Scottish Sanitary Survey Project

Sanitary Survey Report

West Duart Bay

AB 406 807 13

March 2009

Cefas

FOOD STANDARDS AGENCY SCOTLAND
Buidheann Inbhe-Bidhe an Alba

Report Distribution – West Duart Bay

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

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

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1. General Description

Duart Bay is an open, northeast-facing bay, approximately 0.9km in length and 1.3km in width, located on the eastern coast of the Isle of Mull. Its maximum depth of 20 – 50m is found at the entrance of the bay. A sanitary survey of the area was conducted in response to an application for a new production area for Pacific oyster culture on the western side of the bay.

Figure 1.1 Location of Duart Bay

2. Fishery

The fishery at West Duart Bay is a Pacific oyster farm (*Crassostrea gigas*) assigned SIN AB 406 807 13. The actual site is located north of Camas Mor, at a small bay called Port an Eathair.

There is currently no production area or RMP for the West Duart Bay shellfish farm as the area has not previously been classified. A production area and RMP will be established following the recommendations of this report.

There were three rows of oyster trestles, each 8 bags across in place at the time of shoreline survey. The harvester reported having found the main body of the bay at Camas Mor to be too exposed and moved the trestles to a smaller area at Port an Eathair. At the time of shoreline survey, oysters of varying sizes were present, including mature stock. The location of the trestles is identified with a green cross in the map in Figure 2.1. The size of the cross is not representative of the area occupied by the trestles as this area is too small to be visible at the map scales used in this report. The trestles are accessible only during low water at spring tides and so harvesting will only occur at low water springs.

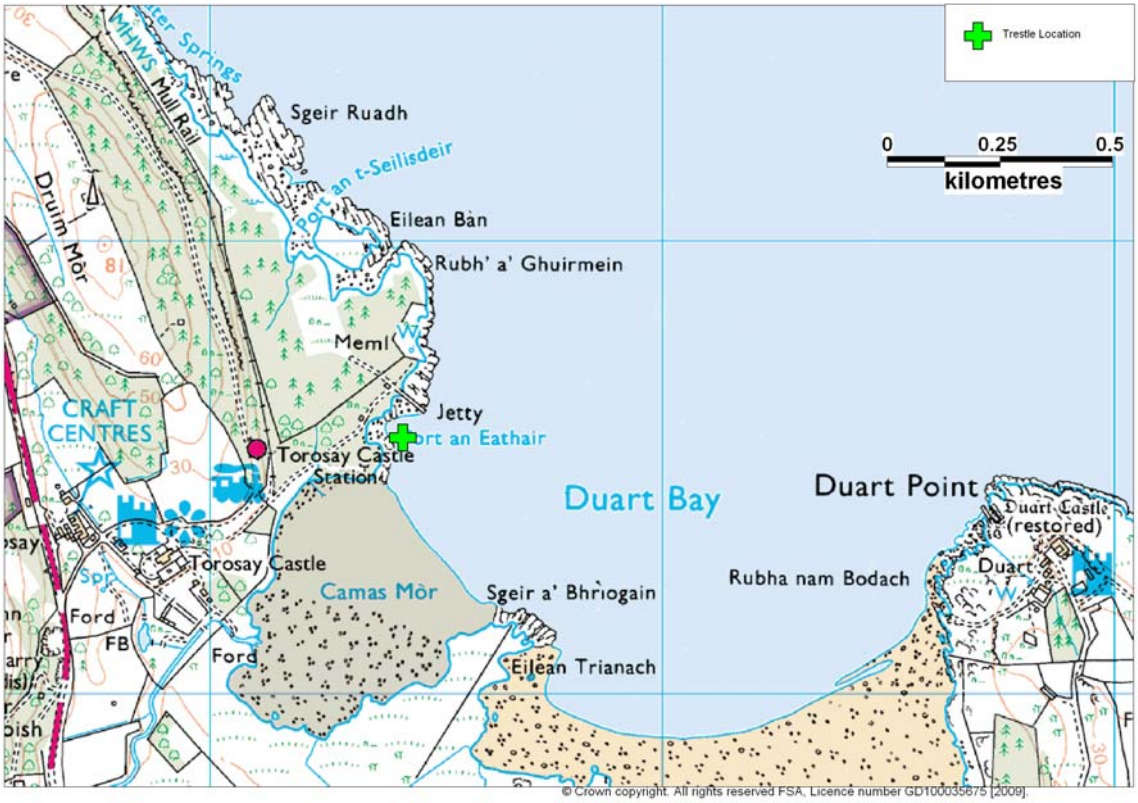

Figure 2.1 West Duart Bay fishery

The fishery was at an early stage in its development at the time of survey.

3. Human Population

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

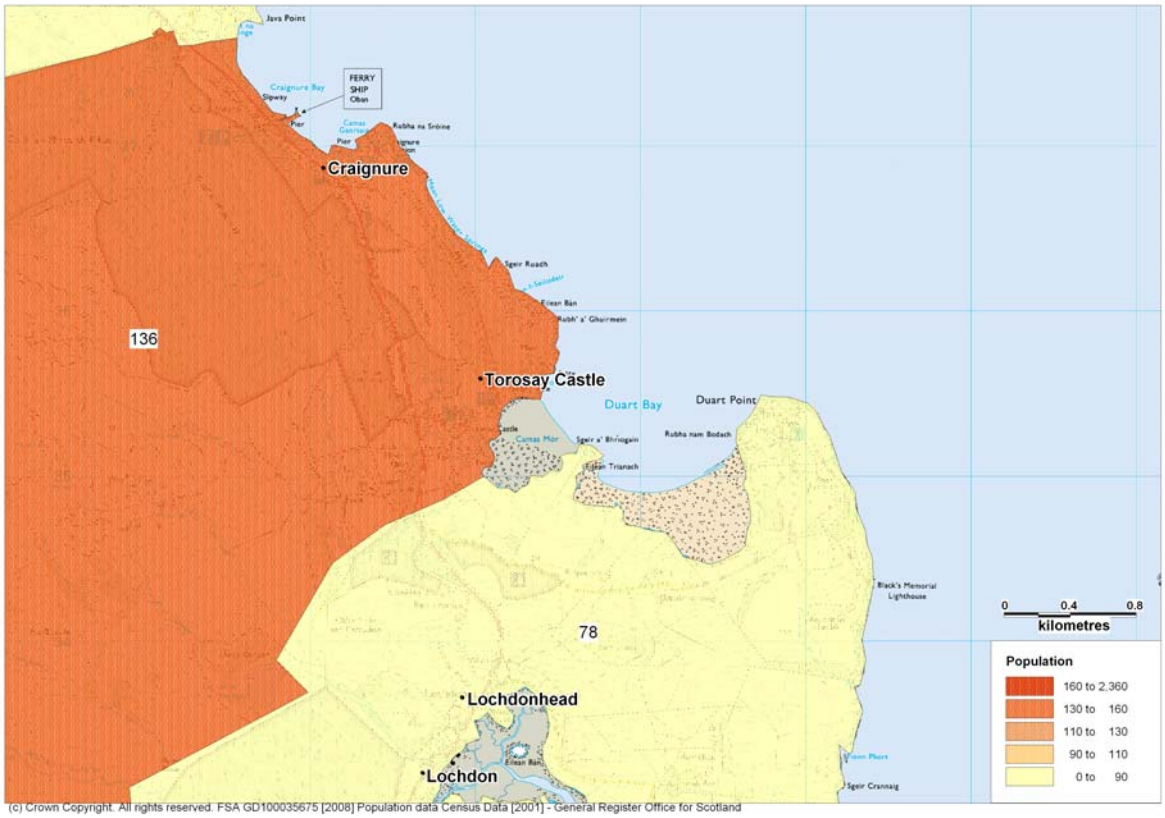

Figure 3.1 Population of Duart Bay

Two census output areas border mmediately on Duart Bay:

60QD000116	78
60QD000117	136
Total	214

On the coastline northwest of the bay is the settlement of Craignure. Torosay Castle is located on the north shore of West Duart Bay. Further inland south of West Duart Bay are the settlements of Lochdonhead and Lochdon. Most of the population is centred around Craignure and associated faecal pollution from human sources is likely to be concentrated in this area.

At the western end of Duart Bay is Torosay castle, which has a small resident population but operates as a visitor attraction. There area two small holiday cottages, one of which is located near the oyster farm at Port an Eathair. A further two dwellings, are located further east along the shore and Duart castle sits on Duart Point at the far eastern extent of the bay. Duart castle is open to visitors from April to October.

Seasonal fluctuations in population are expected to be significant as the area is popular with summer tourists and facilities at both Torosay and Duart castles cater to visitors. A large hotel, gym and swimming pool are located near the shoreline north of Craignure. A scenic railway runs between Craignure and Torosay during the summer months and there is a large campground with capacity for up to approximately 300 people located near the northern end of the railway at Craignure. A ferry service runs between the mainland and Craignure throughout the year, with up to five sailings per day during the winter, increasing to seven per day between late March and late October.

It is expected that the human population, and associated sewage, would be highly seasonal with much higher impact on the fishery during the March-October tourist season

4. Sewage Discharges

Scottish Water identified two community septic tanks for the area surrounding Duart Bay. These are detailed in Table 4.1. No information on consented flow or sanitary content was available for these discharges.

Table 4.1 Discharge identified by Scottish Water

SEPA permit	Discharge Name	NGR of discharge	Discharge Type	Level of Treatment	Consented flow m^3/day	Consented Design PE
WPC-W-72499	Craignure ST	NM 7223 3707	Continuous	Septic tank	65	98
WPC-W-12129	Java ST	NM 716 378	Continuous	Septic tank	Not reported	Not reported

No SEPA permit number was provided for this discharge

SEPA provided discharge consents issued within the local area as detailed in Table 4.2. No discharge consent was provided for the Craignure septic tank.

Table 4.2 SEPA discharge consents

Ref No.	NGR of discharge	Discharge Type	Discharges To	Level of Treatment	Consented flow (DWF) m^3/d	Consented/ design PE
WPC-W-12129 (Java ST)	NM 716 378	Domestic	Sound of Mull	Septic tank	Not reported	Not reported
CAR/R/1023897	NM 7133 3760	Trade-other	Sound of Mull	Dechlorination (swimming pool waste only)	3.4	15
CAR/R/1025819	NM 7189 3706	Domestic	Sound of Mull	Septic tank	-	6

The discharge of swimming pool waste is associated with a hotel and gym located north of Craignure. This discharge is unlikely to contribute significantly to faecal contamination levels at the shellfishery in West Duart Bay. A number of septic tanks and/or outfalls were recorded during the shoreline survey. Observed septic tanks, covers and/or discharge pipes are listed in Table 4.3.

Table 4.3 Discharges and septic tanks observed during shoreline survey

No	NGR	Description
1	NM 72221 36873	Craignure WWTW
2	NM 72341 36942	Septic tank serving campsite
3	NM 74863 35434	Septic tank serving Duart Castle
4	NM 72205 36867	Pipe in side of bank below septic tank, no flow
5	NM 73367 35601	Septic tank with soakaway and overflow discharge, serves 1 holiday cottage
6	NM 73223 35481	Septic tank for staff using railroad engine shed, 2-3 staff during summer only
7	NM 73033 35325	Septic tank for Torosay castle

The locations of all noted discharges are mapped in Figure 4.1.

There are three sewage discharges in the immediate vicinity of the shellfishery. Nearest the oyster farm is a septic tank associated with a holiday cottage (5). According to the owner this discharges to soakaway, but it also has an overflow to the shoreline, which was observed during the shoreline survey. Should the soakaway fail and the discharge divert to overflow, it could severely impact water quality at or near the oyster trestles. There is also a further small septic tank (6) associated with the narrow gauge railway shed which discharges to a small stream on the shore. Both of these discharges are intermittently in use during the summer tourist season only.

The septic tank for Torosay castle (7) which discharges to a small stream near the shoreline is in year round use. It is larger than the other two as it handles

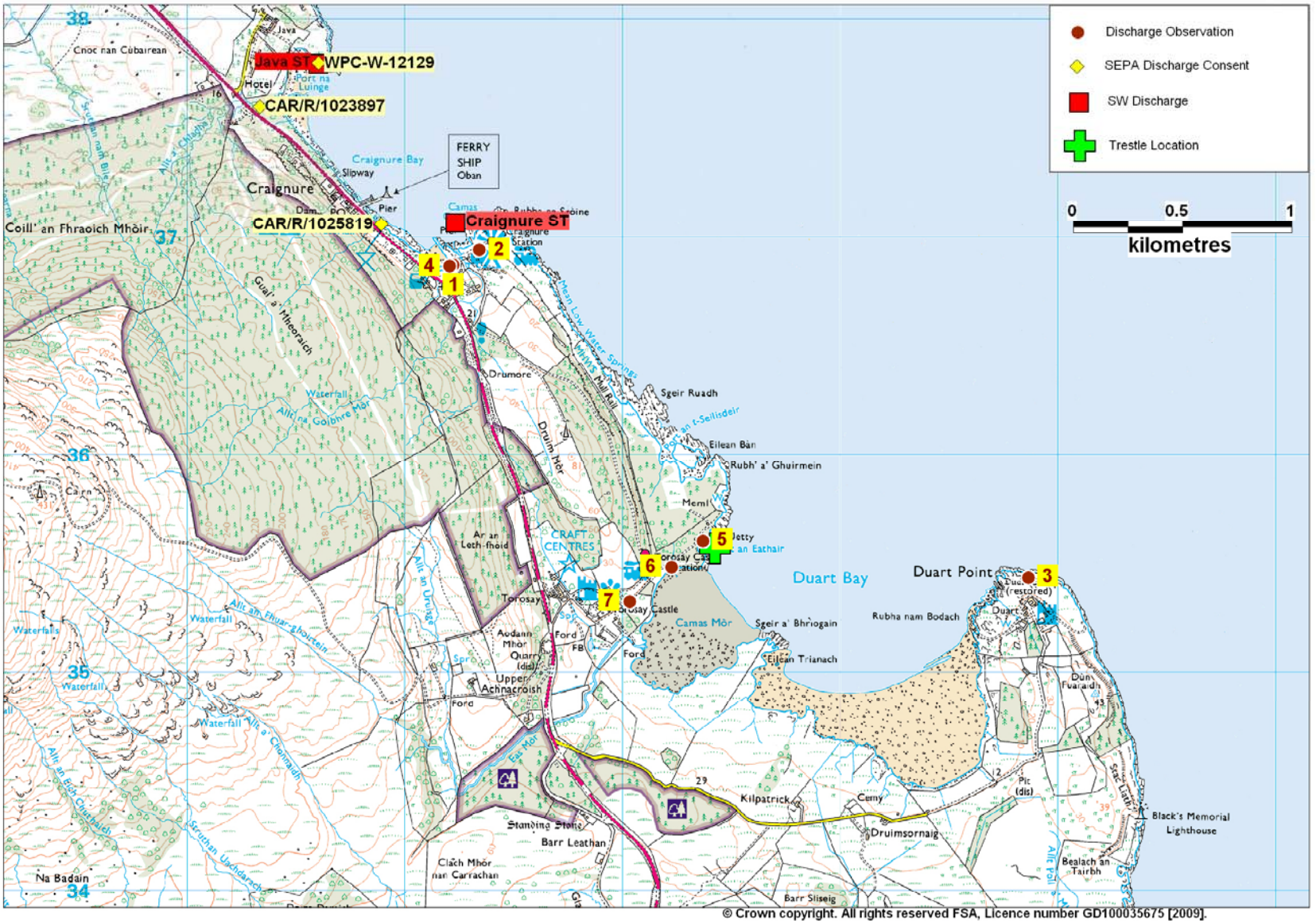

Figure 4.1 Sewage discharges near Duart Bay

discharge from the tearoom and associated visitors facilities as well as those for the permanent occupiers.

