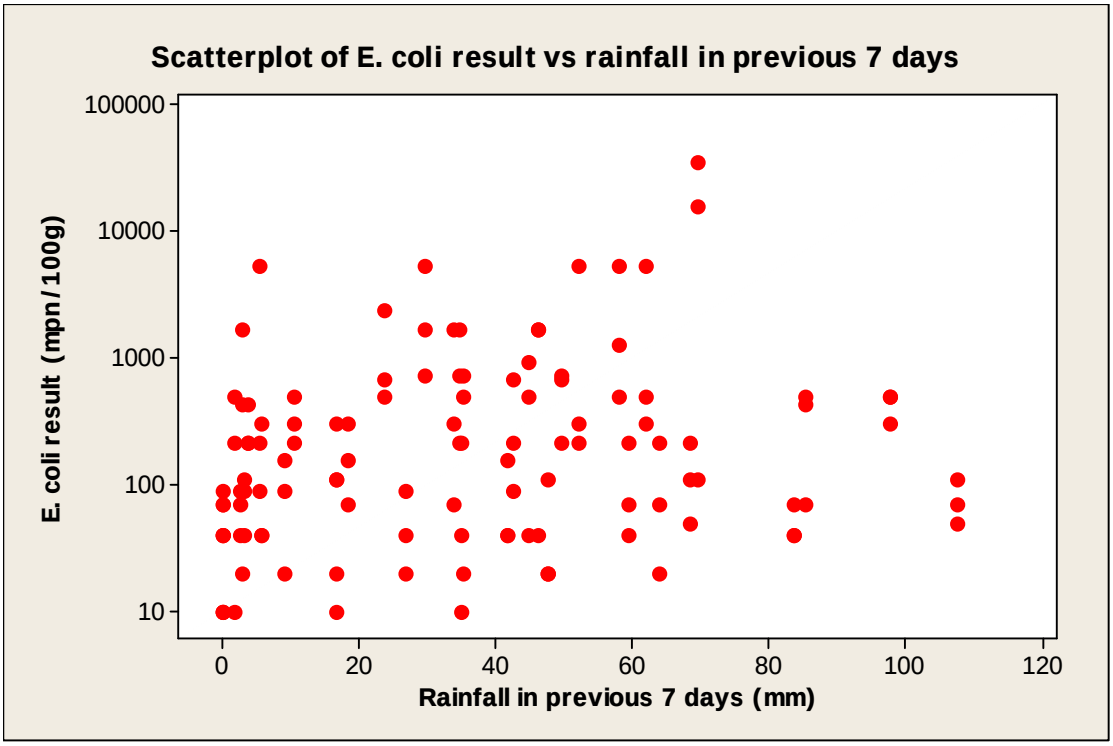

Figure 11.8 Scatterplot of result against rainfall in previous 7 days

The coefficient of determination indicates that there was essentially no relationship between the *E. coli* result and the rainfall in the previous seven days (Adjusted R-sq=3.1%, p=0.034, Appendix 4).

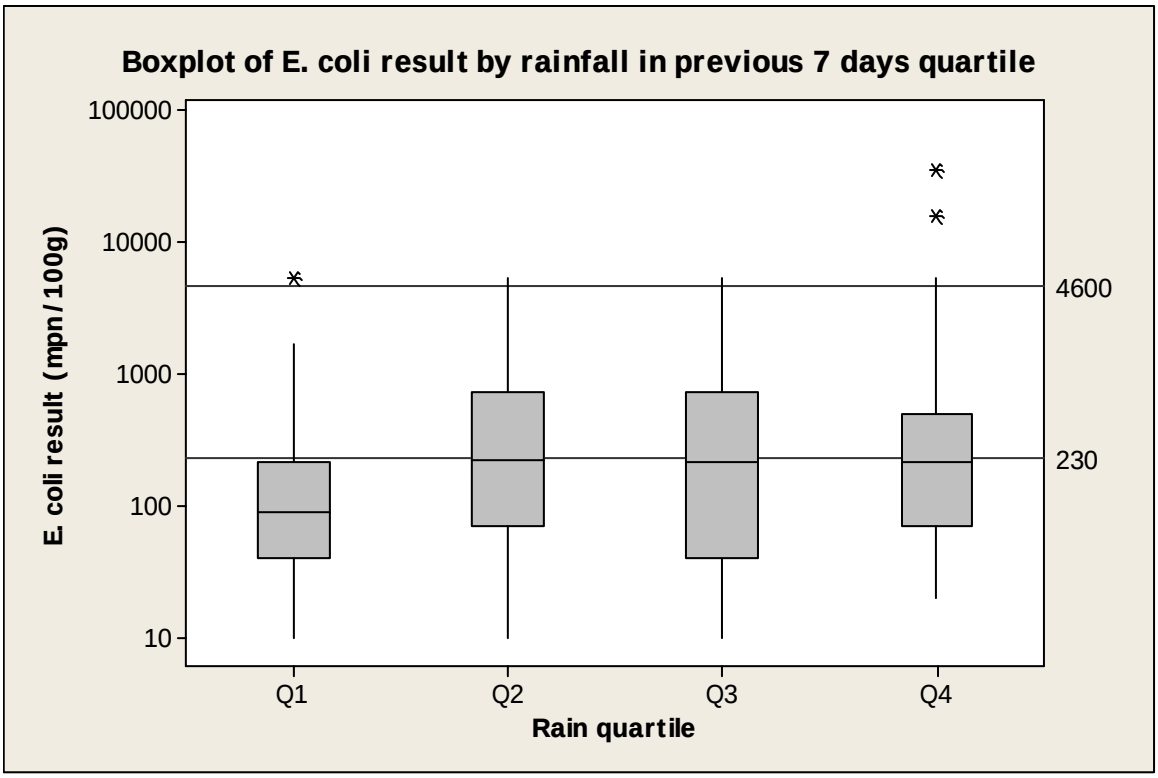

Figure 11.9 Boxplot of result by rainfall in previous 7 days quartile

No difference between results for each quartile was detected (One way ANOVA, p=0.087, Appendix 4).

Overall, no relationship between *E. coli* result and rainfall in the previous 2 days was detected and essentially no relationship between rainfall in the previous 7 days and *E. coli* result was found. The influence of rainfall on microbiological quality will depend on factors such as local geology, topography and land use.

11.4.3 Analysis of results by lunar state

Lunar state dictates tide size, with the largest tides occurring 2 days after either a full or new moon. With the larger tides, circulation of water in the area will increase, and more of the shoreline will be covered, potentially washing more faecal contamination from livestock into the loch. Tidal ranges in the area (as described in section 13) are relatively large. Virtually all samples gathered from Seil Point were collected on the larger tides, which expose the shellfish at low water permitting sampler access. As a consequence, no analysis of the effects of tide size was carried out.

11.4.4 Water temperature

Water temperature is likely to affect the survival time of bacteria in seawater (Burkhardt *et al*, 2000) and presumably 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.

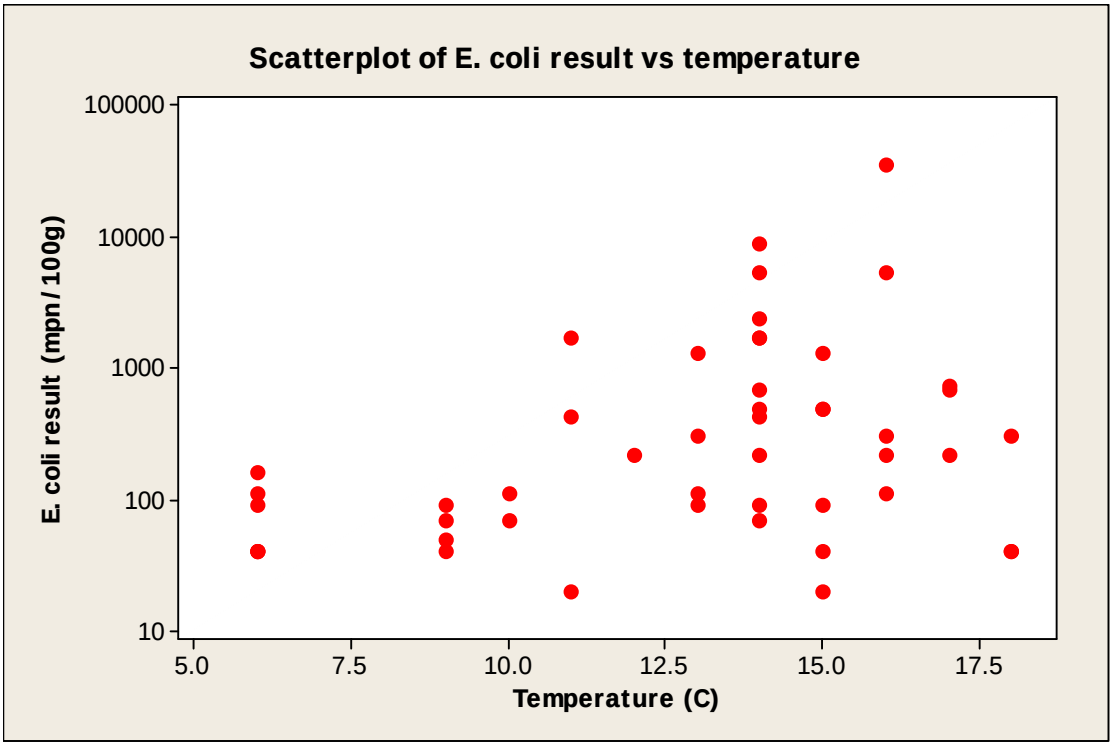

Figure 11.10 Scatterplot of result against water temperature at time of sampling

The coefficient of determination indicates that there was a weak positive relationship between the *E. coli* result and the water temperature at time of sampling (Adjusted R-sq=11.8%, p=0.001, Appendix 4). This is consistent with the seasonal pattern, and suggests that contamination is higher in the warmer months and/or bacteria are accumulated more effectively in warmer water.

11.4.5 Wind direction

Wind speed and direction may change water circulation patterns in the production area. Mean wind direction for the 7 days prior to each sample being collected was calculated from wind data recorded at the Tiree weather station (where data was available), and mean result by mean wind direction in the previous 7 days is plotted in Figure 11.11.

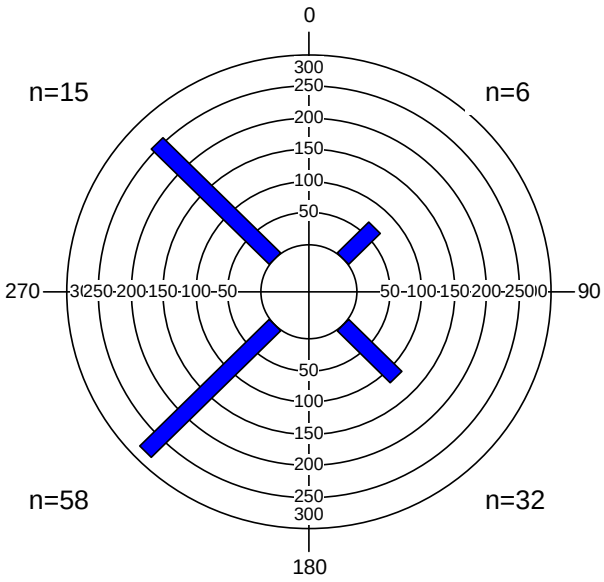

Figure 11.11 Circular histogram of geometric mean *E. coli* result by wind direction, with numbers of samples taken for each wind direction

A weak correlation was found between wind direction and *E. coli* result (circular-linear correlation, r=0.209, p=0.009, Appendix 4), with higher results occurring when the wind was blowing from the west. It must be noted that the prevailing wind direction is from the south west (over 50% of samples were taken following a period of south westerly wind), and when it is blowing in this direction it is likely to be stronger than when blowing from other directions.

