Scottish Sanitary Survey Project

Sanitary Survey Report
Isle of Gigha
AB 541
January 2011

Cefas

Food Standards Agency
food.gov.uk
Buidheann Inbhe-Bìdhe

Report Distribution – Isle of Gigha

Date	Name	Agency*
	Linda Galbraith	Scottish Government
	Mike Watson	Scottish Government
	Morag MacKenzie	SEPA
	Douglas Sinclair	SEPA
	Fiona Garner	Scottish Water
	Alex Adrian	Crown Estate
	Andy Macleod	Argyll & Bute Council
	Christine McLachlan	Argyll & Bute Council
	Anthony Walker	Harvester

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

Table of Contents

1. General Description

The Isle of Gigha is the southernmost island of the Southern Hebrides, and lies in the Sound of Gigha, off the north-west coast of the Kintyre Peninsula. Its main settlement is Ardminish, which holds the majority of the islands population. East Tarbert Bay and West Tarbert Bay lie astride a small isthmus at the northern end of the island. East Tarbert Bay is approximately 1-1.5 km wide and opens to the Sound of Gigha on the east of the island.

Figure 1.1 Location of East Tarbert Bay on the Isle of Gigha

2. Fishery

The sanitary survey was prompted by an application for classification of a new Pacific oyster fishery at East Tarbert Bay on the Isle of Gigha (AB 541 972 13). The site has also had an application for fast-track classification of Pacific oysters.

The site does not fall within a presently classified production area and does not have an associated Crown Estate (CE) lease. The locations of the oyster trestles are shown in Figure 2.1. In addition to the trestles in place at the time of the shoreline survey, the harvester put down a further 2 areas of trestles during the winter of 2010/11. These are situated on either side of the existing trestles on the east side of the bay, one set to the east and one set to the west. The NGR of the newly added trestles to the west is NR 65744 52103. The tide has not yet been suitable to measure the NGR of the other set of trestles. These can be measured fully during better spring/summer tides.

Figure 2.1 Isle of Gigha fishery

3. Human Population

Figure 3.1 shows information obtained from the General Register Office for Scotland on the population within the census output areas in the vicinity of the Isle of Gigha. The last census was undertaken in 2001.