Duart castle, at the eastern end of the bay, is served by a septic tank which discharges to the sea at Duart Point. It also handles waste discharge from a tearoom and tourist facilities that are only open between April and October.

Further north, two Scottish Water septic tanks serve part of the settlement of Craignure. At the south end of Craignure Bay is the Scottish Water 'Craignure ST' septic tank, which serves a population of 98. At the other end of Craignure Bay is the 'Java ST' septic tank (SEPA consent no. WPC-W-12129), for which there was also no information on discharge volumes. The location of the Java discharge was not confirmed during the shoreline survey.

Also at Craignure, a private septic tank serving the campground south of the ferry terminal discharges to the south end of Craignure Bay (2). The campsite has 90 pitches for caravans, plus 18 permanent serviced tents, 10 of which have toilet and shower facilities, and motor caravan waste disposal point. A small private septic tank was also seen in this area (4).

SEPA lists two further consented discharges to Craignure Bay. Consent CAR/R/1025819 relates to a private domestic septic tank. Consent CAR/R/1023897 relates to the discharge of treated swimming pool water from the gym at Isle of Mull Hotel and this should not contain significant bacterial contamination. The locations of the discharges to which these consents relate were not confirmed during the shoreline survey.

Of all sewage discharges in the area, the Torosay Castle septic tank is likely to be of greatest year-round importance to the shellfishery given its size and proximity. The impact of this and the other two discharges in the immediate vicinity of the shellfishery are likely to increase during the summer tourist season. However, as the overflow discharge from the holiday cottage lies so close to the oyster trestles, it would have the greatest impact to the fishery should it operate. Norovirus testing conducted in conjunction with the sanitary survey showed positive results for norovirus genogroup II during February. This is indicative of the presence of human faecal contamination at the time of sample collection and demonstrates that human sewage can impact the fishery even in winter.

The sewage discharges noted at Duart Point and in Craignure Bay could potentially impact the fishery depending upon bathymetry and environmental conditions.

Boat traffic passing through the Sound of Mull, including the Oban-Craignure ferry and ferries to other islands may also contribute to levels of contamination in the area, as there are no sewage pumpout facilities at either terminal.

5. Geology and Soils

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

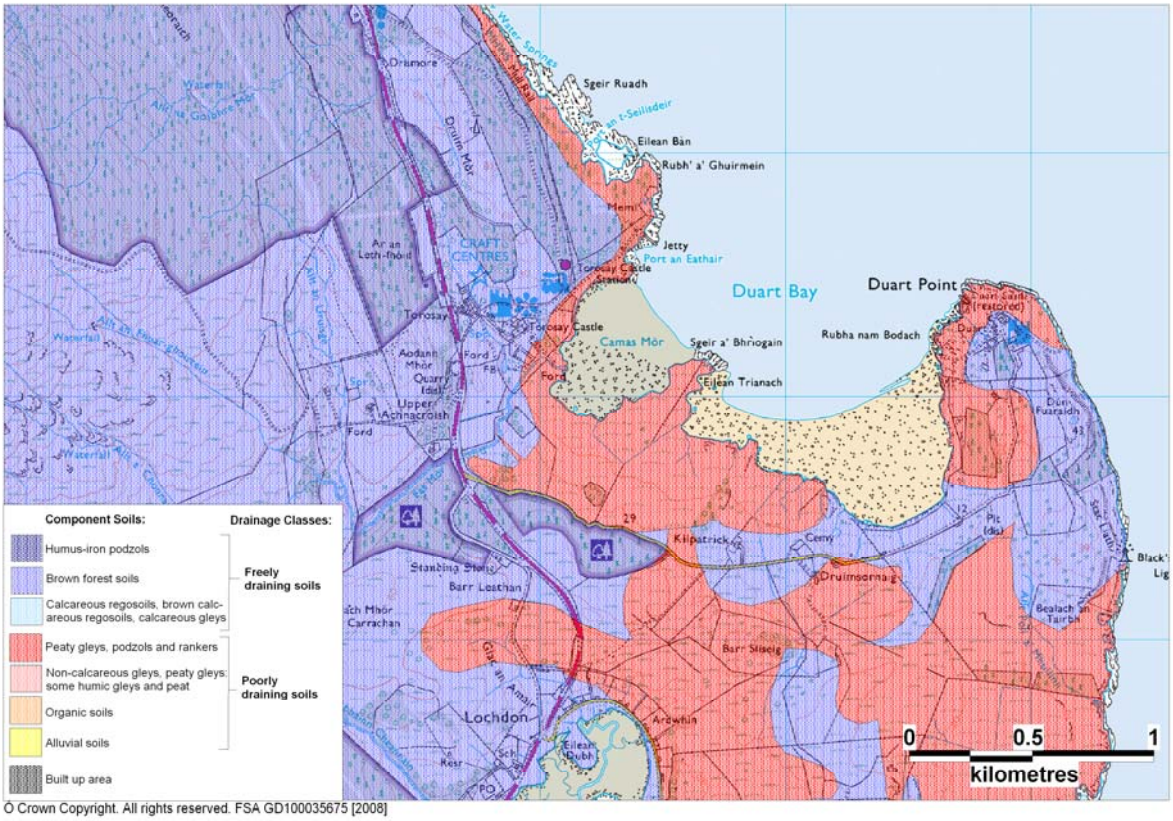

Figure 5.1 Component soils and drainage classes for Duart Bay.

There are two main types of component soils visible in this area. Freely draining brown forest soils cover most of the area inland to the west and also some coastline on the eastern side of the bay.

Poorly draining peaty gleys, podzols and rankers are present along much of the immediate coastline of Duart Bay and Camas Mor and also some area inland on the south eastern coast.

The potential for runoff contaminated with *E. coli* from human and/or animal waste is therefore generally high along the immediate coastline of Duart Bay where poorly draining soils are dominant. Further inland soils are generally more permeable, so the potential for contaminated runoff being carried from these areas through watercourses to the production area is lower.

This is of particular relevance where septic tanks discharge to soakaway, as soakaway systems depend upon permeable soils for proper function. In poorly drained soils, soakaways may clog or fail to drain properly leading to surface runoff or overflow.

6. Land Cover

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

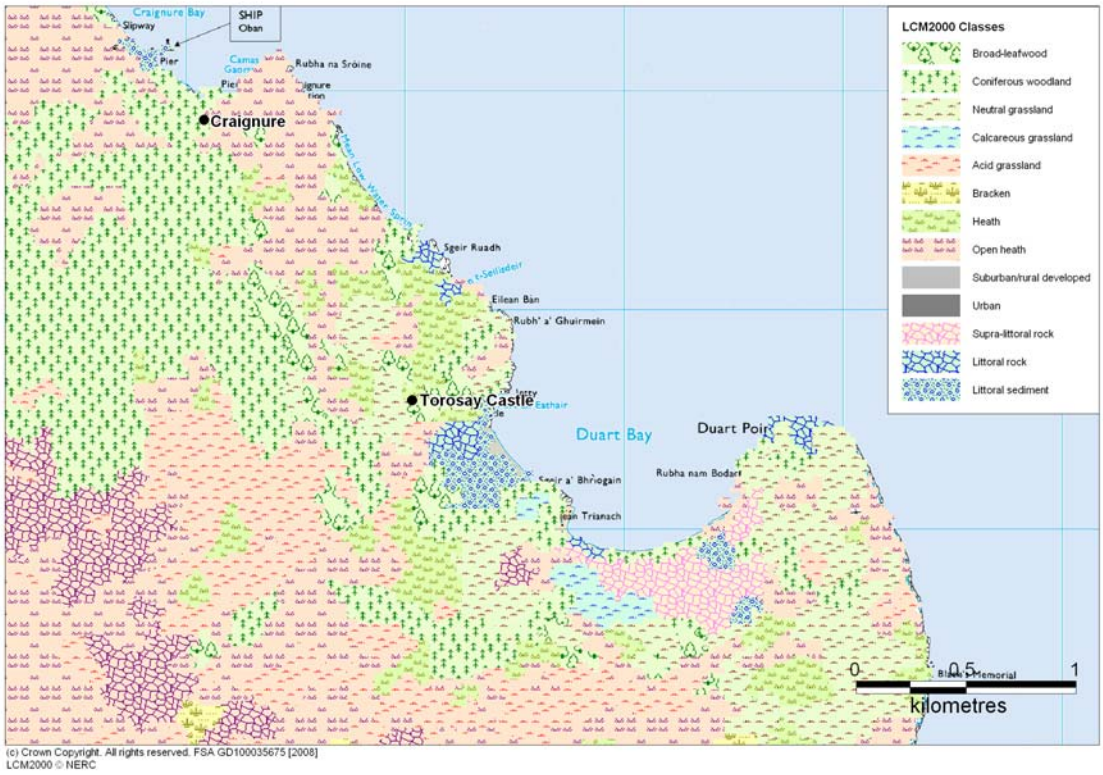

Figure 6.1 LCM2000 class land cover data for Duart Bay

The land cover surrounding Duart Bay is very varied according to LCM2000. The land to the north of Torosay Castle is covered in patches of heath, neutral grassland and both broad-leaf and coniferous woodland. Although unidentified by the LCM2000 data there are small built up areas surrounding both Torosay Castle and Craignure.

Based on comparisons with the ordnance survey maps of the area, and observations from the shoreline survey, there appear to be some inaccuracies in Figure 6.1. These relate primarily to the shoreline of Duart Bay, where intertidal areas and a strip of pasture to the south of the bay are misrepresented as having areas of forest.

The faecal coliform contribution would be expected to be highest from developed areas (approx 1.2 – 2.8x10^9 cfu km^{-2} hr^{-1}), with intermediate contributions from the improved grassland (approximately 8.3x10^8 cfu km^{-2} hr^{-1}) and lowest from the other land cover types (approximately 2.5x10^8 cfu km^{-2} hr^{-1}) (Kay *et al*. 2008). The contributions from all land cover types would be expected to increase significantly after marked rainfall events. This effect is expected to be highest, at more than 100-fold, for the improved grassland. As the shoreline adjacent to West Duart Bay is mainly rough (presumably unimproved) pasture the overall potential for contaminated runoff should fall into the lowest category, increasing following rainfall, although the potential for contaminated runoff from pastures will largely depend on the amount of livestock present, their access to watercourses, and the permeability of the soil.

7. Farm Animals

With regard to potential sources of pollution of animal origin, agricultural census data was requested from the Scottish Government. Agricultural census data was provided by RERAD for the parish of Torosay. This parish covers approximately one third of the island of Mull, encompassing a total land area of 365.1 km^2. Reported livestock populations for the parish in 2007 and 2008 are listed in Table 7.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data.

Table 7.1 Livestock census data for Torosay parish

	2007		2008	
	Holdings	Numbers	Holdings	Numbers
Total pigs	*	*	*	*
Total poultry	6	85	8	197
Total cattle	12	900	13	899
Total sheep	17	15196	16	13047
Deer	*	*	*	*
Horses and Ponies	6	14	6	14

* Data withheld on confidentiality basis.

Both deer and pigs are farmed somewhere within the parish, however specific data on numbers could not be provided. Due to large area of the parish, this data does not provide information on the livestock numbers in the area immediately surrounding West Duart Bay. The only information specific to the area near the shellfishery was therefore the shoreline survey (see Appendix), which only relates to the time of the site visit on 30th April – 1st May 2008. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 7.1.

The farm at Torosay Castle had both sheep and a breeding herd of Highland cattle. During the shoreline survey, 119 sheep and 37 cattle were observed at Torosay. This is lower than the parish average of 69 cattle and 815 sheep per holding. A further 94 sheep were observed around the eastern side of Duart bay between Duart Point and Sgier a' Bhrìogain. It is likely that more sheep are normally present in the area but were unobserved on the day of survey either because they were grazing further away from the shoreline or were obscured by the terrain.

The land immediately surrounding Duart Bay is primarily rough grassland used for grazing livestock. Sheep and cattle are grazed here have free access to the shoreline, and cattle and sheep were observed wading in the bay and across the streams feeding into the bay. The highest concentrations of livestock were seen around Torosay Castle. Contamination from these animals will be carried into the bay either by direct deposition on the shore below the high water mark, or through land runoff. Given their fairly high densities around Torosay Castle, livestock are likely to be an important source of contamination to the shellfishery. Generally, livestock may be regarded as a diffuse source of contamination, but the large stream discharging immediately to the south of Torosay Castle could be

considered as a point source of this contamination. Although this would approach the fishery from the south, given the very small size of the oyster farm there would be no appreciable spatial impact across the trestles. However, it would impact on any southward expansion of the fishery.

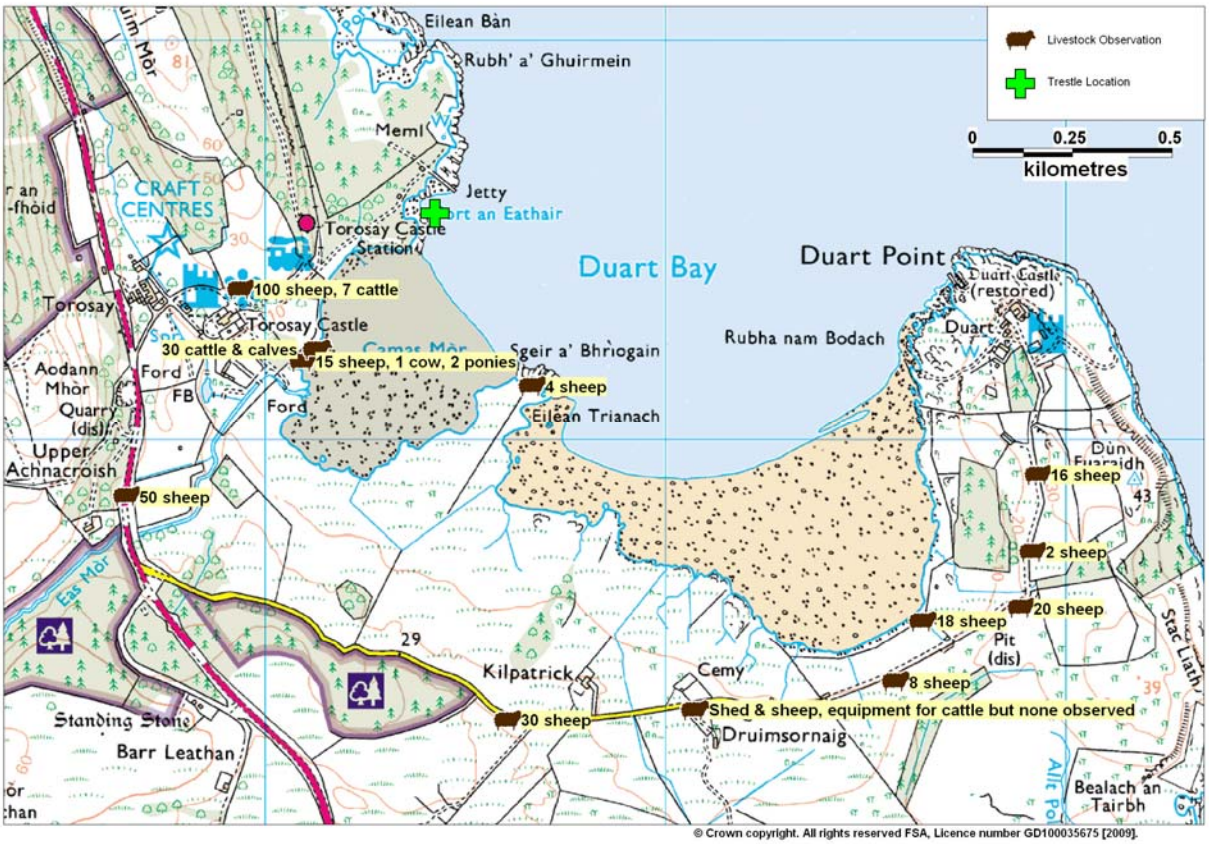

Figure 7.1 Livestock observations at Duart Bay

Generally, numbers of livestock in the area would be expected to increase in spring, when lambs and calves are born, and then decrease again in autumn when they are sold off or sent for slaughter.