11.4.6 Discussion of environmental effects

A strong seasonal effect was found, with results in the summer and autumn higher than in spring and winter. An extremely weak positive relationship between rainfall in the previous 7 days and results were found, but there was no detectable relationship between results and rainfall in the previous two days. Influence of lunar state could not be investigated. A weak positive relationship between results and water temperature was found. Westerly winds were associated with increased contamination.

11.5 Sampling frequency

When a production area has had 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 may be decreased from monthly to bimonthly. This is not appropriate for Seil Point, as the area has held seasonal classifications since 2003.

12. Designated Shellfish Growing Waters Data

The area considered in this report is also a SEPA shellfish growing water which was designated in 1998. The extent of this and the location of the SEPA designated monitoring point is shown on figure 12.1.

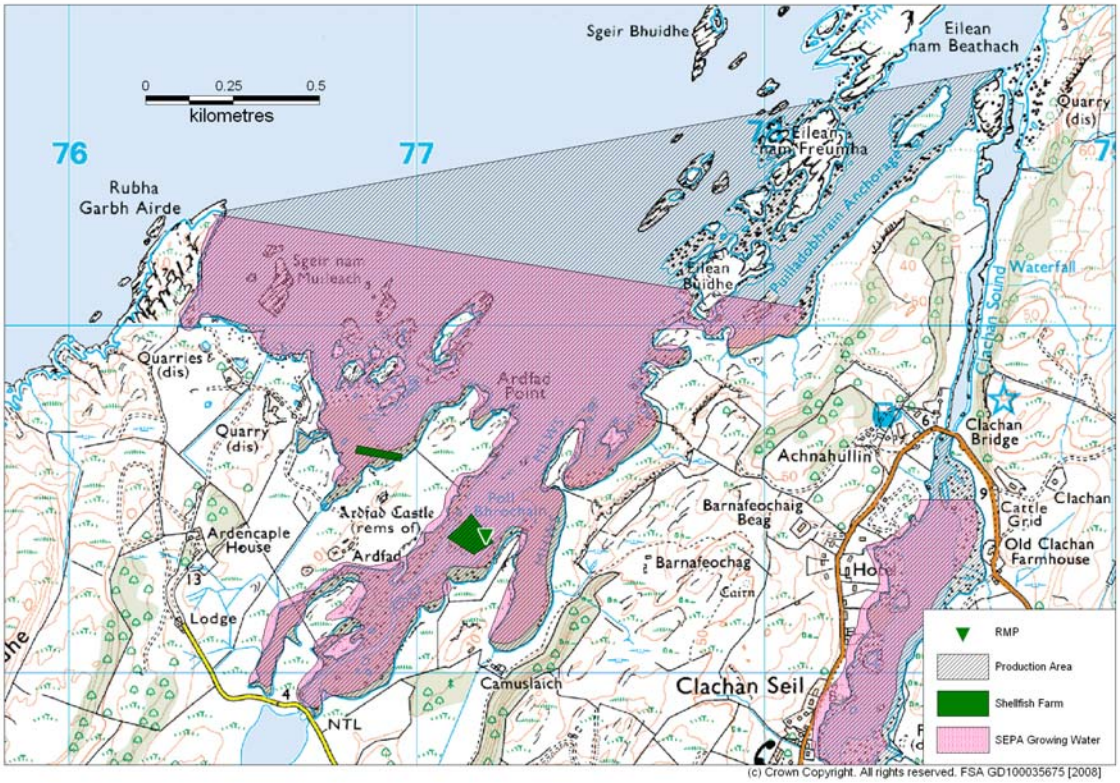

Figure 12.1 Map showing SEPA designated growing water and monitoring point

Monitoring of the area started in 1999, and results to the end of 2006 have been provided by SEPA. Monitoring results for faecal coliforms are presented in Table 12.1.

The SEPA growing water report for this area reports that, initially, sampling was carried out from a point within the production area where water and commercial shellfish samples were taken. Due to access difficulties, the monitoring point was moved to Clachan Bridge to allow easier access for the samplers, but no shellfish (wild mussels) are available at this point. The reported location of the monitoring point falls on land, approximately 200 m outside the designated growing area boundaries, and does not coincide with either of these sampling locations.

The current monitoring regime, which was set in 2005, requires the following testing:

- Quarterly for salinity, dissolved oxygen, pH, temperature and visible oil
- Twice yearly for metals in water
- Monitoring for faecal contamination in shellfish is not currently carried out due to sampling difficulties.

Table 12.1. SEPA Faecal coliform results (F. coliforms / 100g) for commercial shellfish gathered from Seil Point.

	Site	Seil Sound: Ardencaple
	NGR	NM 776 194
1999	Q3	-
	Q4	500
2000	Q1	70
	Q2	40
	Q3	310
	Q4	-
2001	Q1	220
	Q2	500
	Q3	40
	Q4	700
2002	Q1	750
	Q2	40
	Q3	5400
	Q4	500
2003	Q1	<20*
	Q2	-
	Q3	-
	Q4	-

* Assigned a nominal value of 10 for the purpose of calculating the geometric mean

The geometric mean result of the samples reported as being gathered from NGR NM 776194 is 204 faecal coliforms / 100g. 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 geometric mean level of contamination in commercial shellfish taken by SEPA is however very similar the overall geometric mean of the shellfish samples tested for *E. coli* (183 mpn/100g).

Results for the physical and chemical parameters monitored by SEPA are not presented in this report.

13. Bathymetry and Hydrodynamics

Figure 13.1 Seil Point Bathymetry at LAT

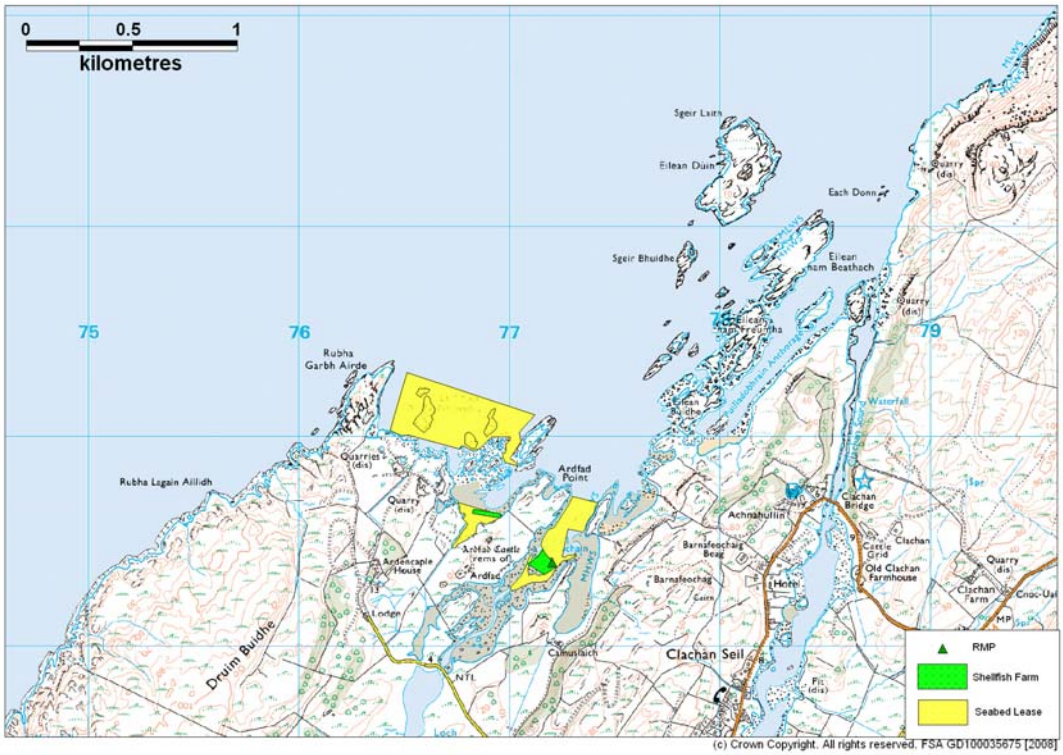

Figure 13.2 Seil Point OS at LAT

The bathymetry chart above shows that the depth ranges from zero to over 50 metres, with extensive drying areas in the vicinity of the shellfish farms. Depths increase rapidly away from shore.

13.1 Tidal Curve and Description

The two tidal curves below are for the port of Seil Sound, which is located south of Seil Point – these have been output from UKHO TotalTide. The first is for seven days beginning 00.00 GMT on 08/08/07 and the second if for seven days beginning 00.00 GMT on 15/08/07. This two-week period covers the date on which the shoreline survey was undertaken. Together they show the predicted tidal heights over high/low water for a full neap/spring tidal cycle.

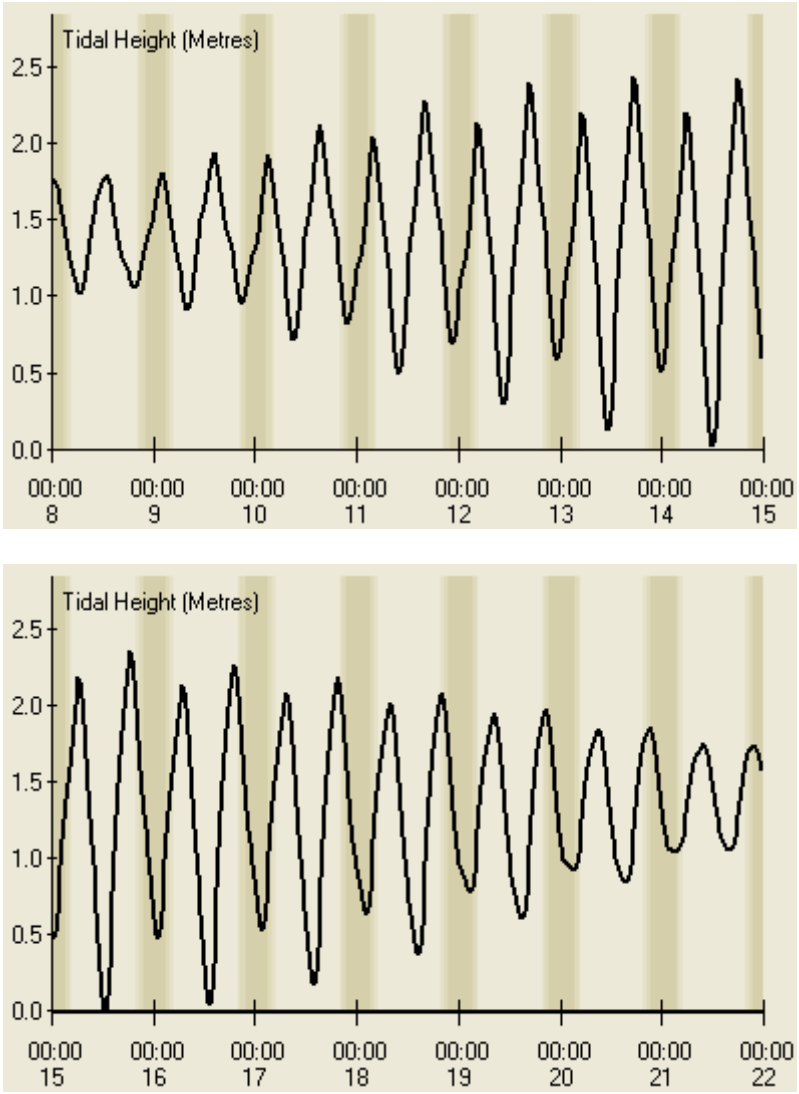

Figure 13.3 Tidal curves for Seil Sound

The following is the summary description for Seil Sound from TotalTide:

The tide type is Semi-Diurnal.