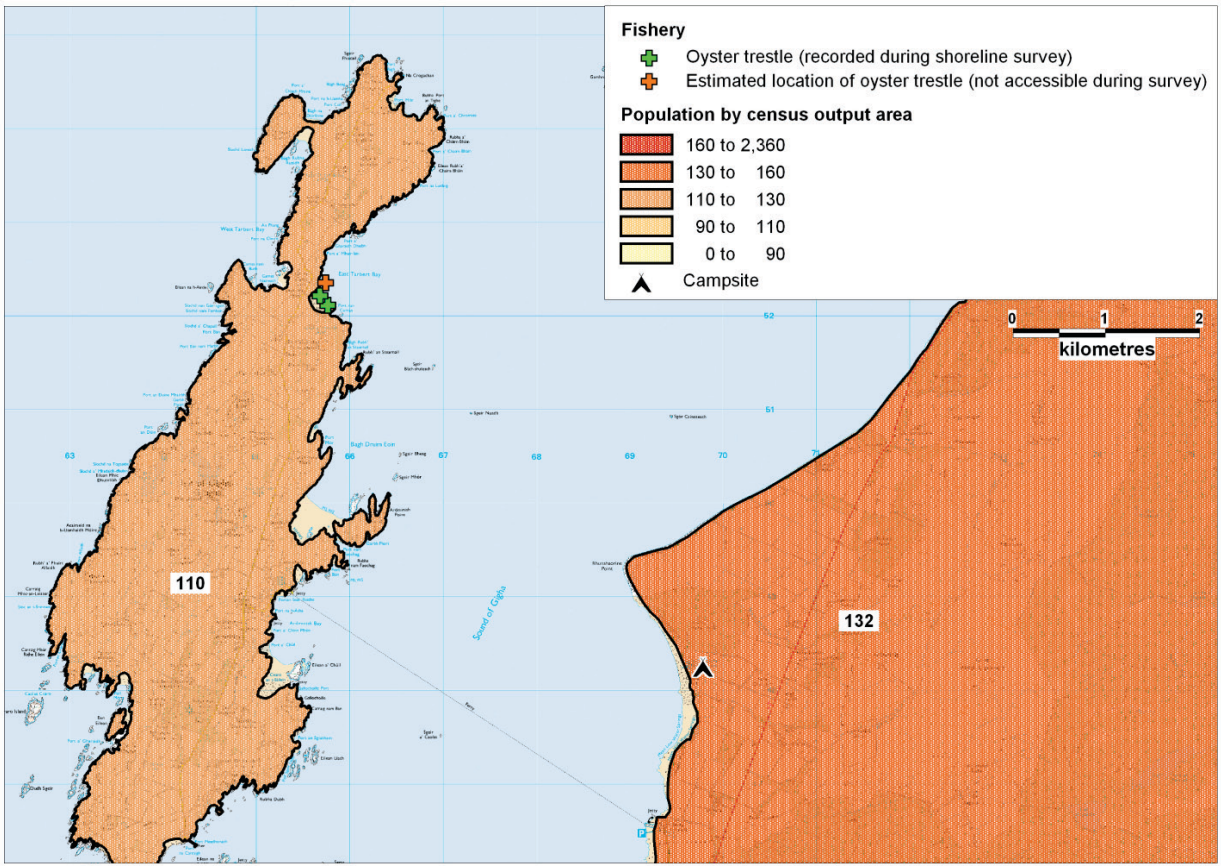


Figure 3.1 Population map for Isle of Gigha

The Isle of Gigha had a population of 110 at the last census, and the census area on the adjacent mainland had a population of 132. There is only one dwelling on the coast adjacent to East Tarbert Bay and most of the inhabited area lies south of the fishery.

The population of the island is concentrated around the village of Ardminish. A report in The Scotsman in 2006 stated that the population of the island had risen to 150 since 2002, when the island was bought by its residents through a development trust (Ross, 2006). A daily car ferry operates between Tayinloan on the mainland and Ardminish. Tourist facilities on the island include a cafe/restaurant, a golf course, a hotel, and a small number of B&Bs and self catering apartments. There is a designated area for camping with access to showers and toilets close to the ferry pier.

It is expected tourism in the area results in a significant increase in population during the summer holiday months. The current resident population of the island is significantly higher than reported in the last census.

4. Sewage Discharges

Scottish Water identified community septic tanks and sewage discharges for the area surrounding East Tarbet Bay. These are detailed in Table 4.1.

Table 4.1 Discharges identified by Scottish Water

Consent Ref No.	NGR of discharge	Discharge Name	Discharge Type	Level of Treatment	Consented flow m^3/day	Consented Design PE
CAR/L/1000369	NR 694 460	Tayinloan ST	Continuous	Septic tank	165	not stated

The Tayinloan septic tank discharges to the Sound of Gigha from Tayinloan, on the mainland and lies 7.2 km southeast of the oyster farm at East Tarbert Bay. No sanitary or microbiological data were available for discharge. The consent reference number and information on consented flow were provided by SEPA. There were no community septic tanks or treatment works reported on the Isle of Gigha. Discharge consents provided by SEPA are listed in Table 4.2.