8. Wildlife

General information related to potential risks to water quality by wildlife can be found in Appendix 4. A number of wildlife species present or likely to be present at Cidhe Eolaigearraidh could potentially affect water quality around the fishery.

Seals

Two species of pinniped (seals, sea lions, walruses) are commonly found around the coasts of Scotland: These are the European harbour, or common, seal (*Phoca vitulina vitulina*) and the grey seal (*Halichoerus grypus*). Scotland hosts significant populations of both species.

A survey conducted by the Sea Mammal Research Unit in 2000 estimated a population of 1616 common seals on Mull. The exact locations of the haul out sites were not specified, so it is uncertain whether they reside in the vicinity of West Duart Bay. No seals were seen during the course of the shoreline survey.

Seals will forage widely for food and it is likely that seals will feed near the shellfishery 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.

Whales/Dolphins

Whales and dolphins are relatively common off the west coast of Scotland and sightings are recorded by the Hebridean Whale and Dolphin trust. These are reported to the trust by ferry skippers, whale watch boats and other observers and are listed in Appendix 4.

Within the Sound of Mull it is likely that cetaceans may be present from time to time, especially the smaller species. Their presence, however, is likely to be fleeting and unpredictable.

Birds

A number of bird species are found on Mull, but seabirds and waterfowl are most likely to occur around or near the fisheries in significant numbers.

Seabird populations were investigated all over Britain as part of the SeaBird 2000 census. The area was surveyed in sections on various dates in late spring of 1999 and 2000. Total counts of all species recorded within 5 km of the trestles are presented in Table 8.1. Counts were of occupied nests, so actual numbers of seabirds breeding in the area will be higher.

Table 8.1 Seabird counts within 5km of the site

Common name	Species	Count	Method
Common Tern	*Sterna hirundo*	772	Occupied nests
Common Gull	*Larus canus*	72	Occupied nests
Arctic Tern	*Sterna paradisaea*	70	Occupied nests
Herring Gull	*Larus argentatus*	41	Occupied nests
Great Black-backed Gull	*Larus marinus*	3	Occupied nests

The largest concentration of breeding seabirds by far was at Glas Eilianan, a small rocky island with a lighthouse in the middle of the Sound of Mull where 772 occupied common tern nests were found. As this colony is located almost 5 km to the north of the shellfishery, it is probably too far away to have a significant impact. Within Duart Bay, a total of only three seabird nesting sites were recorded (Common Gull), and all of these were on the shore immediately adjacent to the trestles. A few small groups of gulls were observed in the bay during the course of the shoreline survey. Though nesting occurs in early summer and after this some species will then disperse, gulls are likely to be present in the area throughout the year.

Waterfowl (ducks and geese) are likely to be present in the area at various times, primarily to overwinter, or briefly during migration, although some species breed on Mull in small numbers. Around 20-30 geese were however observed during the course of the shoreline survey (late May) suggesting there is a small breeding population in the area. Geese would tend to be found grazing on farm fields and open grassland such as the pastures on the shores of Duart Bay and goose droppings were observed during the shoreline survey.

Wading birds would be concentrated on intertidal areas, such as the area on which the trestles are located. A few oystercatchers were observed in the bay during the course of the shoreline survey, but not in large concentrations.

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.

Deer will be present particularly in wooded areas where the habitat is best suited for them. Parts of the shoreline of Duart Bay are wooded, including the shoreline immediately adjacent to the trestles. While no population data were available for this specific area, it can be presumed that they host populations of deer. The DCS report a count of 1011 red deer and 1 roe deer for the whole of Mull, the total area of which is approximately 950 km^2. Therefore the overall density of about 1 deer per km^2 is low relative to that of livestock. The harvester reports that deer are present in the area.

It is possible that some of the indicator organisms detected in the streams feeding into Duart Bay will be of deer origin, although this will not materially affect the sampling plans.

Otters

No otters were observed during the course of the shoreline survey, although otters are known to be present in the area. The harvester reported having seen otters in Duart Bay. However, the typical population densities of coastal otters are low and their impacts on the shellfishery are expected to be minor.

Summary

Potential wildlife impacts to the fishery at West Duart Bay include geese and other waterbirds, deer, seals and otters. Geese grazing on the pastures may constitute a source of diffuse contamination in the same manner as livestock, but their impacts will be minor relative to livestock based on the numbers observed during the shoreline survey, and less predictable as they are free to range more widely. There may be impacts from wading birds and gulls feeding near the trestles or resting on the oyster bags at low tide. These impacts could be significant, but unpredictable in terms of timing and location and will not be considered further. Impacts from deer are likely to be carried via streams and so will be combined with other sources of bacterial contamination to these.

9. Meteorological data

The nearest weather station is located at Torosay, on the shores of the production area. Rainfall data was supplied for the period 01/01/03 to 31/12/2007 (total daily rainfall in mm).

The nearest major weather station where wind is measured is located at Tiree, approximately 73 km to the west of the production area. This weather station was selected as it was the closest to Duart Bay, and is also located within the Western Isles. Wind patterns at Tiree are however likely to differ somewhat from those found at West Duart Bay, as Tiree is more exposed to the open Atlantic and is located 73 km away. Wind direction was recorded at 3 hourly intervals for the majority of the period 1/1/1996 to 31/12/2007. Wind patterns may differ between these two locations due to their distance apart and the effects of local topography.

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 wastewater treatment plant overflows (e.g. Mallin et al, 2001; Lee & Morgan, 2003).

Total annual rainfall and mean monthly rainfall were calculated, and are presented in Figures 9.1 and 9.2.

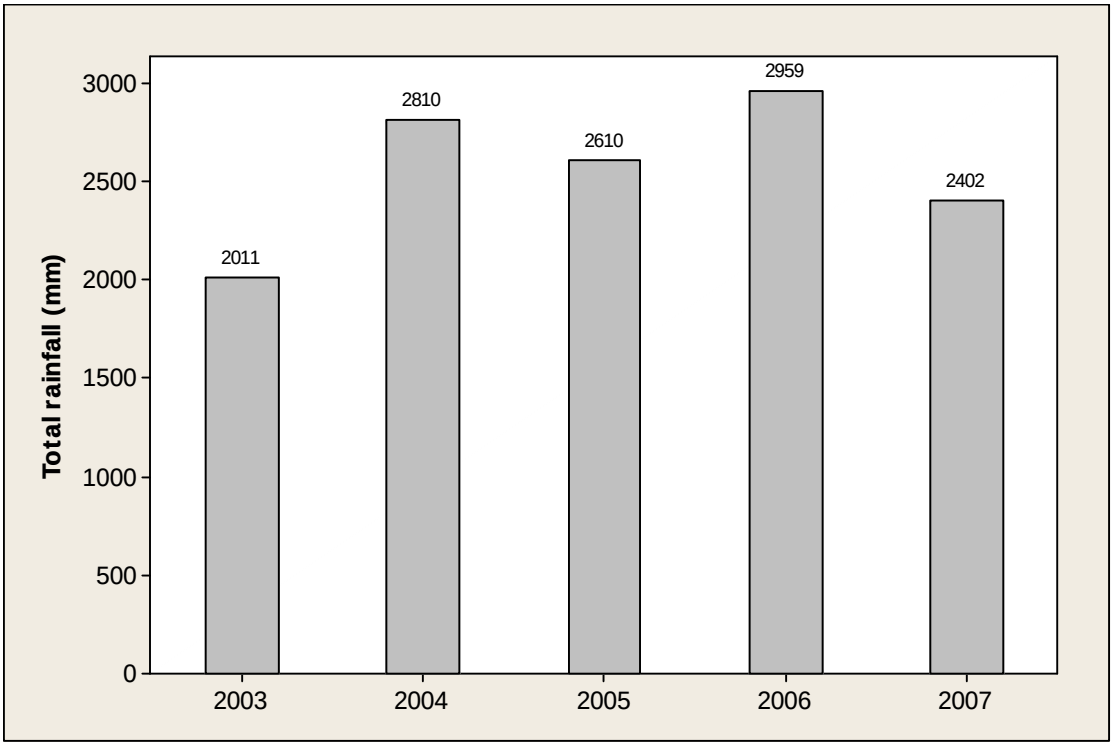

Figure 9.1 Total annual rainfall at Torosay 2003 – 2007

Total annual rainfall at Torosay was variable with no apparent trend over the period identified, though rainfall recorded in 2003 was markedly lower than in subsequent years. The annual variation means that overall effects may vary from year to year.

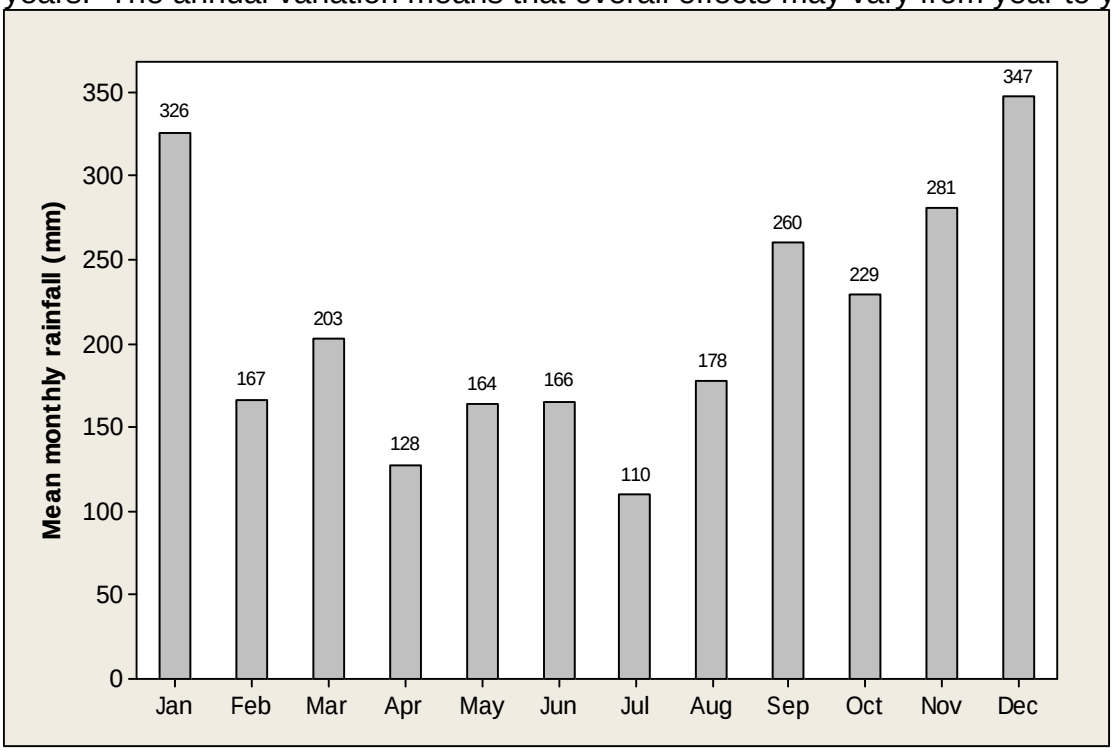

Figure 9.2 Mean monthly rainfall at Torosay 2003 – 2007

There was a marked seasonal pattern to rainfall at Torosay, with much less rain on average from February to August than from September to January. The wettest months were December and January, while the driest months were April and July. For the period considered here (2003 – 2005), 23% of the days experienced no rainfall while 43% of days experienced rainfall of 1 mm or less.

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 early winter months, but episodes of contamination following heavy rain may occur at any time of year. It is also probable that faecal matter will 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 9.3 to 9.7.

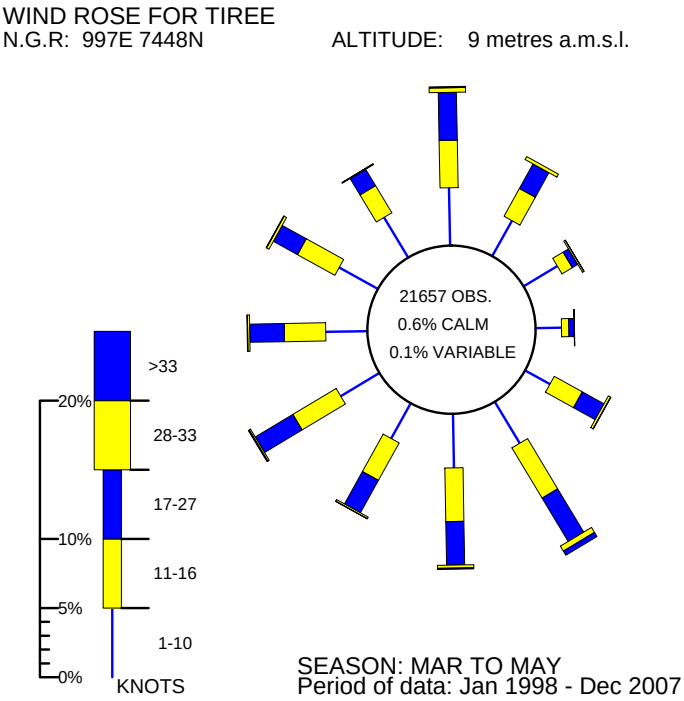

Figure 9.3 Wind rose for Tiree (March to May)

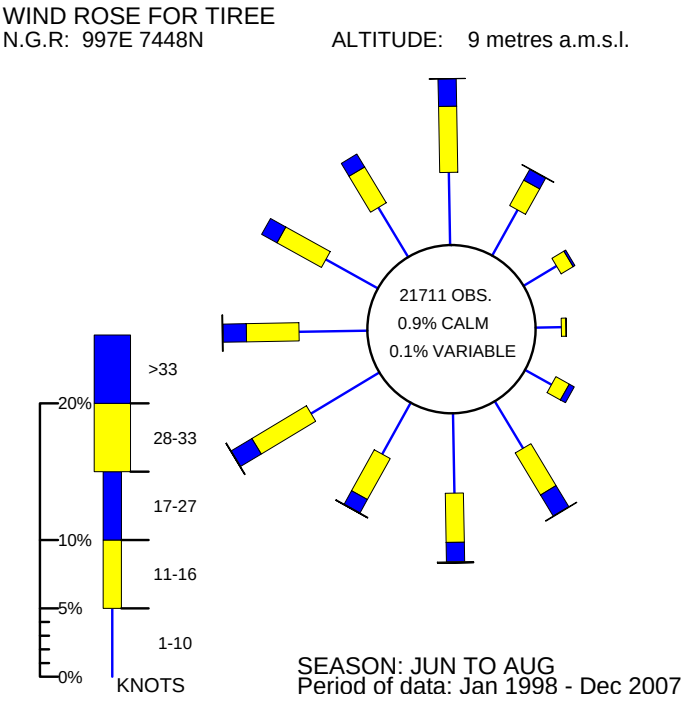

Figure 9.4 Wind rose for Tiree (June to August)