MHWS	2.7 m
MHWN	2.0 m
MLWN	1.1 m
MLWS	0.4 m

Predicted heights are in metres above chart datum. The tidal range at spring tide is therefore approximately 2.3 m and at neap tide 0.9 m.

13.2 Currents – Tidal Stream Software Output and Description

Tidal stream information is available for the Firth of Lorn station SN037J which lies in the Firth of Lorn to the north of the Seil Point shellfish farms and station SN037H which lies to the south of the farms. Following is tidal stream information as recorded for 13 August 2007.

Table 13.1 Tidal stream information

SN037H			SN037J		
Time (GMT)	Speed (m/s)	Direction	Time (GMT)	Speed (m/s)	Direction
01:00	0.18	036°	01:00	0.23	339°
03:00	0.40	025°	03:00	0.27	029°
05:00	0.23	033°	05:00	0.25	064°
07:00	0.10	194°	07:00	0.19	163°
09:00	0.36	209°	09:00	0.29	201°
11:00	0.30	204°	11:00	0.22	237°
13:00	0.18	036°	13:00	0.24	338°
15:00	0.42	025°	15:00	0.29	029°
17:00	0.24	033°	17:00	0.26	064°
19:00	0.10	193°	19:00	0.20	162°
21:00	0.38	209°	21:00	0.30	201°
23:00	0.32	204°	23:00	0.23	236°

Times of maximum ebb at SN037H were 06:00 and 18:00 (0.05 m/s) and maximum flood was at 15:00 (0.46 m/s).

There was less variation in current speeds at SN037J, with the maximum flow rate of 0.31 m/s occurring at 9 of the hourly intervals reported on the day. Lowest current speed (0.15 m/s) was recorded at 06:00 and 12:00.

Figure 13.4 shows the speed and direction of tides at times of highest and lowest current speeds on the date of the shoreline survey. Times are given in GMT without offset for daylight savings time.

Current are slightly stronger on the flood than on the ebb tides. Given the open aspect of the oyster harvesting area, water is likely to be completely exchanged daily and contaminants are unlikely to linger in the vicinity of the fishery. Depths in the Firth of Lorn are likely to provide significant dilution of contaminants, further reducing the impact of pollution near the oyster farms.

Although tidal flows in the Firth of Lorn move water up and down the Firth, it is possible that in the bays at Seil Point eddies form at certain times, thereby slowing the exchange of water.

Figure 13.4 Tidal flows for Seil Sound, 13 August 2007

14. River Flow

There are no river gauging stations on rivers or burns feeding to Seil Point.

The following streams were measured and sampled during the shoreline survey. These represented the largest freshwater inputs to Seil Point.

Table 14.1 River flows and loadings – Seil Point

No	Grid Ref	Description	Width (m)	Depth (m)	Meas. Flow (m/s)	Flow (m3/day)	*E.coli* (cfu/100ml)	Loading (*E.coli* per day)
1	NM 76594 19867	Stream	0.88	0.03	0.4	912	1100	1.0×10^{10}
2	NM 76769 19632	Stream	0.22	0.01	0.2	38	200	7.6×10^{7}
3	NM 76754 19488	Stream	0.52	0.03	0.6	809	1900	1.5×10^{10}
4	NM 77008 19643	Stream	0.28	0.04	1	968	100	9.7×10^{8}
5	NM 76868 19238	Brackish Stream*	2.8	0.07	0.4	6774	290	2.0×10^{10}

* Freshwater stream sampled below the high water mark on an ebbing tide (salinity 20.4 ppt).

Of these, streams number 2, 3, 4 and 5 empty into the bay at points closest to the shellfish farms, as shown on the map in Figure 14.1.

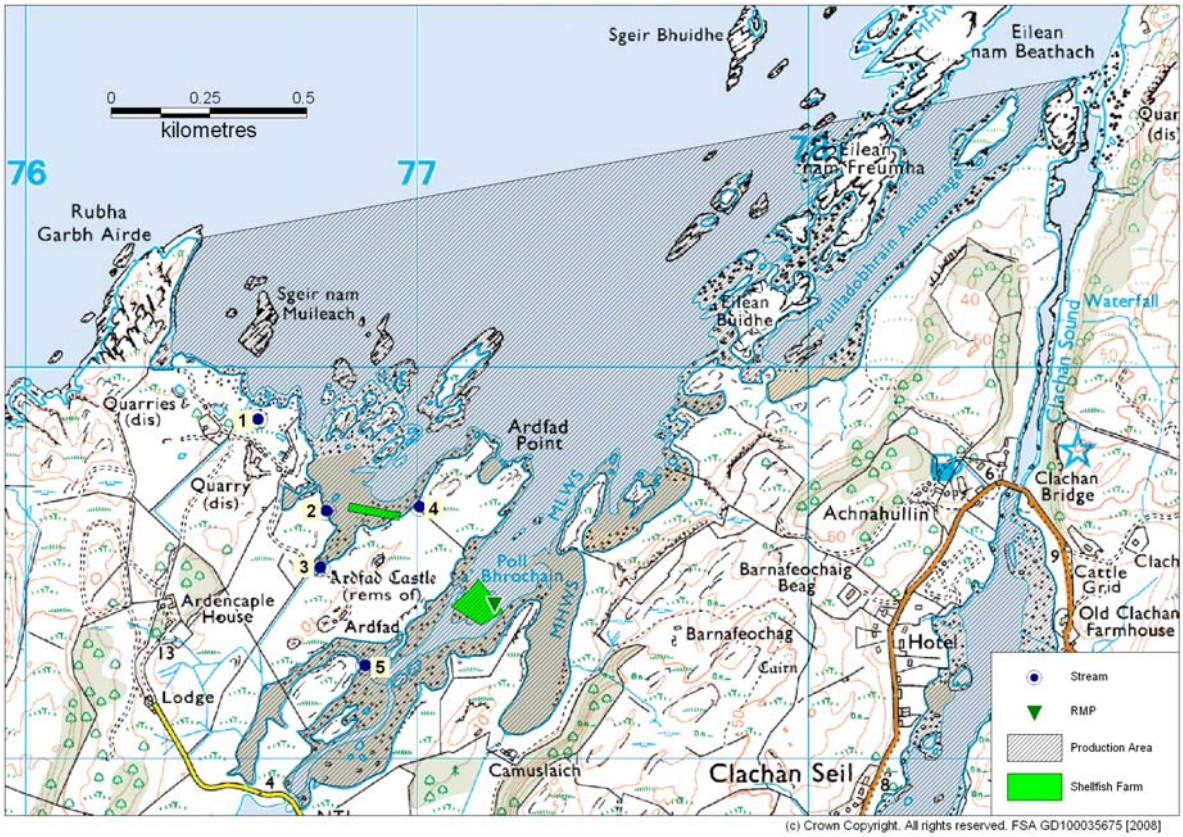

Figure 14.1 Map of significant streams and loadings

In addition to the freshwater inputs described above, there is a small tidal loch (Loch Caithlim) which is connected to the head of the production area. Flow was estimated at 0.75 m^3/s at approaching low tide, but it will flow in the opposite direction as the tide floods, so the bacterial loadings coming from this source cannot be calculated. Salinity and *E. coli* levels at the head of the production area and in Loch Caithlim were very similar.

15. Shoreline Survey Overview

The sanitary survey for this site was triggered by a high score on the risk matrix. This was due to a combination of high number of historic monitoring results outwith its classification, and the species involved (oysters).

The shoreline survey was conducted on 13-14 August 2007.

Human population in the area is low. There are several very small summer houses near the shoreline adjacent to the fishery, and Ardencaple House further back, but no sewage discharges were found directly entering into the production area. Further afield, at Clachan Seil, there is a Scottish Water treatment works discharging into Clachan Sound as well as several private discharges.

The land adjacent to the production area is a mixture of forest, unimproved pasture and heath. Evidence of livestock presence (droppings) was found on the shoreline adjacent of the production area, but no animals were seen during the survey. Some parts of the shoreline are closed to stock from June to September to protect breeding birds. A cattle shed is located on the shore of Loch Caithlim. A dung heap was observed next to this shed, and shed sweepings are sporadically dumped on the shore here.

A number of small streams discharge into the production area but none of their bacterial loadings are particularly high.

A total of 7 seals were observed foraging or resting within the production area. 7 large sailing yachts were seen anchored at the Puilladobhrain Anchorage which lies within the production area, but can be considered as a separate bay at most states of tide.

The two oyster samples taken on the shoreline survey both had moderate levels of *E. coli* (160 and 750 mpn/100g), with the more contaminated sample originating from the eastern area of trestles. Seawater samples were more contaminated at the head of the larger inlet towards the Loch Caithlim outlet where salinity was lower.

In summary, the main sources of potential contamination identified on the shoreline survey were light to moderately contaminated freshwater inputs, seals, sweepings from the livestock shed, and inputs from livestock grazing on or near the shoreline outside of the bird breeding season.

16. Overall Assessment

Human Sewage Impacts

There are no sewage discharges directly to the production area and little in terms human settlements on the adjacent shores. There are several very small summer houses near the shoreline adjacent to the fishery, and Ardencaple House further back.

The nearest sewage discharges are at the settlement of Clachan Seil, approximately 2 km away from the production area boundaries by sea. Here, there are a small number of septic tank and overflow discharges which discharge to Clachan Sound. To reach the production area, contamination originating from Clachan Seil would have to pass through the narrow and shallow northern end of Clachan Sound then be carried south along the shoreline into the production area so it is unlikely that these contamination from these discharges would reach the fishery.

Agricultural Impacts

Numbers of livestock raised on the shoreline adjacent to the production area is uncertain. At the time of the shoreline survey there were no livestock visible around the Seil Point area. However, evidence of livestock presence was found on the shoreline adjacent to the production area, and much of the land adjacent to the production area is unimproved grassland which could be used for grazing. Some parts of the shoreline are closed to stock from June to September to protect breeding birds. The shoreline was not fenced off and so would be accessible to stock, so diffuse inputs from stock might be expected to have some impact on the fishery, primarily outside of the bird breeding season.