Table 4.2 Discharge consents identified by SEPA

No.	Ref No.	NGR of discharge	Discharge Type	Level of Treatment	Consented/ design PE	Discharges to
1	CAR/R/1077782	NR 6585 5313	Domestic sewage	not stated	5	unnamed watercourse
2	CAR/R/1077913	NR 6498 5189	Domestic sewage	not stated	5	Unnamed tributary of Slochd a Chapuill Port Ban
3	CAR/R/1078069	NR 6513 5146	Domestic sewage	not stated	5	Unnamed watercourse
4	CAR/R/1078079	NR 6560 5120	Domestic sewage	not stated	5	Unnamed watercourse
5	CAR/R/1032879	NR 6540 5090	Domestic sewage	not stated	5	Land via soakaway
6	CAR/R/1078104	NR 6541 5055	Domestic sewage	not stated	5	Soakaway
7	CAR/R/1078314	NR 6429 5055	Domestic sewage	not stated	11	Unnamed tributary of Port an Duin
8	CAR/R/1079025	NR 6529 5007	Domestic sewage	not stated	5	Druimyeon Bay
9	CAR/R/1079030	NR 6517 4987	Domestic sewage	not stated	5	Unnamed tributary of Druimyeon Bay
10	CAR/R/1079028	NR 6511 4984	Domestic sewage	not stated	5	Unnamed tributary of Druimyeon Bay
11	CAR/R/1078106	NR 6507 4971	Domestic sewage	not stated	5	Sound of Gigha
12	CAR/R/1078050	NR 6507 4971	Domestic sewage	not stated	5	Unnamed watercourse
13	CAR/R/1078722	NR 6483 4975	Domestic sewage	not stated	5	Unnamed watercourse
14	CAR/R/1077954	NR 6463 4926	Domestic sewage	not stated	5	Unnamed tributary off Portan Sean Reidhe
15	CAR/R/1085204	NR 6482 4926	Domestic sewage	not stated	5	Unnamed watercourse
16	CAR/R/1077994	NR 6486 4894	Domestic sewage	not stated	5	Unnamed watercourse
17	CAR/R/1051750	NR 6501 4898	Domestic sewage	not stated	6	Soakaway
18	CAR/R/1078061	NR 6516 4884	Domestic sewage	not stated	5	Unnamed tributary of Ardminish Bay
19	CAR/R/1078103	NR 6504 4871	Domestic sewage	not stated	10	Burn
20	CAR/R/1078087	NR 6490 4871	Domestic sewage	not stated	5	Unnamed tributary of Ardminish Bay
21	CAR/R/1077942	NR 6483 4865	Domestic sewage	not stated	10	Soakaway
22	CAR/R/1078012	NR 6348 4877	Domestic sewage	not stated	5	Unnamed tributary of coastal water
23	CAR/R/1075678	NR 6345 4872	Domestic sewage	not stated	5	Unnamed tributary of Port an t-Samhlaidh

A moderate number of small discharges were identified on the Isle of Gigha, which is consistent with the absence of larger community treatment works. Only those nearest the fishery are listed above. The level of treatment will generally be septic tank, though it was not specifically identified as such in the data provided. Most of

the consented septic systems discharge to either the sea or watercourses. Although none of the discharges are large, the collective effect would be to contribute to background levels of contamination to the waters around the island. The majority of consents were located in the southeast of the island. There may be further, unconsented discharges to the area, as there was no consent information provided for the public toilets at the ferry jetty, to the south of the fishery.

No septic tanks or outfall pipes were observed during the shoreline survey, which covered only the area around East Tarbert Bay.

The septic tank discharges identified in Table 2.2 above are mapped in Figure 4.1 along with the recorded locations of the oyster trestles.

Of the discharges identified, the septic tank discharge to the watercourse at the north end of East Tarbert Bay is the most likely to have an impact on the waters at the fishery. Discharges to the south could possibly affect water quality in East Tarbert Bay, depending on their loading, current movement and dilution.

Produced by Cefas Weymouth Laboratory. © Crown Copyright and Database 2011. All rights reserved. Ordnance Survey licence number [GD100035675]

Figure 4.1 Map of discharges for East Tarbert Bay

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 and areas that are shaded blue indicate freely draining soils.