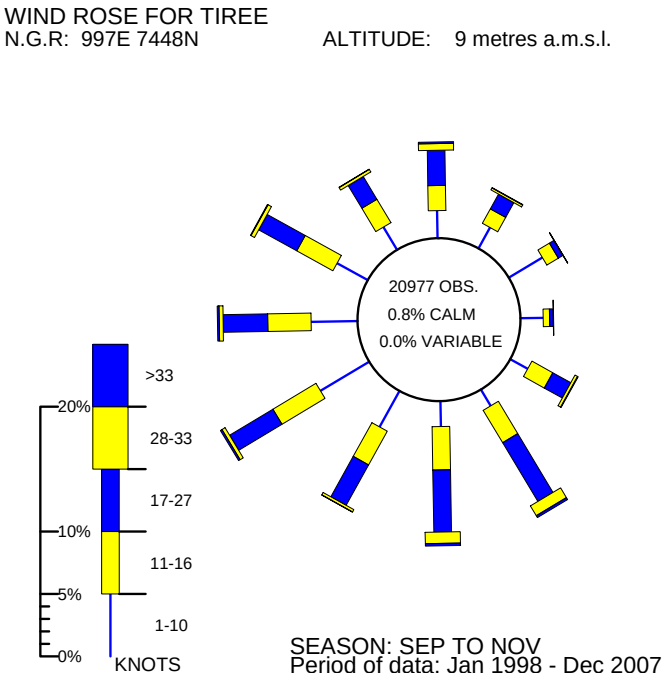

Figure 9.5 Wind rose for Tiree (September to November)

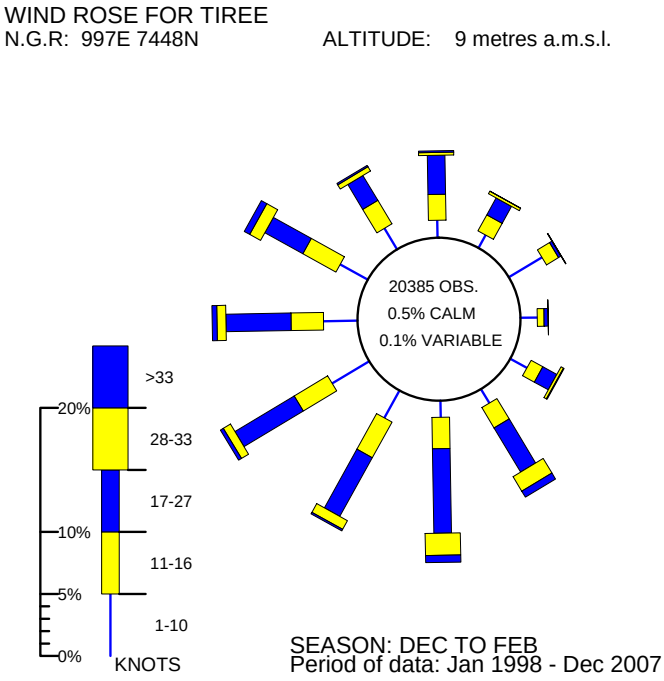

Figure 9.6 Wind rose for Tiree (December to February)

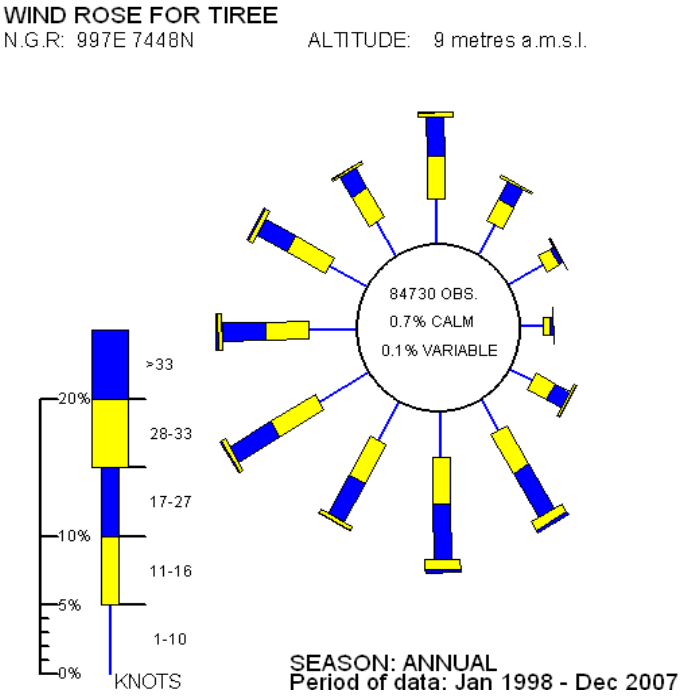

Figure 9.7 Wind rose for Tiree (All year)

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. A significant proportion of winds in spring and summer are from the north.

Duart Bay is a relatively open bay on the east coast of Mull. It is exposed to winds blowing down the Sound of Mull and Loch Linnhe a northerly and easterly direction respectively. The land to the south and west rises to over 100 m within 1 km of the shore in places, providing some shelter from winds from these directions. Winds typically drive surface water currents at about 3% of the wind speed (Brown, 1991) so a gale force wind (34 knots or 17.2 m/s) would drive a surface water current of about 1 knot or 0.5 m/s. Therefore strong winds will significantly alter the pattern of surface currents within the bay and the Sound of Mull.

Strong winds may also affect tide height depending on wind direction and local hydrodynamics. A strong wind and low atmospheric pressure (typical with a weather front) combined with a spring tide may result in higher than usual tides, which will carry accumulated faecal matter from livestock at and above the normal high water mark into the production area. Further, under these conditions the trestles may not be exposed at all, leaving shellfish submerged to filter for a greater proportion of the tidal cycle. An onshore wind will result in increased wave action, which may resuspend any organic matter including bacterial contamination settled in the substrate.

10. Current and historical classification status

West Duart Bay has not yet been classified.

11. Historical *E. coli* data

No records of historical *E. coli* samples for this production area were found on the FSAS database of monitoring results to the end of 2008.

12. Designated Shellfish Growing Waters Data

West Duart Bay does not lie within a designated shellfish growing water.

13. River Flow

There are no river gauging stations on rivers or burns along the West Duart Bay coastline. The following rivers and streams were measured and sampled during the shoreline survey. These represent the largest freshwater inputs to West Duart Bay.

Table 13.1 Stream loadings for Duart Bay

No	Grid Reference	Description	Width (m)	Depth (m)	Flow (m/s)	Flow (m^3/day)	*E.coli* (cfu/ 100 ml)	Loading (*E.coli* per day)
1	NM 74646 73445	Stream	0.45	0.06	0.3	700	100	$7.0x10^8$
2	NM 74341 34459	Stream	0.58	0.04	0.2	401	<100*	-
3	NM 74016 34662	Stream	0.29	0.08	0.3	601	1200	$7.2x10^9$
4	NM 73607 34823	Stream	0.41	0.10	0.1	354	Not sampled	-
5	NM 73073 35115	Eas Mor	8	0.06	0.6	24883	400	$1.0x10^{11}$
6	NM 72261 36906	Stream	0.43	0.03	0.9	1003	1200	$1.2x10^{10}$
7**	NM 73001 35139	Eas Mor	3.6	0.09	0.245	6858	400	$2.7x10^{10}$

* Loading not calculated

** remeasurement of stream 5 undertaken on 17/6/08, results not shown on map

In addition to the streams listed above, several others were observed during the shoreline survey but were too small to measure and sample.

The most significant of the watercourses is Eas Mor, as it discharges closest to the fishery and has the highest loading (1.0×10^{11} *E.coli* / day, when first sampled, then 2.7×10^{10} when resampled). It drains areas of pasture and woodlands, and discharges to the Camas Mor Bay in which the shellfishery is located. Livestock are free to access this stream, and contamination carried to the shellfishery by this stream will largely be of livestock origin. Extensive alga/bacterial growth was observed in this stream during the shoreline survey, suggesting high nutrient inputs. Additionally a number of smaller, unfenced streams drain the pasture on the shore adjacent to Duart Bay, and these will contribute to overall levels of contamination in the area. Further afield, a stream discharges just south of Craignure, and contamination from this may be carried in the direction of the fishery by the tide, but it is likely to be diluted by the time it reaches the fishery.

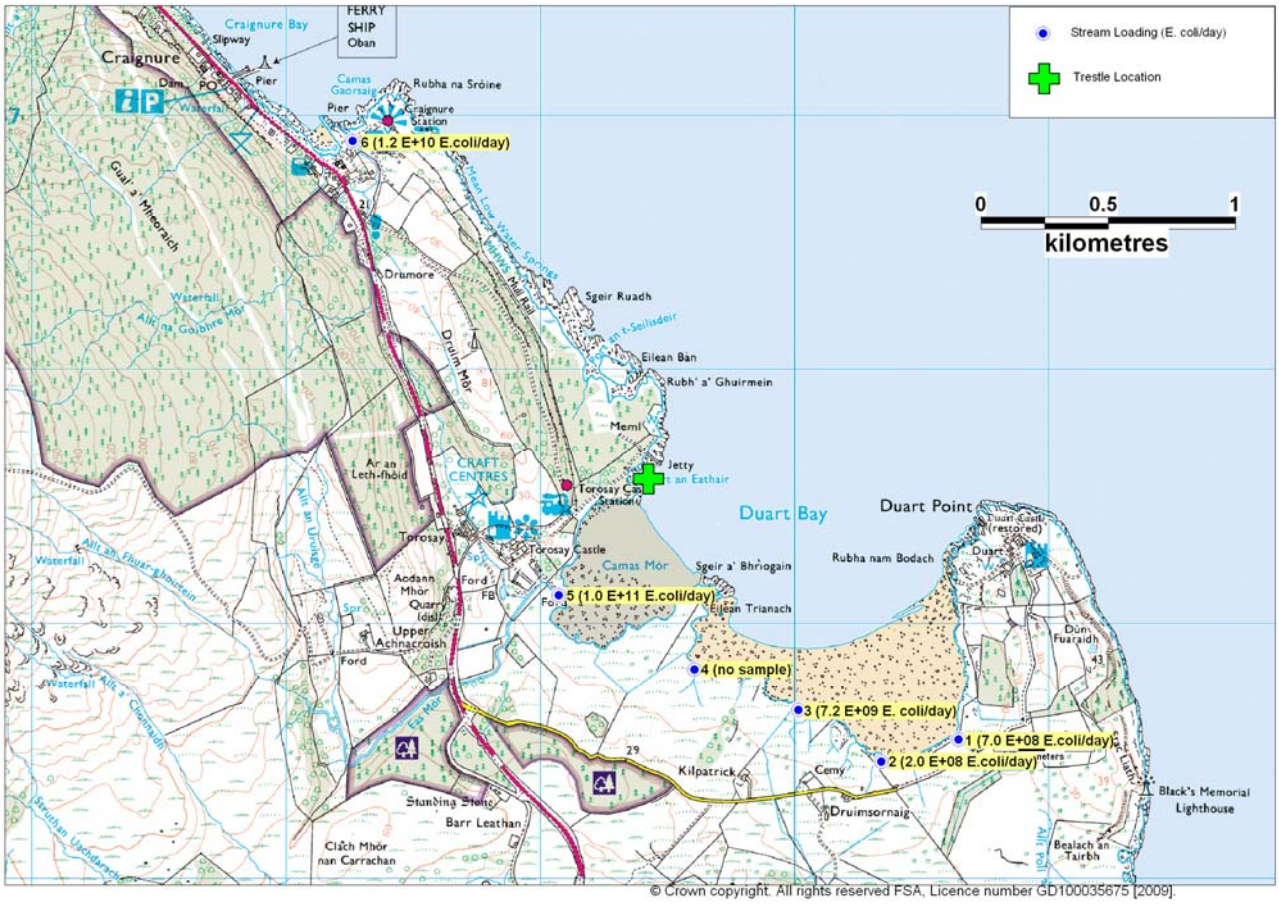

Figure 13.1 Significant streams and loadings for Duart Bay

14. Bathymetry and Hydrodynamics

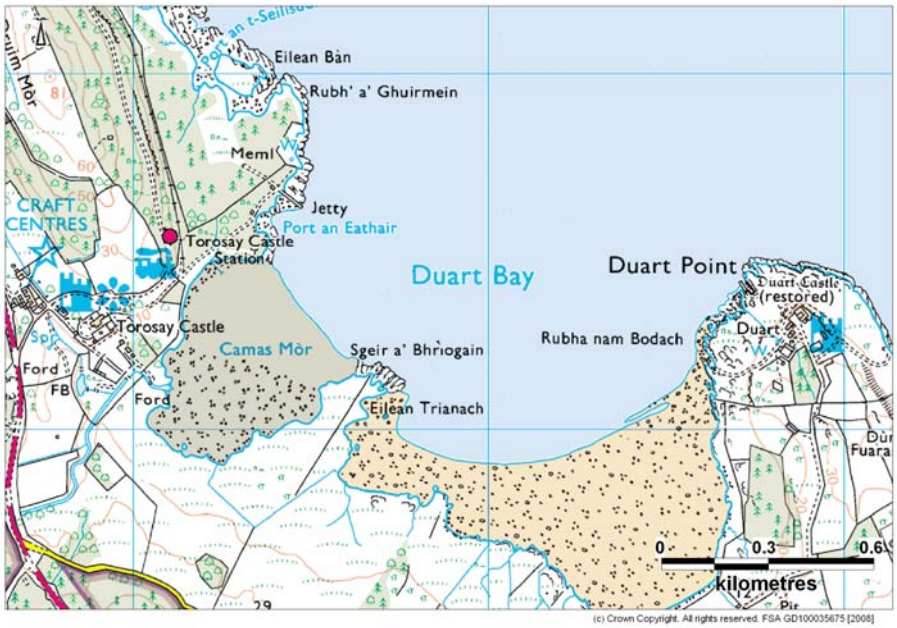

Figure 14.1 OS map of Duart Bay

Figure 14.2 Bathymetry of Duart Bay

The chart above shows that there is a large intertidal area in the bay, which is separated by a ridge running approximately down its centre. Below MLWS, the depth drops off gradually at first, then more rapidly to in excess of 50 m. The bay opens out to the Sound of Mull (which has a north west to south east aspect) and faces the entrance to Loch Linnhe (which has a south west to north east aspect).