A cattle shed is located on the shore of Loch Caithlim, and sweepings from this shed are sporadically dumped on the shore here. This may represent a significant point source close to the head of the eastern bay under certain conditions such as heavy rainfall on fresh sweepings.

Wildlife impacts

There are three significant colonies of harbour seals near to the production area, and a total of seven seals were seen foraging within the production area during the course of the shoreline survey. Their presence is year round, but numbers are likely to fluctuate depending on prey availability here and elsewhere. Under suitable tidal conditions it is probable that the seals forage close to or even amongst the trestles.

Other wildlife such as cetaceans, waterbirds, deer and otter are likely to be resident in or visit the area, but not in large numbers. Overall, wildlife impacts to the fisheries at Seil Point are likely to be localised and unpredictable and will therefore not be explicitly taken into account in determining the sampling plan, but impacts from seals and possibly other wildlife may sometimes be of significance.

Seasonal variation

Historical monitoring results were higher in the summer and autumn compared to the winter and spring. Livestock numbers in the area as a whole are likely to be at their highest during the summer months when lambs and calves are present, but livestock are excluded from parts of the shoreline from June to September. During the warmer months livestock will access streams to drink and cool off more frequently.

Seil Island is a tourist destination, so the population in settlements such as Clachan Seil is likely to be higher in the summer months, although it is unlikely that the impact of this will be significant in the production area. Two very small cottages were seen on the shoreline adjacent to the production area, but whether these are used as tourist accommodation or simply as summer houses for Ardencaple House is uncertain. Numbers of visiting yachts using the Puillodobhrain anchorage are also likely to be higher in the summer.

Rivers and streams

Freshwater inputs to the production areas consist only of small watercourses. Generally, as the watercourse are small and not heavily contaminated, and the body of water into which they are discharging is large, the impacts of these will be minor.

Three small watercourses discharge into the bay where the western set of trestles are located. At least one small stream and Loch Caithlim discharge into the larger bay where the eastern set of trestles are located. It is probable that these will significantly contribute to the *E. coli* content of shellfish here, particularly given the absence of other sources, and it might be expected that levels of contamination from these sources will increase following heavy rainfall.

Meterology and movement of contaminants

Rainfall patterns at Kimelford (the nearest rainfall station) show rainfall is highest from September through to January. An increase in rainfall in September after the drier summer months may be expected to wash a flush of bacteria from the surrounding land into the production area. However, no correlation between rainfall in the previous 2 days and historic monitoring results was found, and only an extremely weak relationship was found between rainfall in the previous 7 days and historic monitoring results.

A correlation between wind direction and *E. coli* result was found with higher results occurring during periods of westerly winds, despite the site being more exposed to northerly winds.

Tidal exchange of water is likely to be high, as the trestles are located in small shallow bays adjacent to a large water body (the Firth of Lorn). In the bay where the eastern set of trestles is located, water exchange may be lessened as water will be held up in Loch Caithlim so contamination may be flushed more slowly from this side.

Analysis of results

Historic shellfish hygiene monitoring results are available from 1999 to present, with samples collected from three reported locations, all within the eastern bay so no comparison of results between the two bays could be made. No difference in the results obtained from these three locations was found, and no overall improvement or deterioration in microbiological quality was seen during this period.

SEPA have reported shellfish growing waters monitoring results from 1999 onward. Commercial shellfish samples from the production area and tested for faecal coliforms up to mid 2002, and the geometric mean result was very similar to the geometric mean *E. coli* result from the FSAS monitoring programme.

Seawater samples taken from the shore during the shoreline survey from within the production area had varying levels of contamination (2 - 420 *E. coli* cfu/100ml) with lower results at they eastern and western extremities of the area, and higher results in the middle of the production area in the bays in which the trestles were located. Highest results were found towards the head of the eastern bay, near the Loch Caithlim outlet, where salinity was lowest.

Levels of contamination and calculated bacterial loadings for streams discharging into the production area were relatively low, and the Firth of Lorn is a large body of water. As noted in the previous paragraph, highest results were found at lower salinities so it is likely that these inputs are responsible for carrying most of the contamination into the production area.

Of the two oyster samples taken on the shoreline survey the one taken from the eastern bay had higher levels of *E. coli* then the one taken from the western bay (750 and 160 mpn/100g respectively), further reinforcing the case for setting the RMP in the eastern bay. Both tested negative for norovirus.

Summary

Factors of relevance to the sampling plan are as follows:

- Seasonality and variability of results, diffuse agricultural inputs and possibly usage of the Puillodobhrain Anchorage would suggest monthly monitoring is appropriate
- Identification of a potentially significant point source of contamination (cattle shed) at the head of the eastern bay would suggest the RMP should be set in the eastern bay.
- More freshwater input to the eastern bay also suggest that the RMP should be set in the eastern bay.
- Water and shellfish results, taken during the shoreline survey confirm the assertion that the RMP should be located in the eastern bay.

Other factors considered in this report have no material affect on the proposed sampling plan for reasons already discussed.

17. Recommendations

The current production area boundaries are given as the area inside of a line drawn between NM 7644 2033 (Rubha Garbh Airde) and NM 7868 2074 (Eilean nam Beathach).

This includes two bays where oysters are currently cultured. Water and oyster samples collected during the shoreline survey from the larger, eastern bay were slightly more contaminated than those taken from the western bay, but this difference was not so great as to constitute a reason for splitting the production area. It must be noted that there has been no historical sampling of the western bay which could be used to confirm these findings.

As there is no oyster culture within the Puillidobhrain Anchorage, and this partially enclosed bay may receive human inputs from visiting yachts at times, it is recommended that the production area boundaries should be moved to exclude this area. This will also bring the production area boundaries to a very similar position to the SEPA designated growing water boundaries. The recommended production area boundaries are the area inside of a line drawn between NM 7644 2033 (Rubha Garbh Airde) and NM 7782 2000 (Eilean Buidhe).

The RMP should be set at NM 7710 1938, in the eastern area of trestles. The sample taken from here during the shoreline survey yielded the highest result of the two samples, and water samples from this area were slightly more contaminated than those taken near the western area of trestles.

No sampling depth is applicable as the shellfish are grown on trestles. It is recommended that a dedicated sampling bag be placed in this location from which mature stock, which have been placed inside this bag for a minimum of two weeks should be sampled.

It is recommended that monthly sampling be maintained for this production area because of the seasonal changes in levels of contamination.

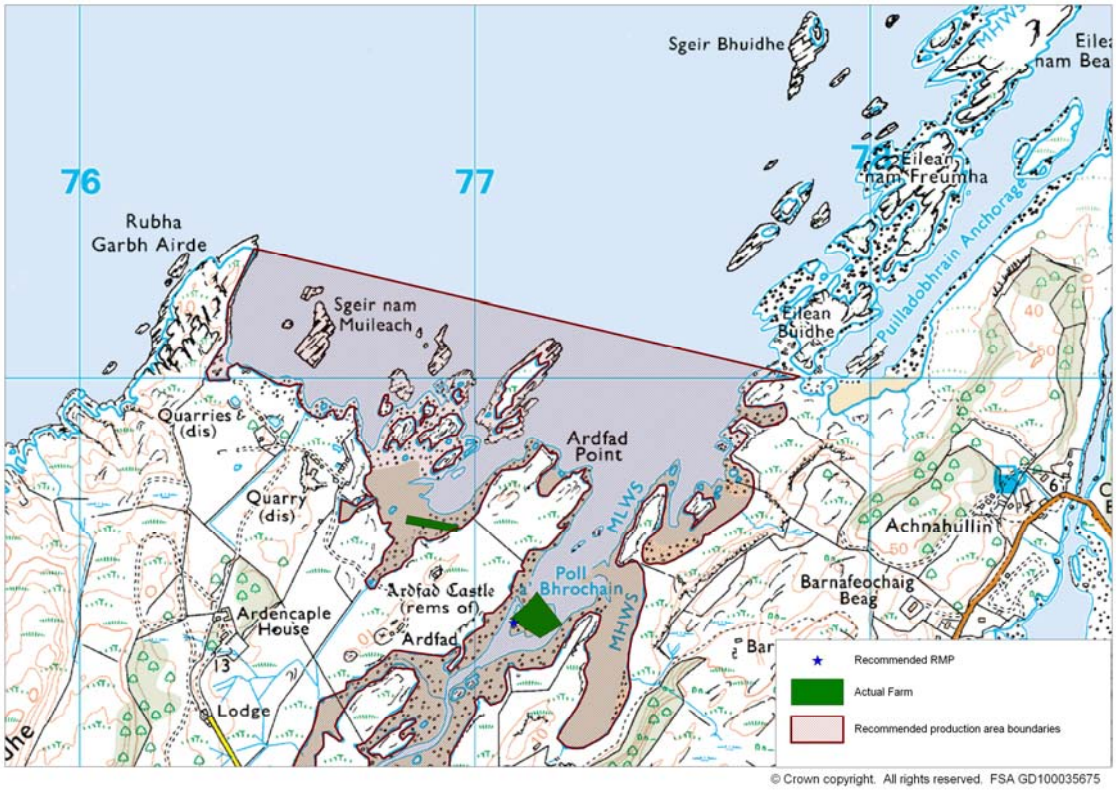

Figure 17.1 Map of recommendations

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19. List of Tables and Figures

Appendices

1. Shoreline Survey Report
2. Sampling Plan
3. Tables of Typical Faecal Bacteria Concentrations
4. Statistical Data
5. Hydrographic Methods
6. Norovirus Testing Summary

Shoreline Survey Report

Seil Point
AB 245

Scottish Sanitary Survey Project

Shoreline Survey Report

Prod. area:	Seil Point
Site names:	Seil Point Ardencaple – Cyster (AB 245 070 13)
	Seil Point Ardencaple – Cadzow (AB 245 069 13)
Species:	Pacific Oyster
Harvester:	Patrick Cadzow, David Cyster
Local Authority:	Argyll & Bute Council
Status:	Classified: 2007-8, A= Dec to Mar, B=Apr to Nov
Date Surveyed:	13-14 August 2007
Surveyed by:	Christine MacLachlan, Alastair Cook
Existing RMP:	NM772194
Area Surveyed:	See Map in Figure 1

Weather observations

Light south-westerly winds, cloudy with sunny spells.

Site Observations

Specific observations taken on site are mapped in Figure 1 and listed in Table 1. Water and shellfish samples were collected at sites marked on the Figures 2 and 3. Bacteriology results are presented in Tables 2 and 3.

Fishery

Ardencaple - Cyster. The site consists of two areas of trestle grown oysters; the entire area of trestles in the western bay, and the western half of the area of trestles in the eastern bay. Harvesting is year round, and dependant on weather. Small seed is used (0.07g) and as a consequence take 4 years to grow to a market size. They are sent to the ScotTrout processors at Bellshill.

Ardencaple - Cadzow. The site is an area of trestle grown oysters covering the eastern half of the area of trestles in the eastern bay.