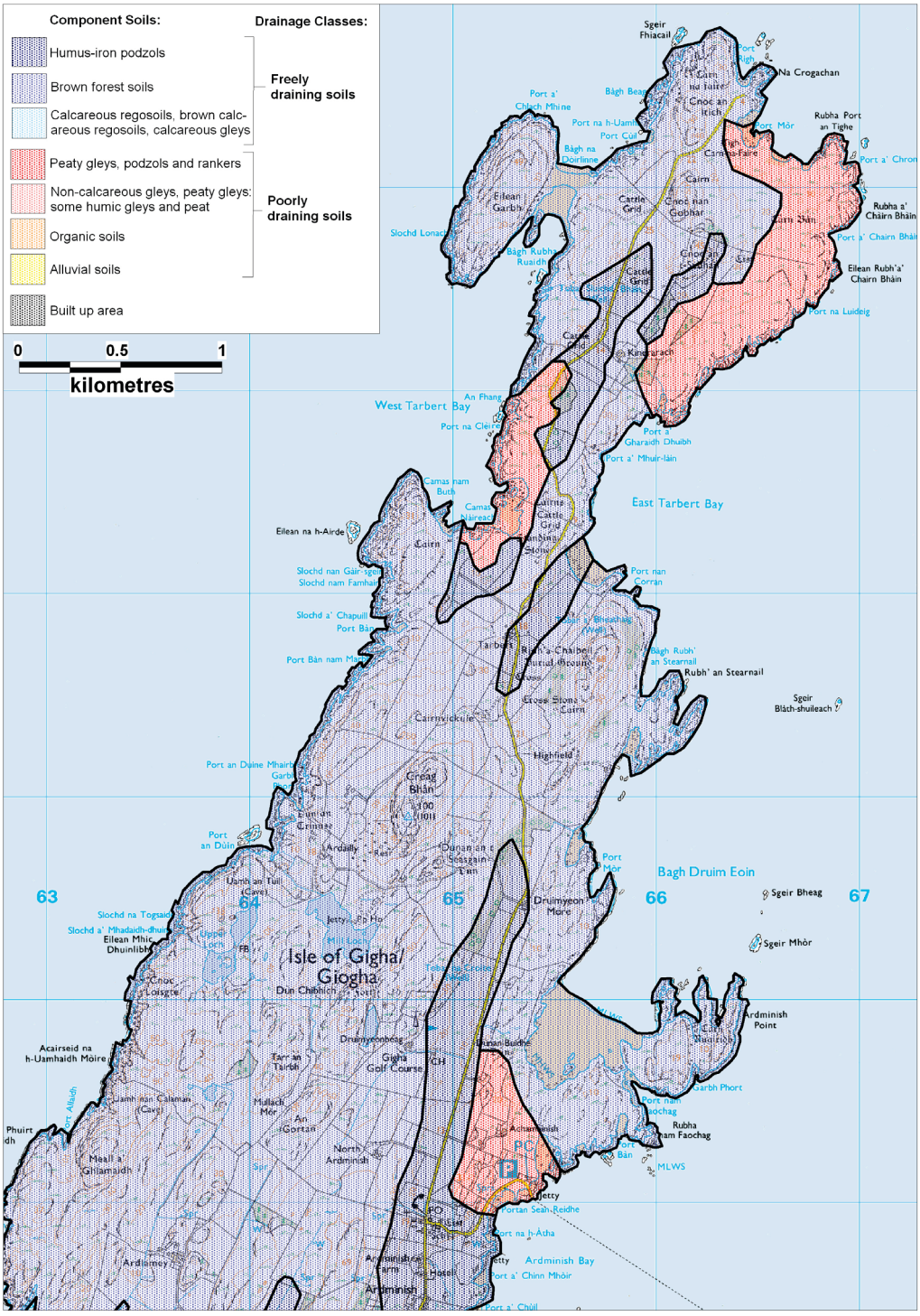


Figure 5.1 Component soils and drainage classes for East Tarbert Bay

Three types of component soils are present in the area: peaty gleys, podzols and rankers, humus-iron podzols and brown forest soils. The peaty gleys, podzols and rankers to the north of the fishery and on the otherside of the island are poorly draining and the brown forest soils and humus-iron podzols that cover most of the island and the shoreline surrounding the fishery are freely draining. Therefore, the potential for runoff contaminated with *E. coli* from human and/or animal waste will be higher to the north of East Tarbert Bay.