Tidal Curve and Description

The two tidal curves below are for Craignure, which lies less than 3km northwest of the oyster farm at West Duart Bay. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 GMT on 20/05/08 and the

second is for seven days beginning 00.00 GMT on 27/05/08. This two-week period covers the date of the shoreline survey. Together they show the predicted tidal heights over high/low water for a full neap/spring tidal cycle.

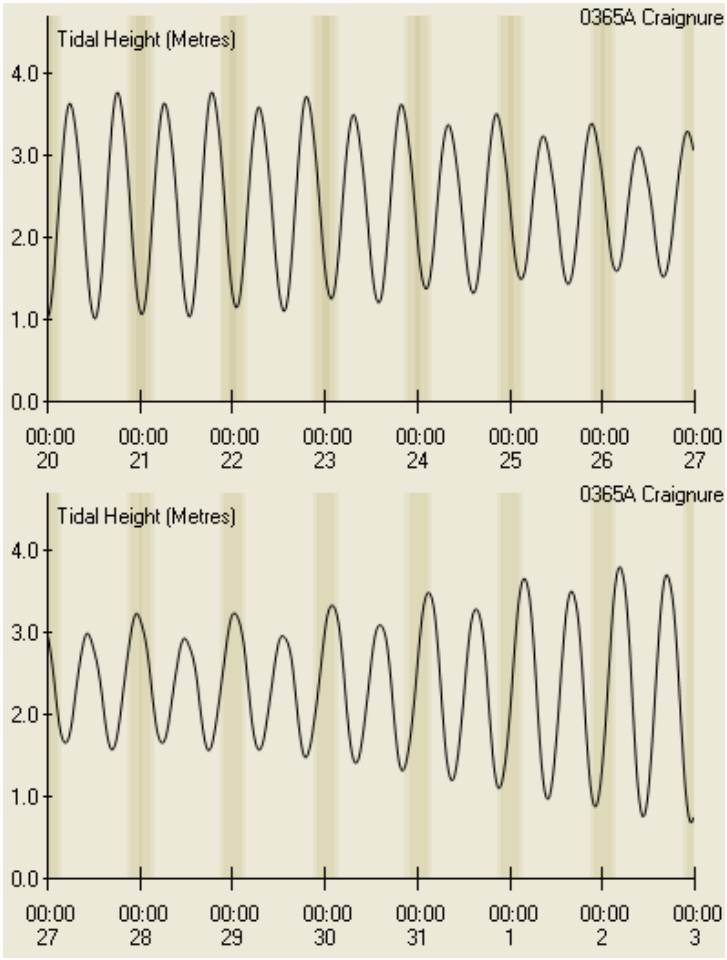

Figure 14.3 Tidal curves for Craignure

The following is the summary description for Craignure from TotalTide:

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

MHWS	4.0 m
MHWN	3.0 m
MLWN	1.7 m
MLWS	0.6 m

The tidal range at spring tide is therefore approximately 3.4 m and at neap tide 2.3 m.

Currents

Currents in coastal waters are driven by a combination of tide, wind and freshwater inputs. The following constitutes a simple assessment of water movements around the area.

Tidal stream information was available for two locations in the Sound of Mull, one approximately 2 km to the east of the shellfishery, and the other approximately 5 km to the northwest of the shellfishery. These are represented on the map in Figure 14.4

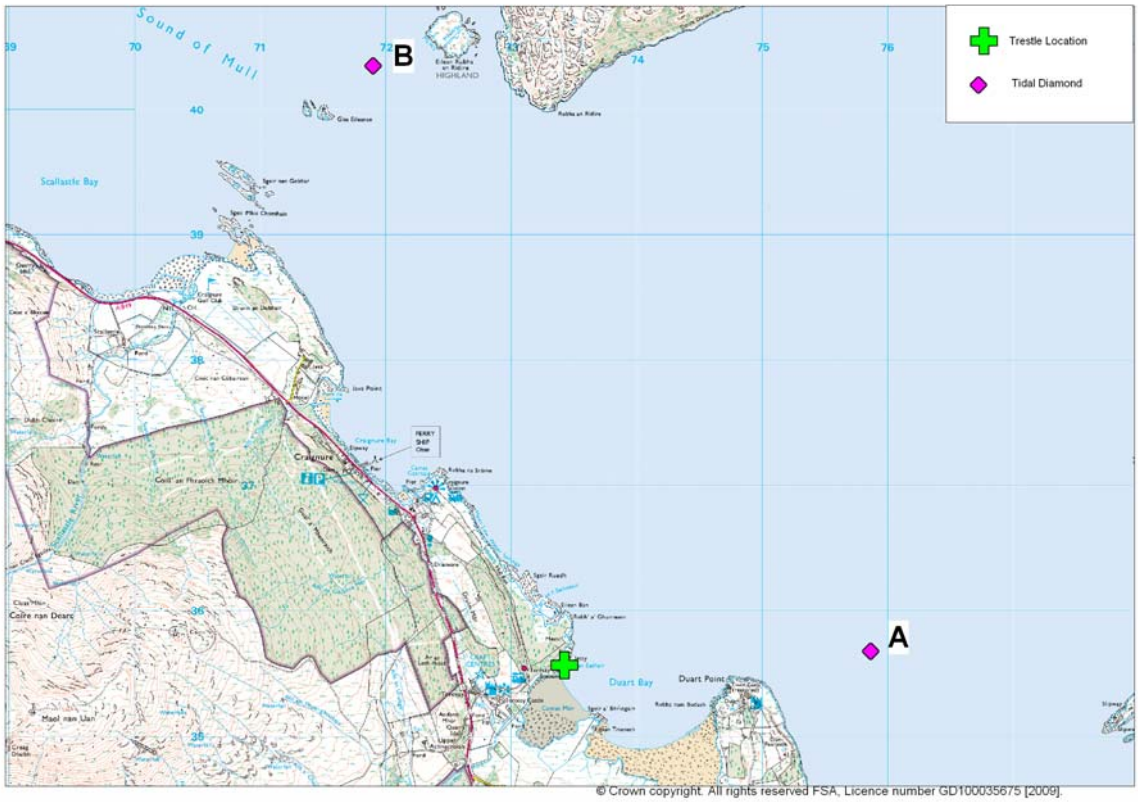

Figure 14.4 Location of tidal diamonds for Sound of Mull near Duart Bay

Tidal flows and directions for both tidal diamonds are listed in Table 14.1. Tidal flows at A are to the north-northwest on the flood tide and to the south -southeast on the ebb. Flows at B are slightly more westerly due to the orientation of the channel at that point.

During spring tides at location A, relatively high flow rates of up to 1.5 m/s are found on the flood, with weaker flows of up to 1.1 m/s on the ebb. It is likely that flooding tides will form an eddy at Duart Point, causing flows within the bay to be somewhat more complicated than further offshore. Within Duart Bay, longshore flows are likely to be weaker than in the Sound of Mull, and tidally driven flow patterns will be more complex and hence more difficult to predict without detailed measurement or modelling. Considering the flow rates stated, over the course of a spring tide particles could potentially travel up to 21 km from their source. As a consequence, contamination from all sources along the shoreline within several kilometres of the site may potentially impact the site although dilution and dispersion may mean that any impact from the more distant sources is negligible. The extent of this is dependent on their magnitude and distance from the shellfishery.

Table 14.1 Tidal flows for lower Sound of Mull

Hours relative to HW Oban	A Direction	A Rate at spring tide (m/s)	B Direction	B Rate at spring tide (m/s)
-6	182	0.3	296	0.1
-5	318	0.3	313	0.7
-4	338	1.0	312	0.9
-3	340	1.5	314	0.9
-2	338	1.3	318	0.7
-1	352	0.7	310	0.3
0	128	0.3	114	0.2
+1	150	0.8	128	0.7
+2	152	1.0	136	0.9
+3	157	1.1	140	0.8
+4	162	1.1	137	0.6
+5	165	0.8	132	0.4
+6	175	0.4	149	0.1

Given the strongly tidal regime in the area, wind driven flows are expected to be less influential in determining movement of contaminants within the bay. Strong winds will create a surface current in the same direction as the wind, but bed currents may well move in a different or even opposite direction. Onshore winds, however, will increase wave action and this may resuspend sediment and contaminants in the water.

Density driven flows are likely to be of little importance in Duart Bay as the bay has an open aspect and has relatively small freshwater inputs.

Contaminants may be transported within the bay as well as from sources beyond the bay toward the fishery. However, considering the magnitude and proximity of the known sources of faecal bacteria in the area it is most likely that sources closer to the fishery within the western half of Duart Bay will more consistently impact water quality there.

15. Shoreline Survey Overview

The sanitary survey at West Duart Bay was carried out in response to an application to harvest Pacific oysters from the production area.

The shoreline survey was conducted on the 20-21 May, with revisits for additional sample collections occurring on 3 June, 17 June, and 3 July 2008.

There were three rows of oyster trestles in place in a small bay to the north of the main bay at Camas Mor. The harvester found the main body of the bay at Camas Mor to be too exposed and shifted the trestles to the smaller area at Port an Eathair. Oysters of varying sizes were present, including some mature stock.

There were three sewage discharges in the immediate vicinity of the shellfishery. The largest of these was the septic tank for Torosay Castle which discharged to a small stream near the shoreline, and was in year round use. The Castle had tearooms and ornamental gardens, and held functions such as wedding receptions, as well as serving as the harvester's family home. A septic tank from a holiday cottage discharged to soakaway, but also had an overflow to the shoreline. There was also a small septic tank associated with the narrow gauge railway shed which discharged to a small stream on the shore. This was used intermittently during the summer months only. At the other end of West Duart Bay, was Duart Castle. This was served by a septic tank which discharged to the sea at Duart Point. The castle was open to visitors from April to October, and had a tea room and shop. Further afield, a Scottish Water septic tank was observed at the south end of Craignure Bay. A private septic tank which served a campsite also discharged here. The campsite had 90 pitches for caravans, plus 18 permanent serviced tents, 10 of which had toilet and shower facilities, and motor caravan waste disposal point. A small private septic tank was also found in this area.

The land immediately surrounding Duart Bay was primarily rough grassland used for grazing livestock. Sheep and cattle grazed here had free access to the shoreline, and were observed wading in the bay and across the streams feeding into the bay. Highest densities of livestock were seen around Torosay Castle. To the north of Camas Mor was mixed woodland. To the west of main road at Torosay and extending northward was a large area of coniferous forest. A recently cut area of this was accessible from the road north of Craignure. Otters and deer were reported to be present in the area, though none were observed during the survey. Geese were present in the area and though roughly 20-30 were observed the evening before the survey, only two were observed and counted during the survey walk itself. Oystercatchers and other wading birds were present but not in large concentrations. Several clusters of gulls numbering fewer than 20 birds were observed on the exposed seabed at low tide.

Boating activity in the immediate vicinity of the shellfishery was limited, but a number of sailboats were observed passing offshore of Duart Bay and the Oban to Craignure ferry passes by the oyster farm 14 times daily during the summer season.

Seawater samples generally had low levels of *E. coli* (<10 cfu/100ml). The one exception to this was a sample taken next to the Duart Castle septic tank outfall, which contained 4000 cfu/100ml. Oyster samples were taken from the small area of trestles on three occasions as part of a bacteriological survey, giving results of 50 *E. coli* MPN/100g on the 21/5/08, and 750 MPN/100g on the 3/6/08 and 3/7/08. A shore mussel sample taken from Camas Mor on 21/5/08 gave a result of 110 *E. coli* MPN/100g.

All larger streams were measured and sampled. *E. coli* levels in the streams sampled ranged from <100 to 1200 cfu/100ml. The largest of these streams, Eas Mor, which also contributed the highest loading in terms of *E. coli* per day, discharges south of where the trestles are located.

Figure 15.1 Summary of shoreline survey observations

16. Overall Assessment

Human sewage impacts

There are three sewage discharges in the immediate vicinity of the shellfishery. The largest of these is the septic tank for Torosay Castle which discharges to another small stream near the shoreline, and is in year round use. The population served by this will vary considerably throughout the year, with much higher use during the summer tourist season. A septic tank from a holiday cottage at Torosay discharges to soakaway, but also has an overflow to the shoreline within 100 metres of the oyster farm. There is a further small septic tank associated with the narrow gauge railway shed which discharges to a small stream on the shore. This is used intermittently during the summer months only. All three of these could affect water quality at the oyster farm, with the impact likely to be much higher in summer. Should the soakaway at the holiday cottage fail and the discharge divert to overflow, it could severely impact water quality at or near the oyster trestles.

At the other end of Duart Bay is the septic tank for Duart Castle, which discharges to the sea at Duart Point. It also will have a seasonal impact as the castle is only open to visitors from April to October. During the summer season, this discharge may affect background water quality within Duart Bay even if it doesn't reach the trestles directly.

Further north is the settlement of Craignure, which is served by several septic tanks discharging to Craignure Bay. These are about 2 km away from the shellfishery and it may affect contamination levels in the bay depending on the state of tide.

Boat traffic passing through the Sound of Mull, including the Oban-Craignure ferry may also give a minor contribution to levels of contamination in the area.

Of all sewage discharges in the area, the Torosay Castle septic tank is likely to be of greatest importance to the shellfishery given its size and proximity. The population served by this and the other two discharges in the immediate vicinity of the shellfishery are likely to increase during the summer tourist season. Some contamination may be carried from discharges at Craignure and Duart Castle towards the shellfishery at certain states of the tide.

Samples submitted for norovirus analysis (Appendix 8) were positive in winter for genogroup II and weakly positive for genogroup I in both autumn and winter, confirming the presence of human sewage contamination at the fishery.

Agricultural impacts

The land immediately surrounding Duart Bay is primarily rough grassland used for grazing livestock. The livestock that are grazed here have free access to the shoreline, and cattle and sheep were observed wading in the bay and across the streams feeding into the bay. The highest concentrations of livestock were seen around Torosay Castle. Contamination from these animals will be carried into the bay either by direct deposition on the shore below the high water mark, or via land runoff. Given their fairly high densities around Torosay Castle, and their

unrestricted access to watercourses and the shore, livestock are likely to be an important source of contamination to the shellfishery. On the basis of their distribution at the time of survey, the .northern end of the bay is likely to be most contaminated by livestock, although it must be noted that shoreline observations only apply to the date of survey.

Wildlife impacts

Potential wildlife impacts to the fisheries at West Duart Bay include geese and other waterfowl, deer, seals and otters. Geese grazing on the pastures may constitute a source of diffuse contamination in the same manner as livestock, but their impacts will be minor relative to the cattle and sheep, and less predictable as they are free to roam more widely. Deer faecal inputs are more likely to be carried via streams to the bay and so will be spatially accounted for by consideration of the locations of streams in the vicinity. Impacts from the other wildlife species are likely to be of less significance, and more localised and unpredictable. As a consequence, wildlife inputs are assumed to be evenly distributed or carried via streams and accounted for with other diffuse inputs.

Seasonal variation

The Isle of Mull is a popular tourist destination which can be reached by a 45 minute ferry ride from Oban. Torosay and Duart Castles are both tourist attractions, and a narrow gauge railway runs between Torosay Castle and Craignure. Further afield, at Craignure there is a large campsite. The ferry terminal at Craignure, which is the main point of entry to the island, is likely to see more traffic during the holiday season.

Livestock numbers will be higher in the summer, so inputs from livestock may be higher during the summer, particularly following high rainfall events. Livestock are moved around the area and so are not always present on fields near the shoreline.