Stock of a range of sizes was observed including some of market size.

Sewage/Faecal Sources

Human population in this area is low. There are several very small summer houses near the shoreline adjacent to the fishery, and Ardencaple House further back, but no sewage discharges were found directly entering into the production area. Further afield, at Clachan Seil, there is a Scottish Water treatment works discharging into Clachan Sound. Although appearing of recent construction, this only serves a part of the population of Clachan Seil, and several private discharges running into Clachan Sound were observed nearby. Scottish Water are considering carrying out improvements to the system so it will have the capacity to serve the entire village. If this scheme goes ahead work will begin in 2008.

Evidence of livestock presence was found on the shoreline adjacent of the production area, but no animals were seen on the day of survey. The Ardencaple gamekeeper advised that some parts of the shoreline are closed to stock from June to September to protect breeding birds. The shoreline was not fenced off and so would be accessible to stock. Of note, a cattle shed is located just above the head of the Ardencaple - Cyster site on the shore of Loch Caithlim. A dung heap was observed next to this shed, and the grower reports that the sweepings from the shed are sporadically dumped on the shore here.

There a number of small streams discharging into the production area but overall freshwater input is low.

Seasonal Population

The area is reportedly popular with holiday makers, and there are a few hotels and some self catering accommodation on Seil Island. No camp-sites were observed.

Boats/Shipping

To the northwest of the production area, around a headland is the Puilladobhrain Anchorage where 7 large sailing yachts were anchored at the time of survey. 5 smaller yachts were moored in Seil Sound, just off Clachan Seil at the time of survey. An unoccupied mooring was observed in the north west of the production area.

Land Use

The surrounding land is a mixture of forest, moorland and pasture. The shoreline adjacent to the production area is owned by Ardencaple House, and is managed for limited livestock grazing and for shooting.

Wildlife/Birds

A total of seven seals were observed either foraging or resting in the production area. The grower reports that seals are resident year round, the maximum numbers are about 20-30, and the population is increasing. It is likely there are deer in the area but none were seen during the course of the survey. No significant concentrations of wildfowl such as geese were observed.

Summary

Identified sources of potentially significant faecal contamination were:

- Light to moderately contaminated minor freshwater inputs.
- Seals foraging in the production area.
- Inputs from livestock grazing on or near the shoreline outside of the bird breeding season.
- Sweepings from the livestock shed on the shore of Loch Caithlim.

Although it is likely than livestock number on the Seil Island are at their highest during the summer months, they are kept away from parts of the shoreline to protect breeding birds. Human population on the island and numbers of visiting pleasure yachts are likely to be at their highest during the summer months.

Figure 1. Map of Shoreline Observations

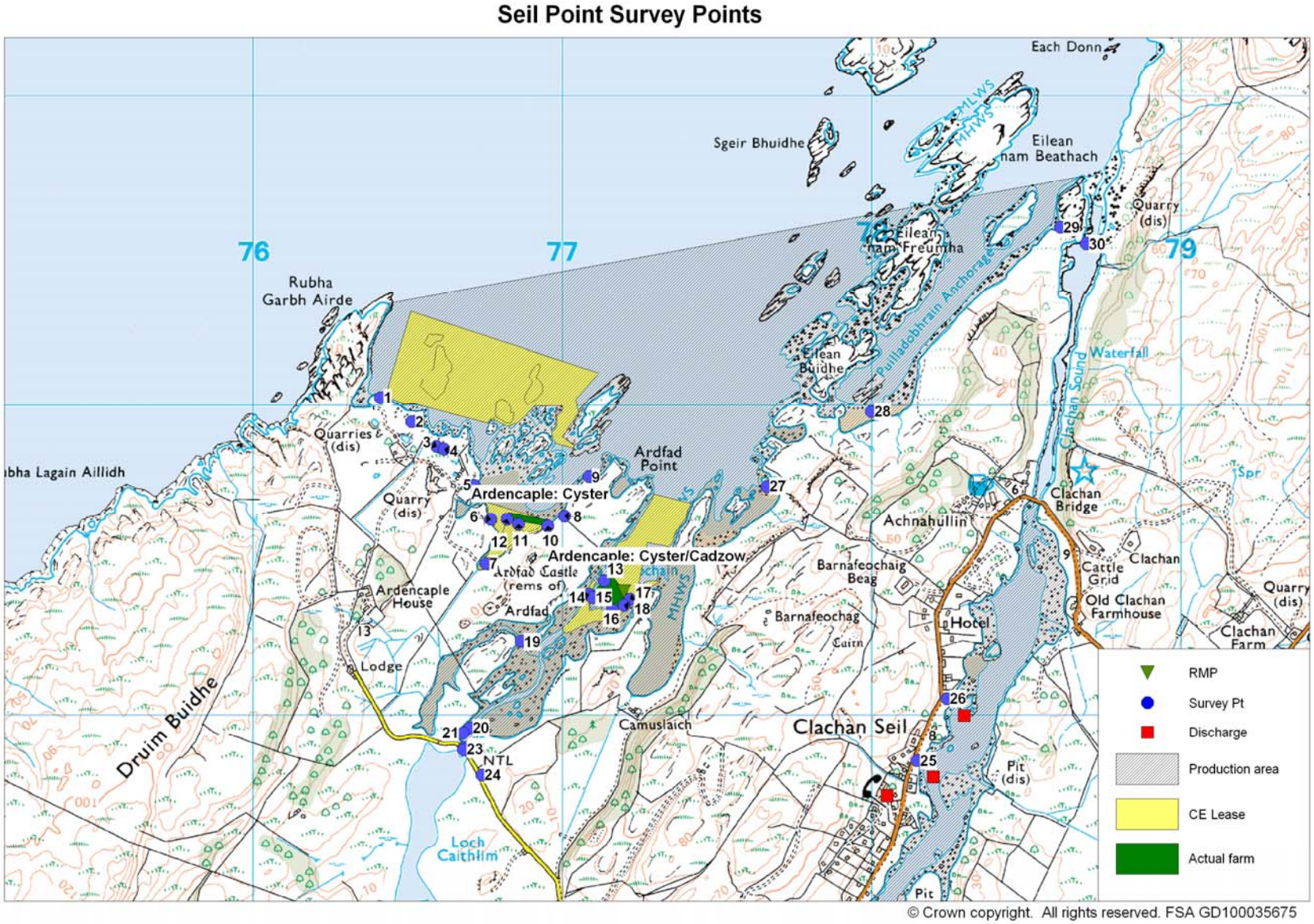


Table 1. Shoreline Observations

No.	Date	Time	NGR	Photograph	Notes
1	13-Aug-07		NM 76412 20026	Figure 4	Water sample 1. 1 mooring buoy just offshore
2	13-Aug-07		NM 76514 19947		Tiny house, unoccupied
3	13-Aug-07		NM 76594 19867	Figure 5	Stream 88cmx3cmx0.4m/s water sample 2 (fresh)
4	13-Aug-07		NM 76619 19858		Tiny house, unoccupied
5	13-Aug-07		NM 76716 19743	Figure 6	Cowpat, shore not fenced off
6	13-Aug-07		NM 76769 19632		Stream 22cmx1cmx0.2m/s water sample 3 (fresh)
7	13-Aug-07		NM 76754 19488		Stream 52cmx3cmx0.6m/s water sample 4 (fresh)
8	13-Aug-07		NM 77008 19643		Stream 28cmx4cmx1m/s water sample 5 (fresh). 7 seals observed in water or resting on rocks.
9	13-Aug-07		NM 77087 19771		water sample 6
10	13-Aug-07		NM 76953 19610	Figures 7 & 8	End of trestles ~20m out from here (water too deep to get there)
11	13-Aug-07		NM 76859 19617		Oyster sample 1 (E Coli) and A (Norovirus). Water sample 7.
12	13-Aug-07		NM 76823 19632		End of trestles (inshore corner, outside corner ~20m out from here but water too deep).
13	13-Aug-07		NM 77136 19435	Figure 9	Corner of trestles 30m north of here. Edge runs straight across bay to other side. Water sample 8.
14	13-Aug-07		NM 77087 19391		Corner of trestles. Edge runs straight across bay to other side. Harvesting area.
15	13-Aug-07		NM 77097 19381		RMP. Oyster sample 2 (E Coli) and B (Norovirus).
16	13-Aug-07		NM 77163 19341		Corner of trestles.
17	13-Aug-07		NM 77219 19376		Corner of trestles.
18	13-Aug-07		NM 77200 19356		Water sample 9.
19	13-Aug-07		NM 76868 19238	Figure 10	Brackish stream 280cmx7cmx0.4m/s. Water sample 10.
20	13-Aug-07		NM 76702 18959		Water sample 11.
21	13-Aug-07		NM 76680 18942	Figure 11	Oysters left here after harvesting for collection by Bells Hill the following day.
22	13-Aug-07		NM 76684 18896	Figure 12	Loch outlet, estimated 1mx25cmx3m/s at time of survey (tidally dependant).
23	13-Aug-07		NM 76681 18888	Figure 13	Water sample 12 (u/s of loch outlet).
24	13-Aug-07		NM 76741 18807	Figures 14 & 15	Cattle shed and dung heap.
25	13-Aug-07		NM 78147 18853	Figure 16	Clachan Seil Sewage pumping station (outlet pipe not visible). Several other private septic pipes also seen from here.
26	13-Aug-07		NM 78244 19054	Figure 17	Inspection cover in layby, probably associated with the 2nd Clachan Seil discharge (pipe not seen however). 5 yachts moored in sound.
27	13-Aug-07		NM 77661 19739		Water sample 13.
28	13-Aug-07		NM 78000 19980		Water sample 14. 7 large yachts in anchorage.
29	13-Aug-07		NM 78611 20575		Water sample 15.
30	13-Aug-07		NM 78694 20524		Water sample 16.

Photographs referenced in the table can be found attached as Figures 4 -17.