Weather is wetter and windier during the winter months, so more rainfall dependent contamination such as runoff from pasture and discharges from sewer overflows may be expected during these times. This is balanced by the lower populations of both people and livestock in the area during the winter.

There is no historic *E. coli* monitoring data from West Duart Bay, so no analysis of the seasonality in levels of contamination could be carried out for this site.

In conclusion, there is likely to be more contamination of both human and livestock origin during the summer months, although rainfall and hence runoff will be higher during the winter months.

Rivers and streams

A number of streams discharging to the area were measured and sampled during the shoreline survey. The most significant of these streams is Eas Mor, which discharges into the north end of Duart Bay, in close proximity to the fishery. It drains areas of pasture and woodlands, and livestock are free to access this stream, so contamination carried to the shellfishery by this stream will largely be of

livestock origin. Extensive algal/bacterial growth was observed in this stream, suggesting high nutrient inputs. Additionally a number of smaller, unfenced streams drain the pasture on the shore adjacent to Duart Bay, and these will contribute to overall levels of contamination in the area. Further afield, a stream discharges just south of Craignure, and contamination from this may be carried in the direction of the fishery by the tide. However, as it is approximately 2 km away any bacterial contamination in the discharge may be sufficiently diluted by the time it reaches the fishery that its impact would be minor.

Meteorology, hydrology, and movement of contaminants

No historical *E. coli* monitoring data was available, so relationships between *E. coli* results and water temperature, rainfall, salinity, tide size and wind direction could not be investigated. The weather is wetter and windier during the autumn and winter months, and the prevailing wind direction is from the south west.

Currents in coastal waters are driven by a combination of tide, wind and freshwater inputs. Tidal stream information indicates that tidally driven flows in the Sound of Mull move in a northwest direction on the flood tide, and a southeast direction on the ebb tide. Contamination from all sources along the shoreline within several kilometres of the site could potentially increase levels of contamination in the Duart Bay. Contamination from the outfall at Duart Point may be carried towards the site on a flooding tide, and contamination from sources at Craignure may be carried towards the site on an ebbing tide, although by the time they reach the site they may be diluted sufficiently that their impacts are minor. Within the Duart Bay, longshore flows are likely to be weaker than in the Sound of Mull, and tidally driven flow patterns may be more complex due to flow disruption around Duart Point and hence more difficult to predict.

The bay is most exposed to the east and north, so winds from this direction are likely to affect circulation in the area the most. Onshore winds will increase wave action, which may resuspend sediment and contaminants in the water.

Density driven flows are likely to be of little or no importance in Duart Bay as the area is unenclosed, and has little in the way of freshwater inputs.

Temporal and geographical patterns of sampling results

Given that the site has no monitoring history, there is little information available under this heading with which to advise the sampling plan apart from sampling results from the shoreline survey, which must be treated with caution as they are specific to the conditions on the day.

No obvious spatial pattern was observed in seawater sample results within Duart Bay, with all four samples taken within the bay giving results of under 10 *E. coli* cfu/100ml. A seawater sample taken at Duart Point, just next to the Duart Castle septic tanks outfall gave a result of 4000 *E. coli* cfu/100ml, indicating significant but highly localised impacts from this discharge.

Oyster samples were taken from the small area of trestles on three occasions, giving results of 50 *E. coli* MPN/100g on the 21/5/08, and 750 MPN/100g on the 3/6/08 and 3/7/08, indicating some temporal variation in levels of contamination in shellfish. The area of trestles was too small to allow sampling from different locations within it to assess any geographical patterns of contamination across it.

Of the streams sampled, Eas Mor contributed the highest loading in terms of *E. coli* per day, and flows into the north end of the bay near where the trestles are located. A number of small streams drain the pasture at the head of the bay, and whilst none of these were particularly contaminated at the time of survey, it is likely that they carry contamination of livestock origin into the bay and contribute to overall levels of contamination here.

Overall

The principle potential sources of contamination to the fishery are:

- Septic tanks at Torosay
- Diffuse pollution from livestock on or near shoreline
- Contamination from Eas Mor

17. Recommendations

Based on the assessment, it is not recommended that the entire bay be included in the classified production area. However, the harvester has expressed a desire to have an area greater than that occupied at the time of survey classified so as to allow for movement and/or expansion of the fishery as conditions warrant.

Therefore, the recommended production area boundaries are the area bounded by lines drawn between NM 7321 3547 to NM 7355 3502 and between NM 7362 3515 to NM 7363 3519 to NM 7352 3557 to NM 7342 3566 and extending to MHWS. This permits some room for the fishery to expand, but prevents expansion near to the two main identified contamination sources (Torosay Castle septic tank outflow and Eas Mor) while still allowing for potential use of the width of the bay. The harvester should take care to observe the condition of the overflow at the holiday cottage near the trestles and should it operate, avoid harvesting for a reasonable time afterward to allow the shellfish to clear any contaminants.

Water and shellfish sampling results from the shoreline survey do not provide robust evidence for the location of the RMP in any particular place. As the oyster farm occupied a very small area at the time of survey, there may be little spatial variation across it. However, as the important sources of contamination identified during the survey are located to the southwest of the fishery, so the RMP should be set as near as possible to the southwest corner of the trestles. Though the extended production area includes the discharge from the railway shed, it only operates seasonally and the Eas Mor is both larger and is likely to contain septic tank effluent year-round.

Therefore, it is recommended that two RMPs be established: one at NM 7343 3556 on the current oyster farm near the holiday cottage overflow and a second at NM 7326 3543 at the southwestern end of the classified area, nearest the stream at the production area boundary. Bagged Pacific oysters should be placed at the second monitoring point if no oyster trestles are located there. Only stock of a harvestable size should be sampled. No sampling depth is applicable and a sampling tolerance should be set at 10 m.

As this is a new production area, and there are likely to be seasonal fluctuations in *E. coli* results, the sampling frequency from both monitoring points should be monthly.

Both monitoring points should be sampled until such time as sufficient monitoring data exists to permit selection of one over another as being more protective of public health.

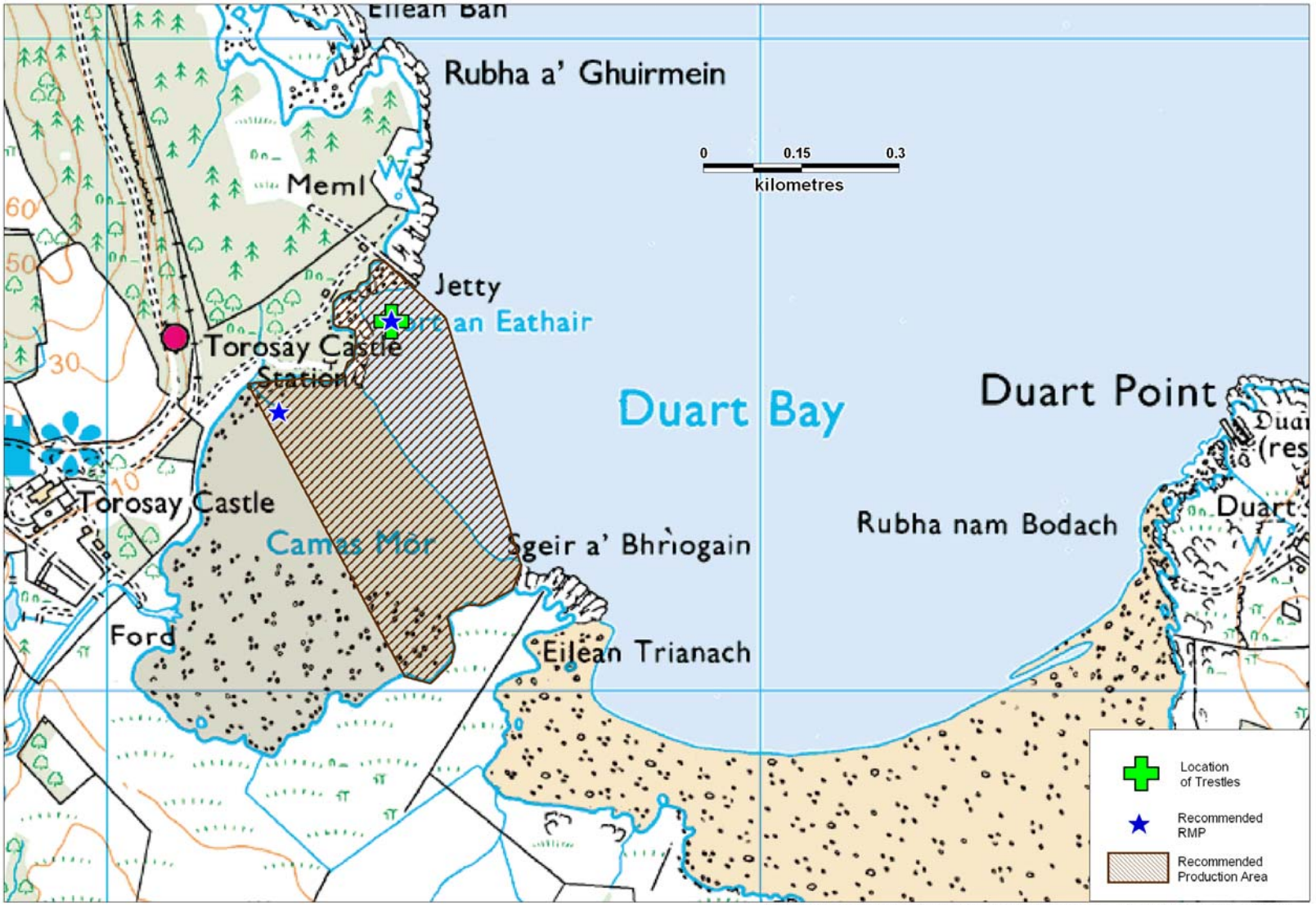

Figure 17.1. Recommended production area boundaries and RMPs

18. References

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Sampling Plan for West Duart Bay

PRODUC-TION AREA	SITE NAME	SIN	SP.	TYPE OF FISH-ERY	NGR OF RMP	EAST	NORTH	TOLER-ANCE (M)	DEPTH (M)	METHOD OF SAMPLING	FREQ OF SAMPLING	LOCAL AUTHORITY	AUTHORISED SAMPLER(S)	LOCAL AUTHORITY LIAISON OFFICER
West Duart Bay	Camas Mor	AB 406 807 13	Pacific oyster	Trestles	NM 7343 3556	173430	735560	10 m	N/A	Hand	Monthly	Argyll & Bute Council	Christine McLachlan William MacQuarrie Ewan McDougall Donald Campbell	Christine McLachlan
					NM 7326 3543	173260	735430	10m	N/A	Hand	Monthly	Argyll & Bute Council	Christine McLachlan William MacQuarrie Ewan McDougall Donald Campbell	Christine McLachlan

For the purpose of providing monitoring samples, bagged shellfish (Pacific oysters) shall be placed at NM 7326 3543 if no trestles with stock are currently located at this point.

Table of Proposed Boundaries and RMPs – West Duart Bay

Production Area	Species	SIN	Existing Boundary	Existing RMP	New Boundary	New RMP	Comments
West Duart Bay	Pacific oyster	AB 406 807 13	N/A	N/A	Area bounded by lines drawn between NM 7321 3547 and NM 7355 3502 and between NM 7362 3515 and NM 7363 3519 and NM 7352 3557 and NM 7342 3566, extending to MHWS	NM 7343 3556 and NM 7326 3543	New production area and RMP. Area constrained by stream and septic tank discharges to southwest.

Geology and Soils Information

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

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

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

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

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

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

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

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

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

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

Glossary of Soil Terminology

Calcareous: Containing free calcium carbonate.

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

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

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

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

References

Macaulay Institute. http://www.macaulay.ac.uk/explorescotland. Accessed September 2007.

General Information on Wildlife Impacts

Pinnipeds

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

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

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

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

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

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

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

Cetaceans

As mammals, whales and dolphins would be expected to have resident populations of *E. coli* and other faecal indicator bacteria in the gut. Little is known about the concentration of indicator bacteria in whale or dolphin

faeces, in large part because the animals are widely dispersed and sample collection difficult.

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

Table 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.

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

Birds

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

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

A study conducted on both gulls and geese in the northeast United States found that Canada geese (*Branta canadiensis*) contributed approximately 1.28 x 10^5 faecal coliforms (FC) per faecal deposit and ring-billed gulls (*Larus delawarensis*) approximately 1.77 x 10^8 FC per faecal deposit to a local

reservoir (Alderisio and DeLuca, 1999). An earlier study found that geese averaged from 5.23 to 18.79 defecations per hour while feeding, though it did not specify how many hours per day they typically feed (Bedard and Gauthier, 1986).

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

Deer

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

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

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

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

Otters

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

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

References:

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

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Stoddard, R. A., Gulland, F.M.D., Atwill, E.R., Lawrence, J., Jang, S. and Conrad, P.A. (2005). Salmonella and Campylobacter spp. in Northern elephant seals, California. *Emerging Infectious Diseases* www.cdc.gov/eid 12:1967-1969.

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.

Hydrographic Methods Document

1.0 Introduction

This document outlines the methodology used by Cefas to fulfil the requirements of the sanitary survey procedure with regard to hydrographic evaluation of shellfish production areas. It is written as far as possible to be understandable by someone who is not an expert in oceanography or computer modelling. This document collects together information common to all hydrographic assessments avoiding the repetition of information in each individual report.

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

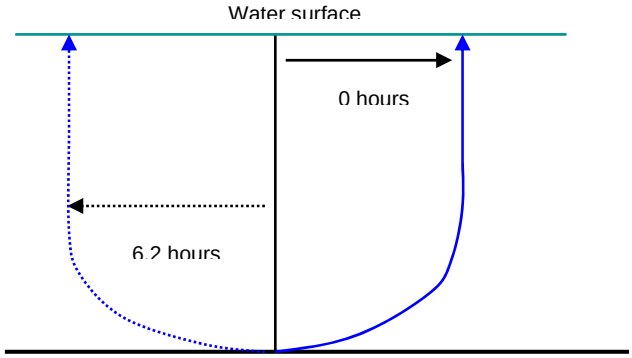
The regulations require an appreciation of the hydrography and currents within a region classified for shellfish production.

2.0 Background processes

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

Movement in the estuarine and coastal waters is generally driven by one of three mechanisms: 1) Tides, 2) Winds, 3) Density differences. Unless tidal flows are weak they usually dominate over the short term (~12 hours) and move material over the length of the tidal excursion. The tidal residual flow acts over longer time scales to give a net direction of transport. Whilst tidal flows generally move material in more or less the same direction at all depths, wind and density driven flows often move material in different directions at the surface and at the bed. Typical vertical profiles are depicted in figure 1. However, it should be understood that in a given water body, movement will often be the sum of all three processes.

a)



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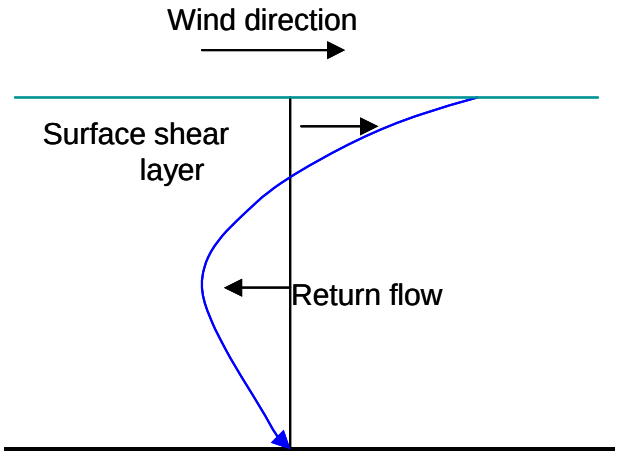

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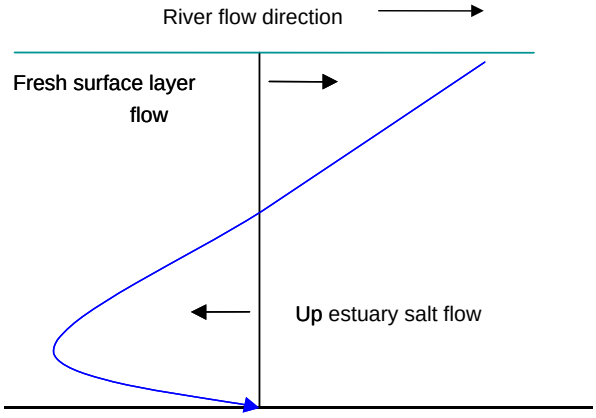


Figure 1. Typical vertical profiles for water currents. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction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

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

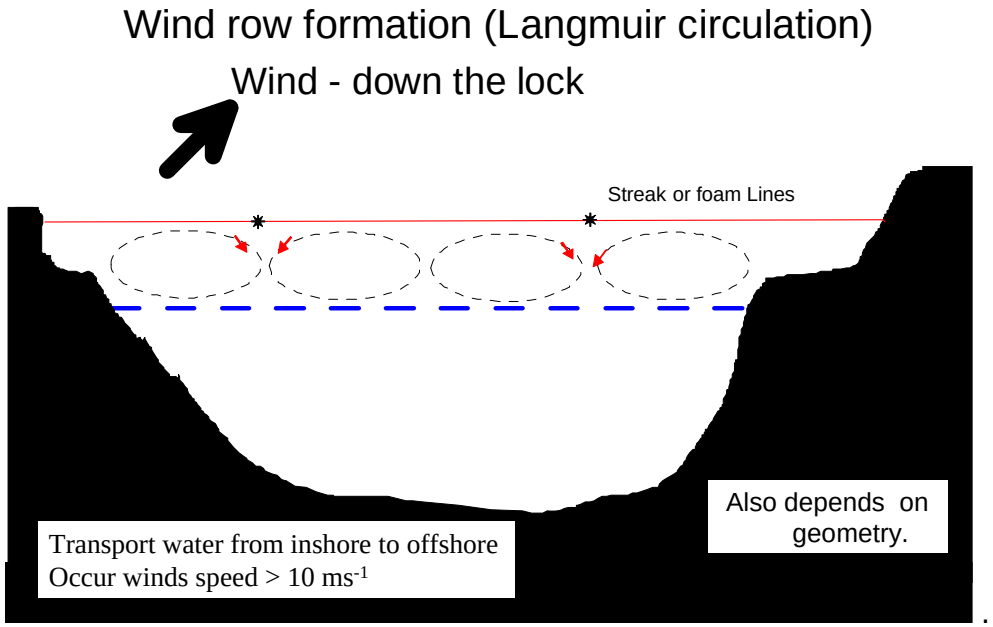


Figure 2: Schematic of wind driven ‘wind row’ currents. The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

Shoreline Survey Report

West Duart Bay
AB 406

Scottish Sanitary Survey Project

Shoreline Survey Report

Prod. area:	West Duart Bay
Site name:	Camas Mor (SI 416 821 08)
Species:	Pacific Oysters
Harvester:	Christopher James
Local Authority:	Argyll & Bute Council
Status:	New Site
Date Surveyed:	20-21 May, 17 June, and 3 July 2008
Surveyed by:	Michelle Price-Hayward, Christine McLachlan
Existing RMP:	Not yet established
Area Surveyed:	See Map in Figure 1

Weather observations
20-21 May: Dry, overcast to partly cloudy. No significant rain 3 weeks prior to survey. Air temperature 12-14°C. Wind SE, force 3.
17 June: Rain. Air temp 10°C. Wind NE, force 5.
3 July: Dry, sunny.

Site Observations

Fishery
The oyster farm at West Duart Bay is located in a small cove at Eathair, on the north western shore of Duart Bay. Duart Bay is divided into two by a small headland.

There are currently three rows of oyster trestles, each 8 bags across in place at Camas Mor, in a small bay to the north of the main bay. The harvester found the main body of the bay at Camas Mor to be too exposed and shifted the trestles to the smaller area at Port an Eathair. Oysters of varying sizes were present, including some mature stock.

The trestles are accessible only during low water at spring tides.

Sewage/Faecal Sources
There is a holiday cottage on the shoreline adjacent the trestles. It is owned by the harvester and has a septic tank discharging to soak away with an overflow to the shoreline in case ground water levels prevent adequate functioning of the soak away.

Above Camas Mor is Torosay Castle and farm. The castle is open to the public. A small gauge railway runs between the castle and Craignure. The septic tank for the castle discharges to a stream that runs out into Duart Bay. There is a smaller septic tank associated with the train shed that is used intermittently and only in summer.

Sheep and cattle are grazed on the surrounding fields and have free access to the shoreline. Cattle and sheep were observed wading in the bay and across the streams feeding into the bay.

The burn Eas Mor flows passed the farm around Torosay and discharges into Camas Mor. Bright green algal growth was observed on the rocks around this area and extensive alga/bacterial growth was observed growing on the bottom within the main stream. Water sample WD11 collected from this stream contained 400 *E. coli* cfu/100 ml.

Duart Castle, at the eastern end of Duart Bay, is also open to the public and a septic tank was observed with discharge pipe into the sea to the east of Duart Point. A seawater sample collected from adjacent to this outfall contained 4000 *E.coli* cfu/100 ml.

Further away from the fishery, there is a community septic tank at Craignure as well as a smaller tank serving the campsite located to the south of the ferry pier. This smaller tank discharged into a stream, Allt na Goibhre Mor. Water sample WD13 was taken from downstream of the discharge and contained 1200 *E. coli* cfu/100 ml. The outfall for the Craignure septic tank was not immediately apparent as there was no discharge pipe running into the bay. It is possible that this also discharged to the stream though this was not visually confirmed.

Seasonal Population

There is likely to be a significantly higher impact in the summer due to tourism as Mull is a very popular tourist destination. There is a campground on the southern end of Craignure Bay with 90 pitches for caravans, plus 18 permanent serviced tents, 10 of which have toilet and shower facilities, and motor caravan waste disposal point. This waste goes to the septic tank observed on the premises.

Boats/Shipping

A number of sailboats were observed passing offshore of Duart Bay and the Oban to Craignure ferry passes by the oyster farm 14 times daily during the summer season. It is not known where toilet waste from the ferry is discharged as there are no pumpout facilities at either Oban or Craignure, but it can be presumed that sewage waste is discharged somewhere en-route between the two piers.

Land Use

The nearest settlement is Craignure, which sits along the main road north from the ferry pier. To the south, the road turns to single track with passing places before it reaches Torosay Castle and then further along the turnoff to Duart Castle. There are car parks and tourist facilities at both castles. A narrow gauge scenic railway operates between Craignure and Torosay castles during the summer.

The land immediately surrounding Duart Bay is primarily rough grassland used for grazing livestock. To the north of Camas Mor is mixed woodland through which runs the scenic railway and a walking trail.

To the west of main road at Torosay and extending northward is a large area of coniferous forest. A recently cut area of this was accessible from the road north of Craignure.

Wildlife/Birds

Otters were reported to be present in the area by both the owner of the campground and by the harvester, though no otters were observed during the survey.

Geese were present in the area and though roughly 20-30 were observed the evening before the survey, only two were observed and counted during the survey walk itself. Oyster catchers and other wading birds were present but not in large concentrations. Several clusters of gulls numbering fewer than 20 birds were observed on the exposed seabed at low tide.

No seals were observed during the shoreline survey.

No deer were observed during the shoreline survey, though the owner of the campground reported that she had seen deer on the campsite. The harvester reported that all the deer on Mull are surveyed by the Deer Commission for Scotland and that there were a fair number about the area.

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

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

Figure 1. Map of Shoreline Observations

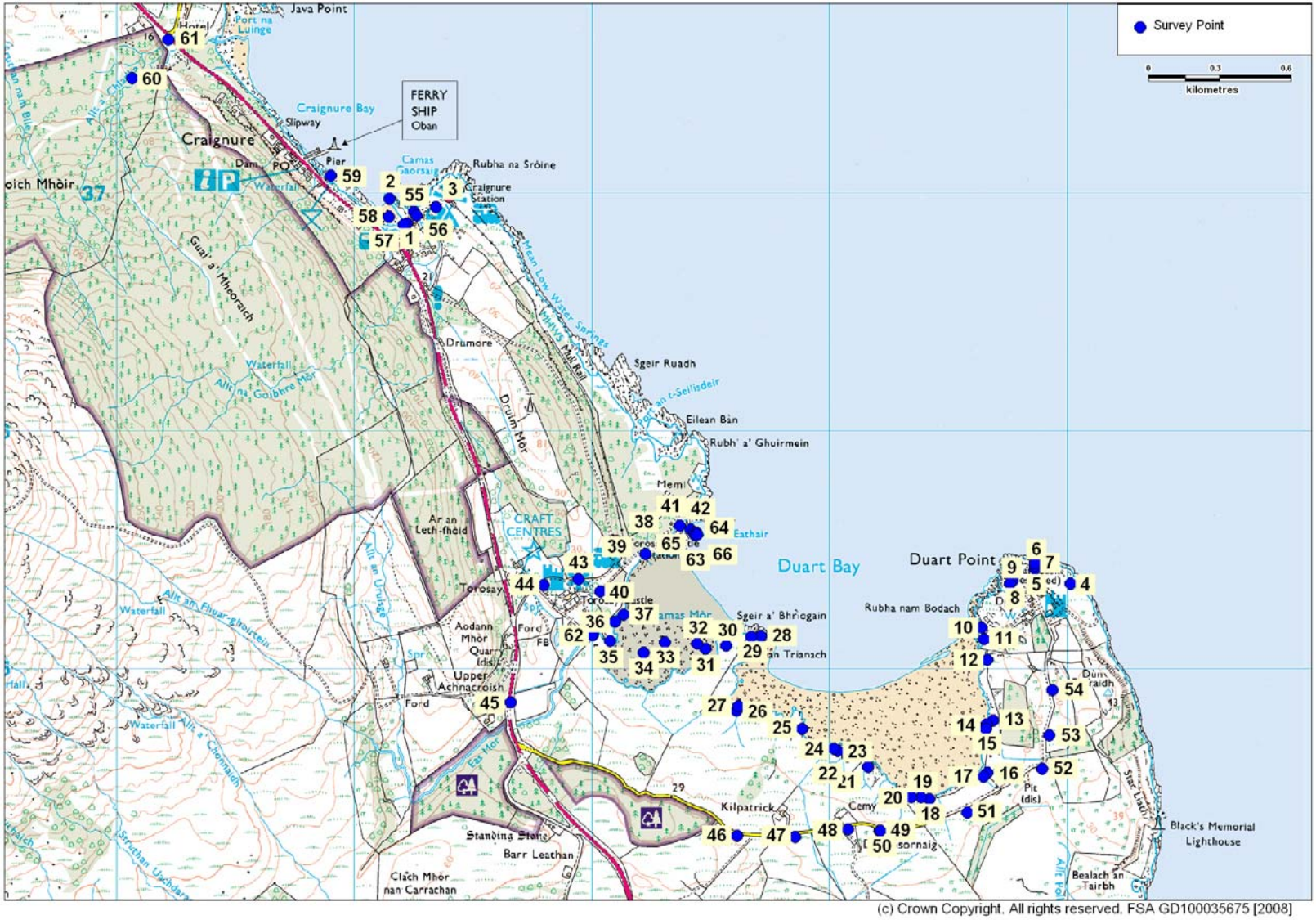


Table 1. Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Description
1	20/05/08	18:55	NM 72221 36873	172221	736873	Figure 5	Craignure WWTW
2	20/05/08	19:01	NM 72147 36978	172147	736978		Sanitary debris on top of pier
3	20/05/08	19:08	NM 72341 36942	172341	736942	Figure 6	Septic tank adjacent to campsite, odorous
4	21/05/08	09:29	NM 75011 35358	175011	735358		Area of bog cotton and sphagnum moss, dry underfoot
5	21/05/08	09:33	NM 74863 35421	174863	735421	Figure 7	Water flowing through concrete tank with cover removed, appears dirty
6	21/05/08	09:36	NM 74863 35434	174863	735434	Figure 8	Septic tank down hill from tank above
7	21/05/08	09:38	NM 74863 35444	174863	735444	Figure 9	Discharge from septic tank, water sample 1, seawater
8	21/05/08	09:49	NM 74768 35369	174768	735369		Sheep dropping
9	21/05/08	09:50	NM 74757 35358	174757	735358	Figure 10	Slipway, still in use
10	21/05/08	10:00	NM 74637 35172	174637	735172		Possible old slipway with small beach. Clam and razor shells
11	21/05/08	10:05	NM 74647 35123	174647	735123		Water sample 2
12	21/05/08	10:11	NM 74660 35038	174660	735038		Ground seepage, nearly dry
13	21/05/08	10:19	NM 74685 34781	174685	734781		Small stream, barely flowing. Not deep enough to sample
14	21/05/08	10:23	NM 74658 34765	174658	734765		Water sample 3, seawater near where stream discharges
15	21/05/08	10:26	NM 74656 34747	174656	734747	Figure 11	Several small streams converge, flow into bay. Water sample 4, fresh water
16	21/05/08	10:36	NM 74661 34563	174661	734563	Figure 12	Water seeping from land across and under beach. Bright green algae on shore. Broken fence at foreshore
17	21/05/08	10:40	NM 74646 34545	174646	734545		Stream, water sample 5, 0.45 m wide x 0.06 m deep, flow 0.3m/s. 18 sheep in view, 10 plovers
18	21/05/08	10:52	NM 74416 34451	174416	734451		End of sandy part of shore
19	21/05/08	10:53	NM 74382 34459	174382	734459		10 gulls 50m offshore of this point
20	21/05/08	10:55	NM 74341 34459	174341	734459		Stream, water sample 6, 0.58 m x 0.04 m, flow 0.2 m/s
21	21/05/08	11:08	NM 74158 34588	174158	734588		Small stream, barely flowing. Sheep hoof prints in mud. Shore side of cemetery
22	21/05/08	11:11	NM 74073 34631	174073	734631		Stream, flow low, no suitable run for measurement. Water sample 7
23	21/05/08	11:18	NM 74031 34654	174031	734654		Occasional sheep droppings, 1 every 1-2 metres
24	21/05/08	11:20	NM 74016 34662	174016	734662	Figure 13	Stream, 0.29 m x 0.08 m, flow 0.3 m/s. 2 dead sheep nearby. Water