Table 2. Water Sample Results

No.	Sample ID	*E. coli* (cfu/100ml)	Salinity (g/L)
1	Water sample 1	2	31.6
2	Water sample 2	1100	0
3	Water sample 3	200	0
4	Water sample 4	1900	0
5	Water sample 5	100	0
6	Water sample 6	25	31.0
7	Water sample 7	220	24.7
8	Water sample 8	14	31.1
9	Water sample 9	330	23.2
10	Water sample 10	290	20.4
11	Water sample 11	420	23.7
12	Water sample 12	310	23.7
13	Water sample 13	27	27.8
14	Water sample 14	24	30.3
15	Water sample 15	2	31.0
16	Water sample 16	4	30.7

Table 3. Shellfish Sample Results

No.	Sample ID	*E. coli* (MPN/100g)	Norovirus genogroup I	Norovirus genogroup II
1	Oyster sample 1	160	Not detected	Not detected
2	Oyster sample 2	750	Not detected	Not detected

Fig. 2. Water sample results map

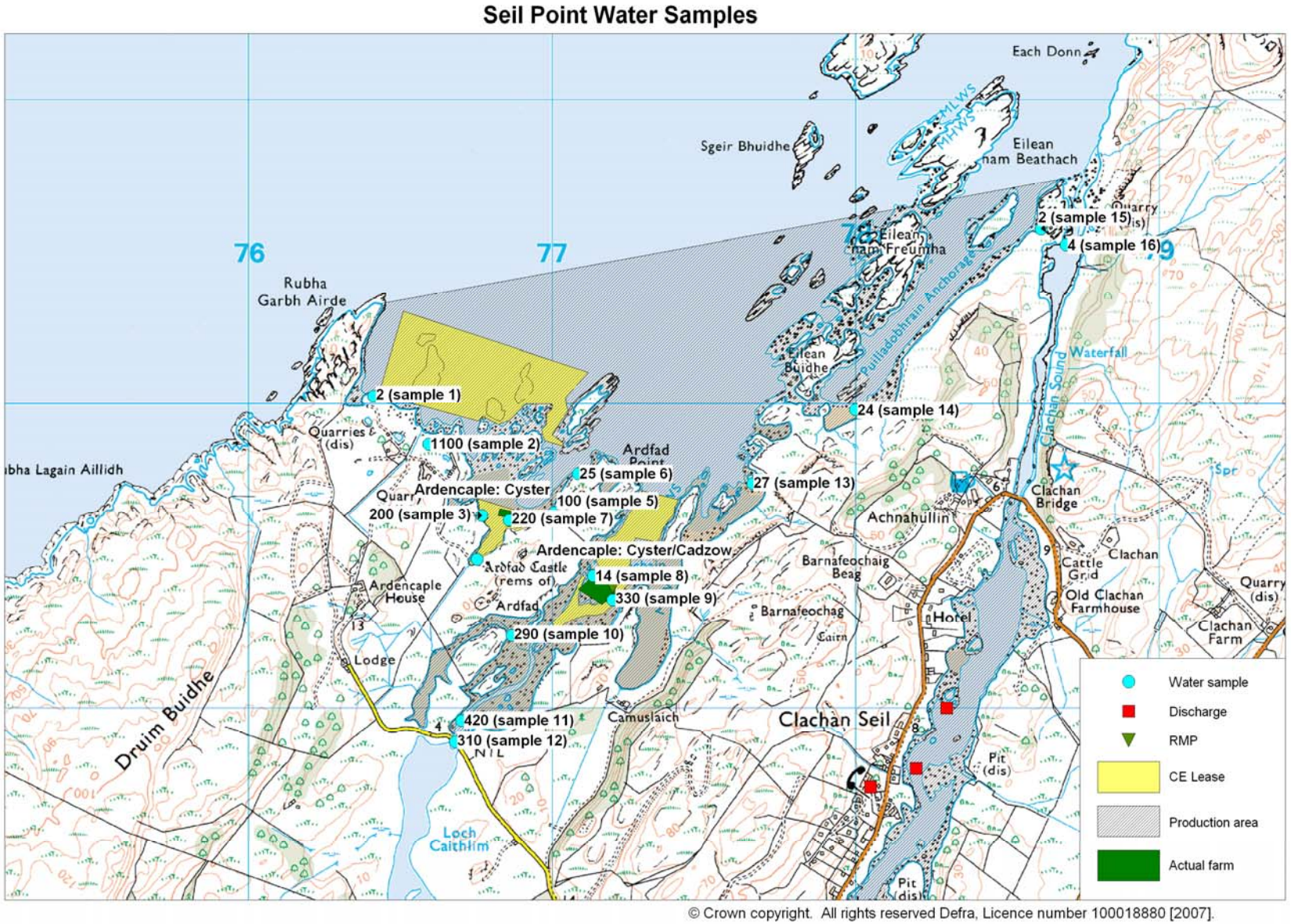
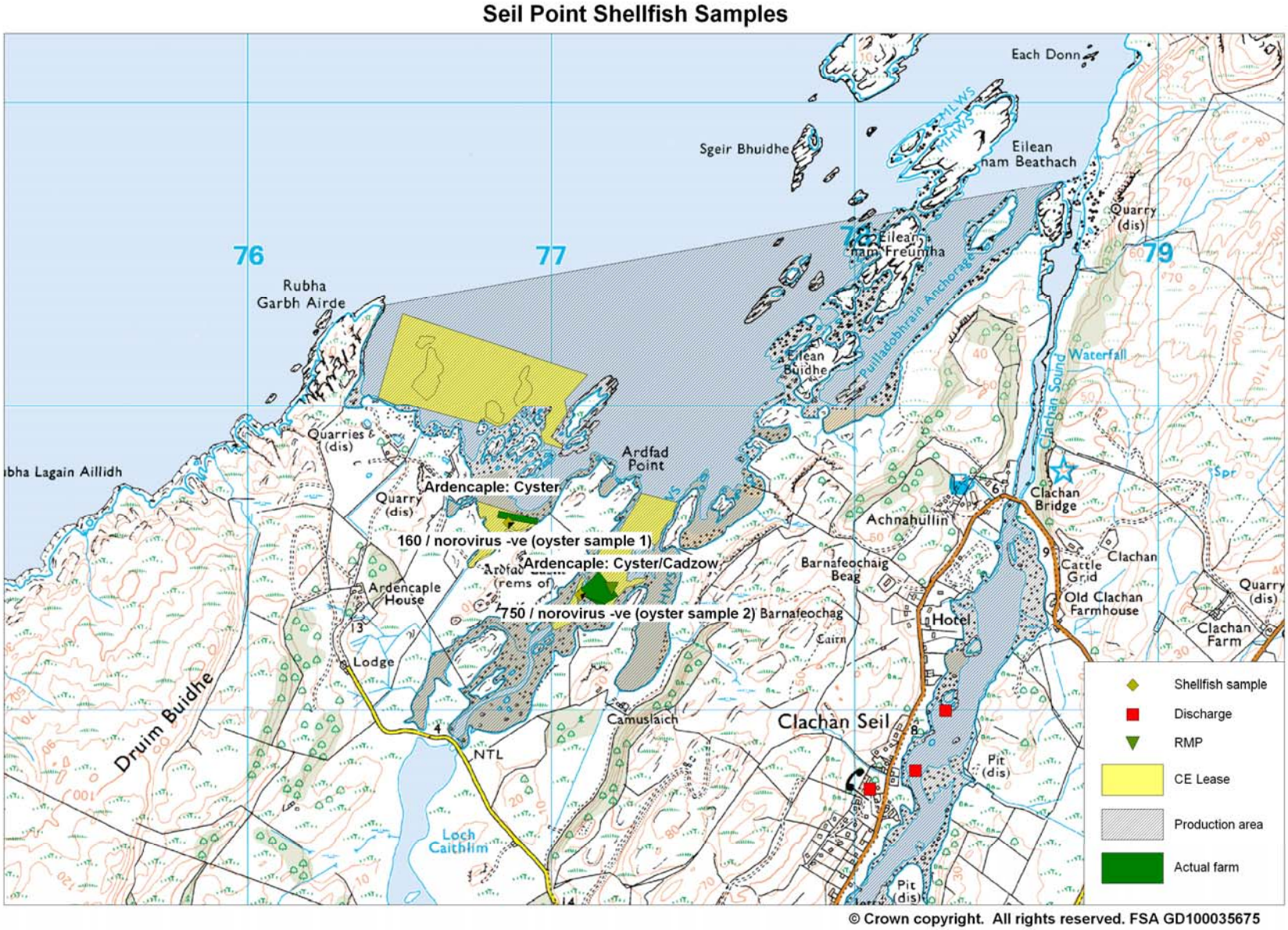