No.	Date	Time	NGR	East	North	Associated photograph	Description
							sample 8.
25	21/05/08	11:34	NM 73883 34747	173883	734747		Goose dropping, two geese nearby
26	21/05/08	11:40	NM 73607 34823	173607	734823		Stream 0.41 m x 0.10 m, flow 0.1 m/s. No shore mussels noted in this part of the bay
27	21/05/08	11:43	NM 73613 34841	173613	734841		Water sample 9
28	21/05/08	12:00	NM 73708 35138	173708	735138		Water sample 10, seawater
29	21/05/08	12:03	NM 73669 35135	173669	735135		4 sheep
30	21/05/08	12:06	NM 73563 35096	173563	735096		Goose droppings common, approx 1 per metre
31	21/05/08	12:08	NM 73476 35082	173476	735082		Shore mussels observed in this bay
32	21/05/08	12:10	NM 73441 35104	173441	735104		Shellfish sample 1, shore mussels. 2 gulls, 1 heron
33	21/05/08	12:19	NM 73306 35111	173306	735111	Figure 14	Stream crossing exposed shore, bright green algae
34	21/05/08	12:22	NM 73214 35066	173214	735066		5 ducks, 9 gulls, dead maggots caught in seaweed in stream
35	21/05/08	12:26	NM 73073 35115	173073	735115	Figure 15	Cow dung, large stream 8 m x 0.06 m, flow 0.6 m/s. Water sample 11. Flows past Torosay castle farm and gardens
36	21/05/08	12:40	NM 73097 35196	173097	735196	Figure 16	Stand of trees, 15 sheep, 1 cow, 2 ponies
37	21/05/08	12:42	NM 73131 35226	173131	735226	Figure 17	30 cattle and calves
38	21/05/08	13:04	NM 73367 35601	173367	735601		Self catering cottage, on septic tank with soak away and overflow discharge. Dry
39	21/05/08	13:08	NM 73223 35481	173223	735481		Septic tank for staff using railroad engine shed, 2-3 staff during summer only
40	21/05/08	13:11	NM 73033 35325	173033	735325		Septic tank for Torosay castle
41	21/05/08	13:46	NM 73412 35585	173412	735585		Waters edge, oyster trestles approx 30 m from here
42	21/05/08	13:47	NM 73432 35569	173432	735569		Shellfish sample 2, oyster, 3 rows of trestles, 8 bags wide. Water sample 12. Only one nearest to shore exposed.
43	21/05/08	14:19	NM 72941 35375	172941	735375		Approximately 100 sheep, 7 cattle
44	21/05/08	14:22	NM 72795 35353	172795	735353		Corner of field containing sheep and cattle
45	21/05/08	14:23	NM 72657 34857	172657	734857		50 sheep
46	21/05/08	14:27	NM 73608 34297	173608	734297		30 sheep
47	21/05/08	14:28	NM 73853 34291	173853	734291		Converted barn
48	21/05/08	14:28	NM 74076 34323	174076	734323		Shed and sheep, equipment for cattle but none observed

No.	Date	Time	NGR	East	North	Associated photograph	Description
50	21/05/08	14:29	NM 74210 34317	174210	734317		House
51	21/05/08	14:30	NM 74578 34394	174578	734394		8 sheep
52	21/05/08	14:31	NM 74892 34580	174892	734580		Approximately 20 sheep in view, others likely hidden by terrain
53	21/05/08	14:32	NM 74921 34719	174921	734719		2 sheep
54	21/05/08	14:32	NM 74934 34911	174934	734911		16 sheep
55	21/05/08	14:49	NM 72250 36922	172250	736922		Stream
56	21/05/08	14:58	NM 72261 36906	172261	736906	Figure 18	Culvert, stream measured here 0.43m x 0.03 m, flow 0.9 m/s. Water sample 13
57	21/05/08	15:18	NM 72205 36867	172205	736867		Pipe in side of bank below Craignure WWTW, no flow
58	21/05/08	15:21	NM 72144 36902	172144	736902	Figure 19	Water sample 14, sea water, taken from near WWTW
59	21/05/08	15:34	NM 71899 37074	171899	737074		Water sample 15, sea water, taken from near pier
60	21/05/08	17:04	NM 71065 37483	171065	737483		Scottish Water Craignure Water Treatment Works - signage
61	21/05/08	17:06	NM 71217 37646	171217	737646		Area of recent logging activity
62	17/06/08	15:08	NM 73001 35139	173001	735139		Stream at Torosay 3.6m wide x 9 cm deep, flow 0.245 m/s.
63	03/07/08		NM 73426 35572	173426	735572	Figure 20	Corner of oyster trestles
64	03/07/08		NM 73438 35572	173438	735572		Corner of oyster trestles
65	03/07/08		NM 73431 35560	173431	735560		Corner of oyster trestles
66	03/07/08		NM 73441 35564	173441	735564		Corner of oyster trestles

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

Sampling

Water and shellfish samples were collected at sites marked on the map. Bacteriology results follow in Tables 2 and 3.

As only the trestle nearest the shore was exposed during the first visit, an oyster sample was only collected from that trestle. Laboratory analysis showed it 50 *E. coli* mpn/100 g. A second attempt was made to record the extent of farm and take a sample from the outermost end of the trestles on 17 June. Due to weather conditions on the day, this was not possible. However, the stream at Torosay was sampled and measured a second time on this date. Both water samples contained *E. coli* concentrations of 400 cfu/100 ml, though the flows were taken at different locations along the stream and were not directly comparable.

A second oyster sample was collected and the extent of the farm recorded by C. McLachlan on 3 June. This sample contained 750 *E. coli* mpn/100 g. A third sample was collected to complete the bacteriological survey on 3 July and also contained 750 *E. coli* mpn/100 g.

Seawater samples were tested for salinity using a hand held refractometer. These readings are recorded in Table 1 as salinity in parts per thousand (ppt).

Samples were also tested for salinity by the laboratory using a salinity meter under more controlled conditions. These results are shown in Table 2, given in units of grams salt per litre of water. This is the same as ppt.

Table 2. Water Sample Results

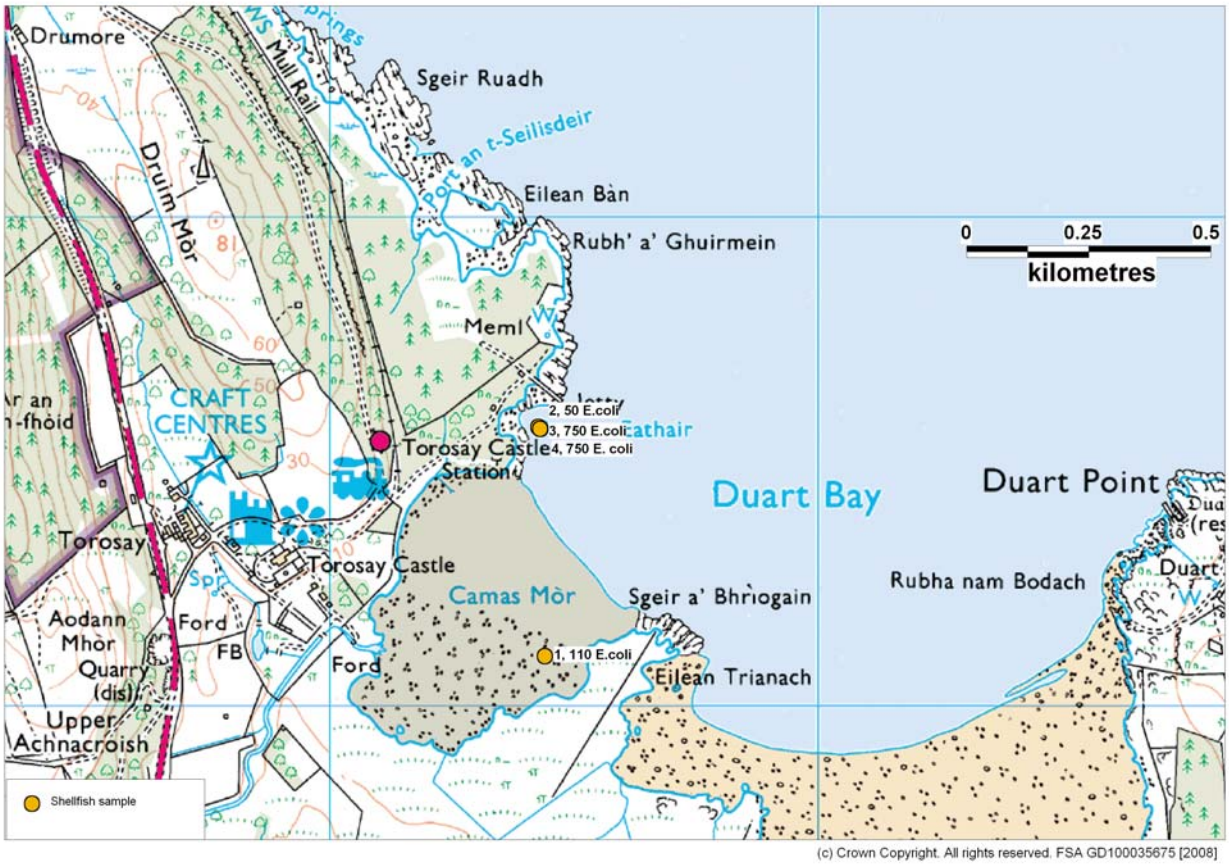
No.	Date	Sample	Grid Ref	Type	E. coli (cfu/100 ml)	Salinity (g/L)
1	21/05/08	WD1	NM 74863 35444	sea water	4000	35.2
2	21/05/08	WD2	NM 74647 35123	sea water	1	34.3
3	21/05/08	WD3	NM 74658 34765	sea water	9	33.8
4	21/05/08	WD4	NM 74656 34747	fresh water	100	
5	21/05/08	WD5	NM 74646 34545	fresh water	100	
6	21/05/08	WD6	NM 74341 34459	fresh water	<100	
7	21/05/08	WD7	NM 74073 34631	fresh water	<100	
8	21/05/08	WD8	NM 74016 34662	fresh water	1200	
9	21/05/08	WD9	NM 73616 34841	fresh water	<100	
10	21/05/08	WD10	NM 73708 35138	sea water	7	34.7
11	21/05/08	WD11	NM 73073 35115	fresh water	400	
12	21/05/08	WD12	NM 73432 35569	sea water	3	33.8
13	21/05/08	WD13	NM 72261 36906	fresh water	1200	
14	21/05/08	WD14	NM 72144 36902	sea water	0	34.7
15	21/05/08	WD15	NM 71899 37074	sea water	9	35.1
16	17/06/08	Toro1	NM 73001 35139	fresh water	400	

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (mpn/100g)
1	21/05/08	WD Mussel	NM 73441 35104	shore mussel	110
2	21/05/08	WD Oyster 1	NM 73432 35569	oyster	50
3	03/06/08	WD Oyster 2	NM 73427 35573	oyster	750
4	03/07/08	WD Oyster 3	NM 73431 35569	oyster	750

Figure 3. Water sample results map

Figure 4. Shellfish sample results map



Photographs

Figure 5. Criagnure WWTW pump and tanks

Figure 6. Septic tank adjacent to campsite

Figure 7. Open tank with dirty water flow

Figure 8. Duart Castle septic tank

Figure 9. Discharge pipe

Figure 10. Slipway still in use near Duart Castle

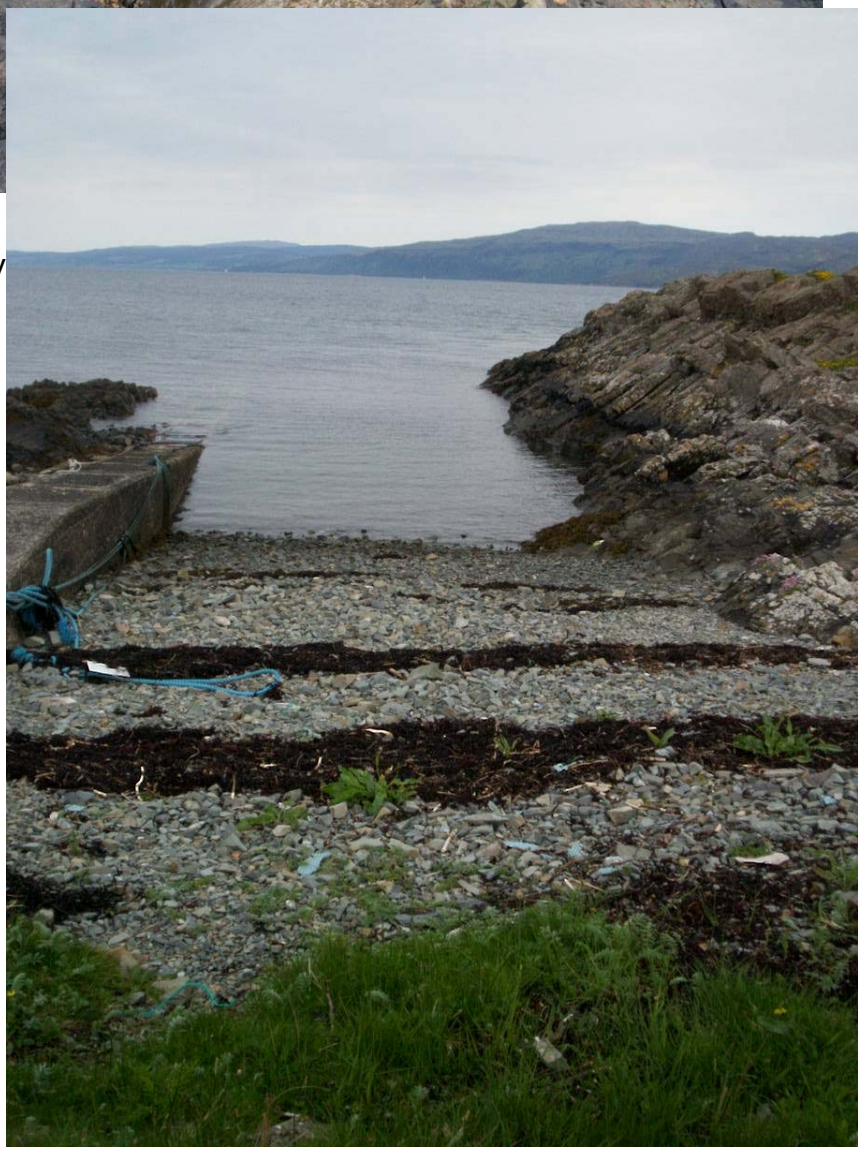


Figure 11. Stream

Figure 12.

Figure 13. Stream

Figure 14. Algal growth along stream on shoreline

Figure 15. Stream flowing through Torosay gardens

Figure 16. Sheep at shoreline near Torosay

Figure 17. Cattle herd on shoreline

Figure 18. Stream and culvert near Craignure

Figure 19. Bay adjacent Craignure WWTW, ferry pier in background

Figure 20. Oyster trestles at West Duart Bay

Norovirus Testing Summary

West Duart Bay
AB 406 807 13

Pacific oyster samples were taken from the farm at West Duart Bay quarterly and submitted for Norovirus analysis beginning 21/05/2008.

Results are tabulated below.

Ref No.	Date	NGR	GI	GII
08/132	21/05/08	NM 73432 35569	Not detected	Not detected
08/167	19/08/08	NM 73432 35571	Not detected	Not detected
08/257	11/11/08	NM 73431 35573	Positive at Limit of Detection	Not detected
09/009	10/02/09	NM 73430 35574	Positive at Limit of Detection	Positive