Figure 3. Shellfish sample results map



Photographs

Figure 4. Water sample 1 being collected from the west end of the area

Figure 5. Stream from which water sample 2 was collected

Figure 6. Cowpat close to shoreline

Figure 7. Trestles in the western bay

Figure 8. Trestles in the western bay

Figure 9. Trestles in the eastern bay

Figure 10. Water sample 10 being collected

Figure 11. Spot where oysters are left for collection by the processors

Figure 12. Loch Caithlim outlet looking north the eastern area of trestles

Figure 13. Upstream end of Loch Caithlim outlet

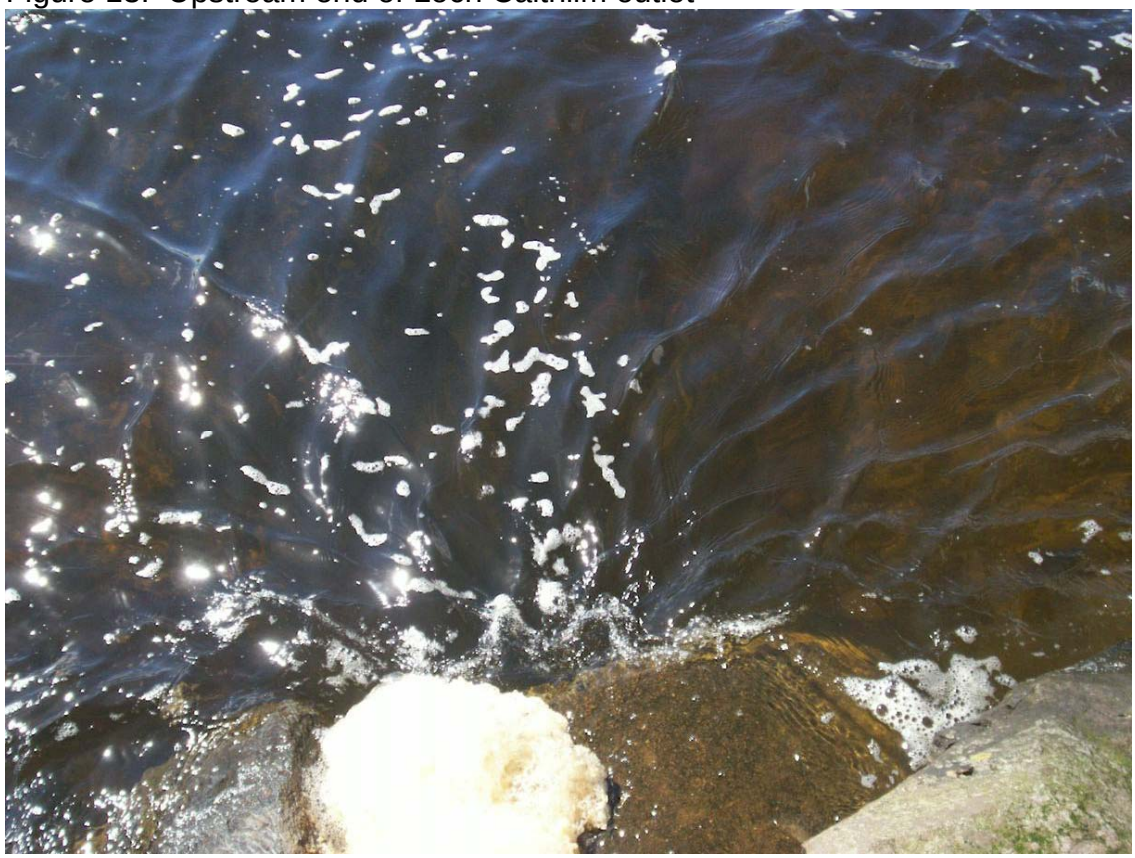


Figure 14. Dung heap on shore of Loch Caithlim just upstream of outlet

Figure 15. Cattle shed by shore of Loch Caithlim just upstream of outlet

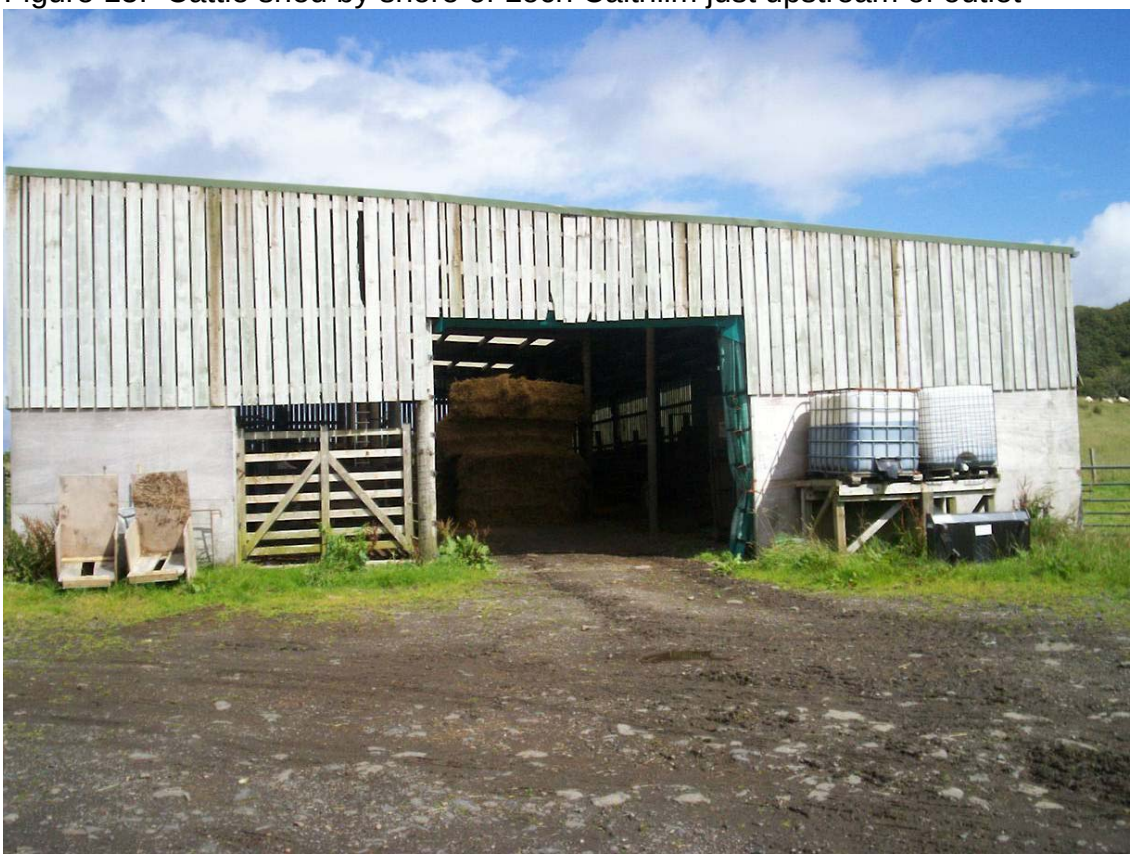


Figure 16. Clachan seil sewage works

Figure 17. Puilladobhrain anchorage viewed from the southern end

Sampling Plan for Seil Point

PRODUC-TION AREA	SITE NAME	SIN	SPECIES	TYPE OF FISH-ERY	NGR OF RMP	EAST	NORTH	TOLER-ANCE (M)	DEPTH (M)	METHOD OF SAMPLING	FREQ OF SAMPLING	LOCAL AUTHORITY	AUTHORISED SAMPLER(S)	LOCAL AUTHORITY LIAISON OFFICER
Seil Point	Ardencaple: Cyster	AB 245 070 13	Pacific oyster	Trestles	NM 7710 1938	17710	71938	10	NA	Hand	Monthly	Argyll & Bute Council	Christine McLachlan William MacQuarrie Ewan McDougall Donald Campbell	Christine McLachlan

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

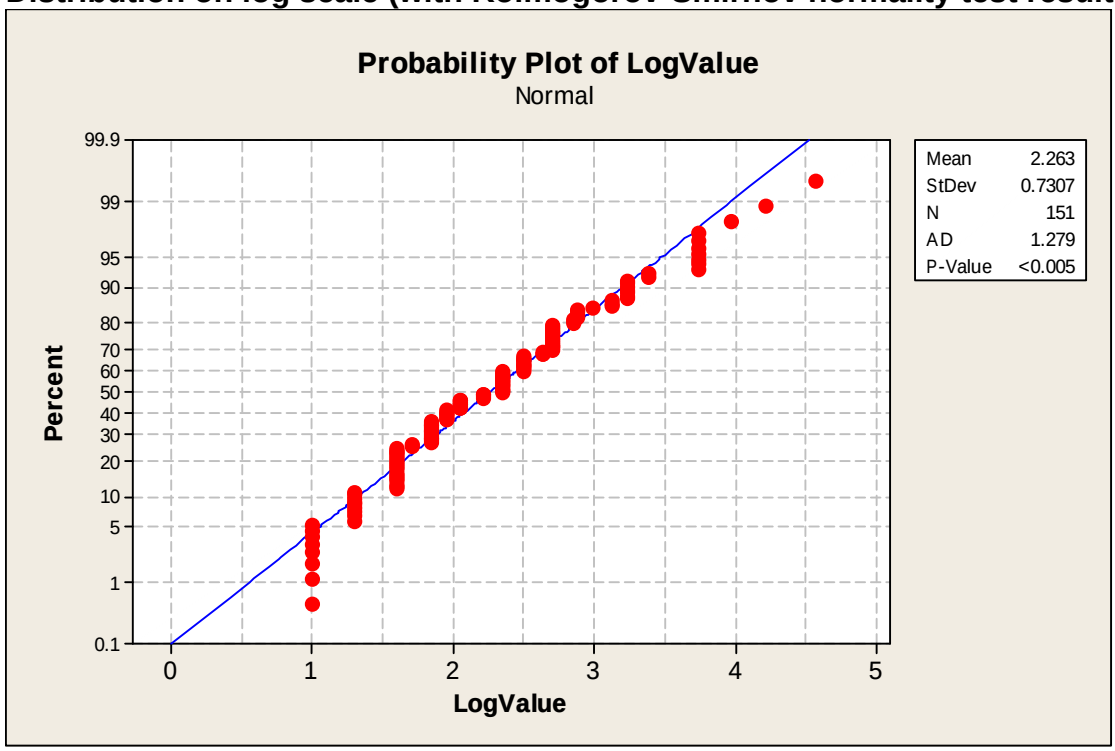
Animal	Faecal coliforms (FC) number	Excretion (g/day)	FC Load (numbers /day)
Chicken	1,300,000	182	2.3×10^{8}
Cow	230,000	23,600	5.4×10^{9}
Duck	33,000,000	336	1.1×10^{10}
Horse	12,600	20,000	2.5×10^{8}
Pig	3,300,000	2,700	8.9×10^{8}
Sheep	16,000,000	1,130	1.8×10^{10}
Turkey	290,000	448	1.3×10^{8}
Human	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 analyses were undertaken using log transformed results as this gives a more normal distribution.

Distribution on log scale (with Kolmogorov-Smirnov normality test results)



ANOVA comparison of log results by reported sampling location

```
Source   DF      SS     MS     F      P
MapRef    2   0.979  0.490  0.92  0.402
Error   148  79.101  0.534
Total   150  80.080

S = 0.7311   R-Sq = 1.22%   R-Sq(adj) = 0.00%

                              Individual 95% CIs For Mean Based on
                              Pooled StDev
Level      N    Mean   StDev  ----+---------+---------+---------+-----
NM769193  54  2.2087  0.8098  (-----------*-----------)
NM772194  55  2.2178  0.6606  (-----------*-----------)
NM773194  42  2.3928  0.7119            (------------*------------)
                              ----+---------+---------+---------+-----
                                2.08      2.24      2.40      2.56

Pooled StDev = 0.7311
```

ANOVA comparison of log results by season with Tukeys comparison

```
Source   DF      SS     MS      F      P
Season    3  16.941  5.647  13.15  0.000
Error   147  63.139  0.430
Total   150  80.080

S = 0.6554   R-Sq = 21.16%   R-Sq(adj) = 19.55%
```

```
                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N    Mean   StDev  ---------+---------+---------+---------+
1      41  2.0500  0.7210             (-----*----)
2      42  2.6319  0.7296                          (-----*-----)
3      43  2.4368  0.6531                     (-----*----)
4      25  1.6950  0.3295  (------*-------)
                          ---------+---------+---------+---------+
                                 1.75      2.10      2.45      2.80

Pooled StDev = 0.6554


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

Individual confidence level = 98.98%


Season = 1 subtracted from:

Season    Lower   Center   Upper     +---------+---------+---------+---------
2        0.2075   0.5819  0.9563                          (----*-----)
3        0.0145   0.3868  0.7590                    (-----*----)
4       -0.7878  -0.3551  0.0777              (-----*-----)
                          +---------+---------+---------+---------
                        -1.40     -0.70      0.00      0.70


Season = 2 subtracted from:

Season    Lower   Center    Upper     +---------+---------+---------+---------
3       -0.5651  -0.1951   0.1749                (----*----)
4       -1.3677  -0.9369  -0.5062     (------*-----)
                                     +---------+---------+---------+---------
                                   -1.40     -0.70      0.00      0.70


Season = 3 subtracted from:

Season    Lower   Center    Upper     +---------+---------+---------+---------
4       -1.1707  -0.7418  -0.3129        (-----*------)
                                     +---------+---------+---------+---------
                                   -1.40     -0.70      0.00      0.70
```

Regression analysis (log Result versus rain in previous 2 days).

```
The regression equation is
LogValue for rain = 2.16 + 0.00793 Rainfall in prev 2 days


Predictor                   Coef   SE Coef      T      P
Constant                 2.16333   0.08805  24.57  0.000
Rainfall in prev 2 days  0.007928  0.005752   1.38  0.171


S = 0.722881   R-Sq = 1.6%   R-Sq(adj) = 0.8%


Analysis of Variance

Source           DF       SS      MS     F      P
Regression        1   0.9927  0.9927  1.90  0.171
Residual Error  114  59.5715  0.5226
Total           115  60.5642
```

```
Unusual Observations

     Rainfall
      in prev  LogValue
Obs    2 days  for rain     Fit  SE Fit  Residual  St Resid
 13       8.4    3.7324  2.2299  0.0677    1.5025      2.09R
 57       2.8    3.7324  2.1855  0.0786    1.5469      2.15R
 79      34.2    4.2041  2.4344  0.1550    1.7697      2.51R
 80      34.2    4.5563  2.4344  0.1550    2.1219      3.01R
 82       6.8    3.7324  2.2172  0.0695    1.5152      2.11R
 93      41.8    1.8451  2.4947  0.1953   -0.6496     -0.93 X
 94      41.8    2.0414  2.4947  0.1953   -0.4533     -0.65 X
 95      41.8    1.6990  2.4947  0.1953   -0.7957     -1.14 X
114       7.5    3.7324  2.2228  0.0685    1.5096      2.10R

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

ANOVA comparison of log Result versus rainfall quartile (previous 2 days).

```
Source                 DF      SS     MS     F      P
2 days rain quartile    3   2.779  0.926  1.80  0.152
Error                 112  57.786  0.516
Total                 115  60.564

S = 0.7183   R-Sq = 4.59%   R-Sq(adj) = 2.03%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N    Mean   StDev  ---+---------+---------+---------+------
Q1     27  1.9989  0.6213  (---------*--------)
Q2     33  2.2144  0.6345           (-------*-------)
Q3     32  2.3283  0.7405              (--------*-------)
Q4     24  2.4377  0.8814                 (--------*---------)
                          ---+---------+---------+---------+------
                           1.80      2.10      2.40      2.70

Pooled StDev = 0.7183
```

Regression analysis (log Result versus rain in previous 7 days).

```
The regression equation is
LogValue for rain = 2.07 + 0.00488 Rainfall in prev 7 days


Predictor                   Coef   SE Coef      T      P
Constant                  2.0666    0.1051  19.66  0.000
Rainfall in prev 7 days  0.004881  0.002271   2.15  0.034


S = 0.714546   R-Sq = 3.9%   R-Sq(adj) = 3.1%


Analysis of Variance

Source           DF       SS      MS     F      P
Regression        1   2.3586  2.3586  4.62  0.034
Residual Error  114  58.2056  0.5106
Total           115  60.5642


Unusual Observations
```

```
     Rainfall
      in prev  LogValue
Obs    7 days  for rain     Fit  SE Fit  Residual  St Resid
 49        30    3.7324  2.2111  0.0679    1.5213      2.14R
 57         5    3.7324  2.0925  0.0961    1.6399      2.32R
 79        70    4.2041  2.4064  0.1013    1.7977      2.54R
 80        70    4.5563  2.4064  0.1013    2.1499      3.04R
 93       108    1.8451  2.5914  0.1756   -0.7463     -1.08 X
 94       108    2.0414  2.5914  0.1756   -0.5500     -0.79 X
 95       108    1.6990  2.5914  0.1756   -0.8924     -1.29 X

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

ANOVA comparison of log Result versus rainfall quartile (previous 7 days).

```
Source                 DF      SS     MS     F      P
7 days rain quartile    3   3.431  1.144  2.24  0.087
Error                 112  57.134  0.510
Total                 115  60.564

S = 0.7142   R-Sq = 5.66%   R-Sq(adj) = 3.14%


                           Individual 95% CIs For Mean Based on Pooled StDev
Level   N    Mean   StDev    +---------+---------+---------+---------
Q1     36  1.9914  0.6227    (---------*--------)
Q2     20  2.3301  0.7497              (-----------*------------)
Q3     30  2.3144  0.7039               (----------*---------)
Q4     30  2.4111  0.7990                   (---------*----------)
                           +---------+---------+---------+---------
                          1.75      2.00      2.25      2.50

Pooled StDev = 0.7142
```

Regression analysis (log Result vs water temperature)

```
The regression equation is
LogValue (temp) = 1.41 + 0.0769 Temperature


Predictor       Coef  SE Coef     T      P
Constant      1.4114   0.3800  3.71  0.001
Temperature  0.07685  0.02848  2.70  0.010


S = 0.692489   R-Sq = 13.7%   R-Sq(adj) = 11.8%


Analysis of Variance

Source          DF       SS      MS     F      P
Regression       1   3.4923  3.4923  7.28  0.010
Residual Error  46  22.0589  0.4795
Total           47  25.5512


Unusual Observations

                 LogValue
Obs  Temperature    (temp)    Fit  SE Fit  Residual  St Resid
  8         16.0     4.556  2.641   0.134     1.915      2.82R
 43         14.0     3.959  2.487   0.105     1.472      2.15R

R denotes an observation with a large standardized residual.
```

Circular-linear correlation of wind direction and log result

CIRCULAR-LINEAR CORRELATION
Seil Point
Analysis begun: 28 January 2008 14:16:06

Variables (& observations)	r	p
Angles & Linear (111)	0.209	0.009

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 and is not discussed in any detail in this document. Selected sites will be assessed in more detail using either: 1) a hydrodynamic model, or 2) an extended consideration of sources, available field studies and expert assessment. This document will focus on this more detailed hydrographic assessment and describes the common methodology applied to all sites.

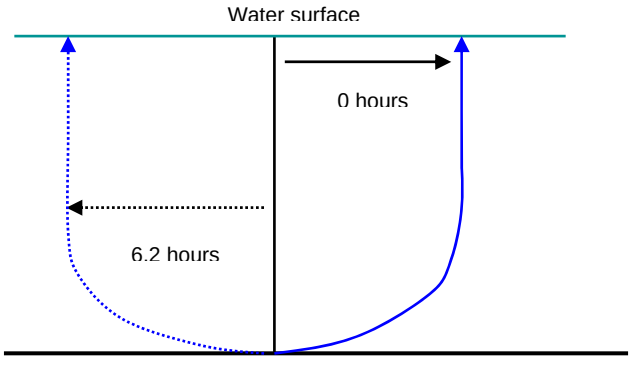
<u>Background processes</u>

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.

a)



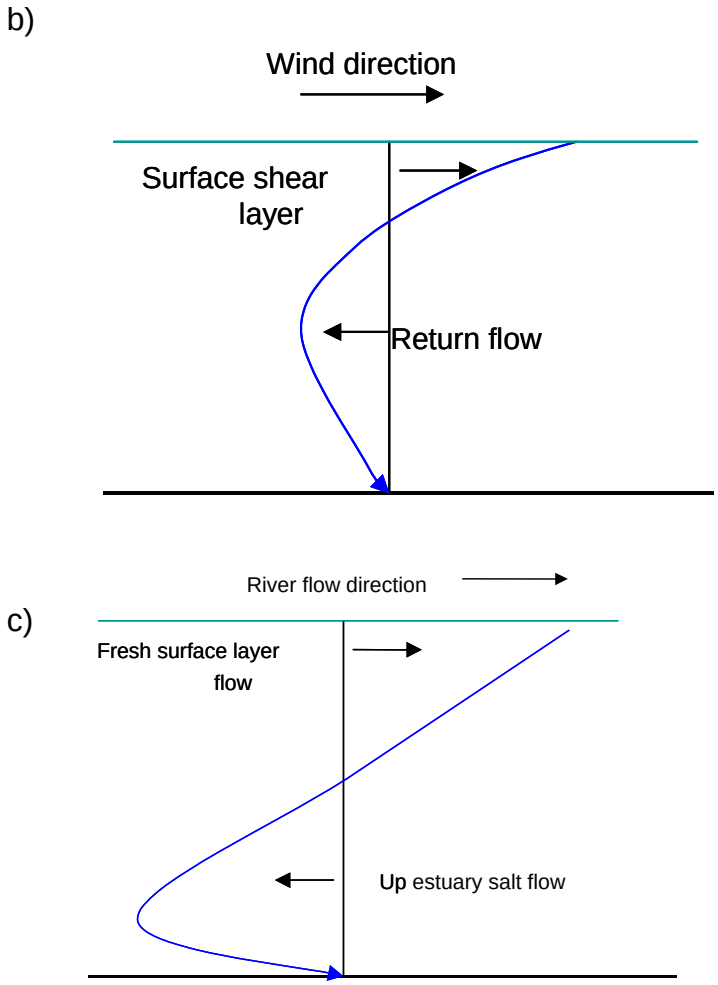


Figure 1. Typical vertical profiles for currents generated by different mechanisms. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main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

In sea lochs, currents associated with *windrows* can transport contaminated water near the shore to production areas further offshore. Windrows are often generated by winds directed along the main length of the loch. Figure 2 illustrates the water movements associated with this. As can be seen the water circulates in a series of cells that draw material across the loch at right angles to the wind direction. This is a particularly common situation for lochs with high land on either side as these tend to act as a steering mechanism to align winds along the water body.

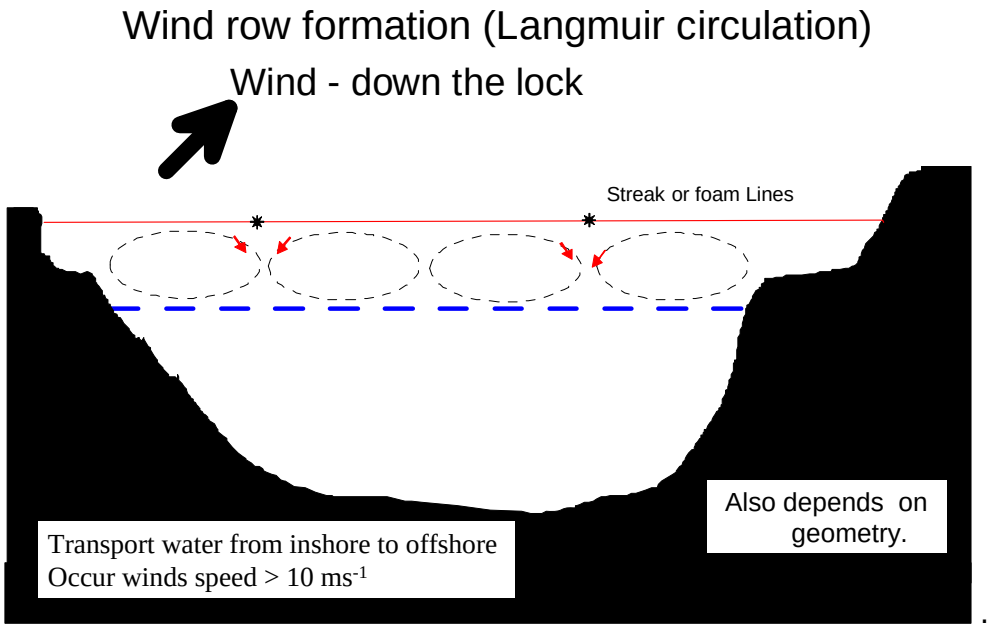


Figure 2: Schematic of wind driven 'wind row' currents. View is down the loch.The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

Norovirus Testing Summary
Seil Point: Ardencaple

Oyster samples taken from Seil Point: Ardencaple were submitted for Norovirus analysis quarterly between August 2007 and May 2008.

Results are tabulated below. One sample, submitted February 2008, was positive at the limit of detection for Norovirus Genogroup I only. All other samples tested negative for Norovirus.

Ref No.	**Date rec'd**	**NGR**	**GI**	**GII**
07/531	17/08/07	NM 76859 19617	Not detected	Not detected
07/532	17/08/07	NM 77097 19381	Not detected	Not detected
07/765	23/11/07	NM 77097 19376	Not detected	Not detected
08/29	21/02/08	NM 77098 19382	Positive at limit of detection	Not detected
08/129	22/05/08	NM 77097 19380	Not detected	Not detected