6. Land Cover

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

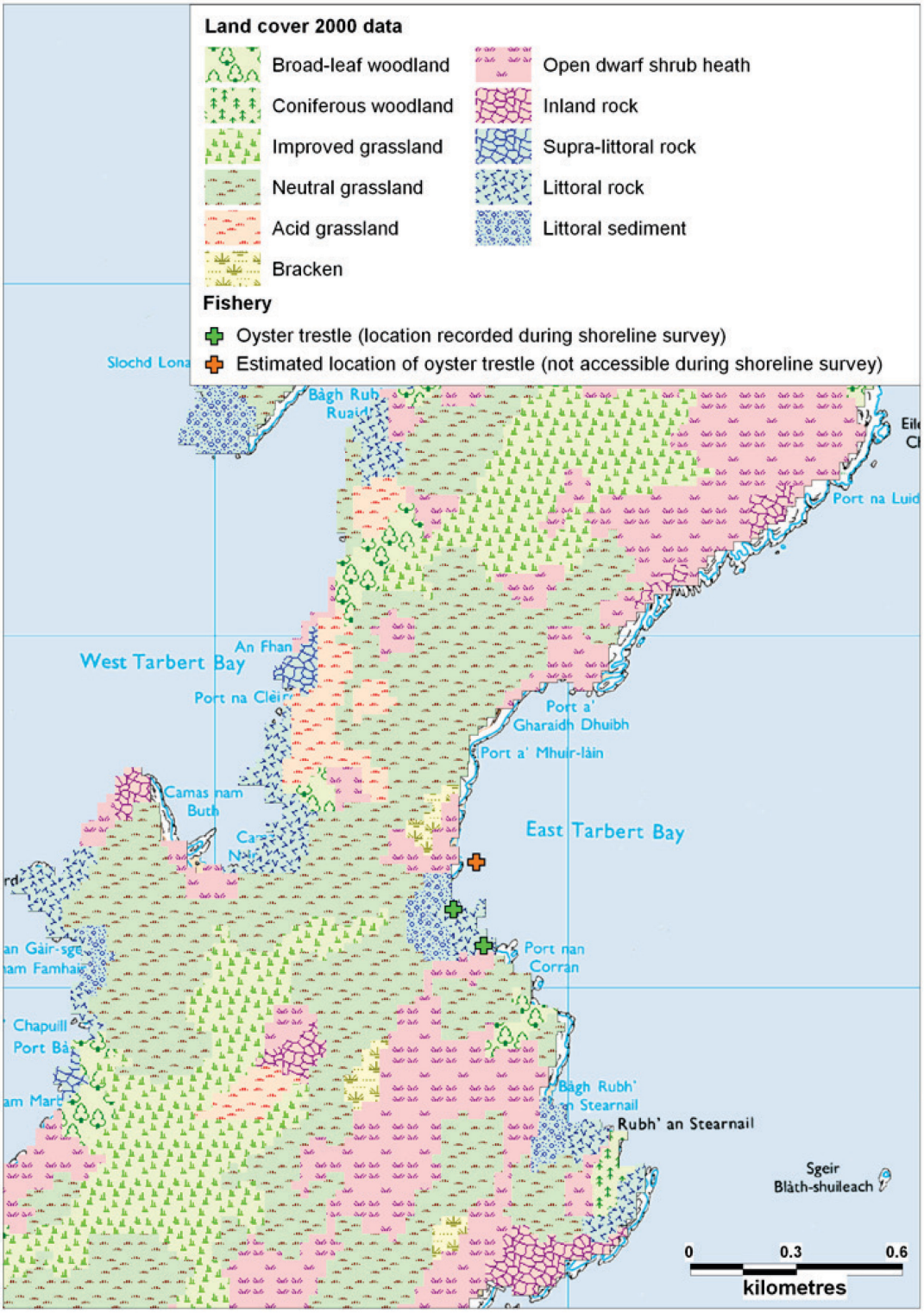


Figure 6.1 LCM2000 class land cover data for Isle of Gigha

Landcover around East Tarbert Bay is predominantly improved and natural grasslands (both neutral and acid) and heathland. There are some small areas of woodland along the coast to the south of the bay and also to the west and northwest. Substantial areas of improved grassland are found stretching southwestward from the south end of the bay and also to the north of the bay. Natural grassland areas and the edges of the heathland adjacent to them will be most likely used for rough grazing.

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

Therefore, the overall predicted contribution of contaminated runoff from these land cover types would be low to intermediate, and would be expected to increase significantly following rainfall events. Impact would be highest for runoff draining from the improved grassland areas west of the fishery.

7. Farm Animals

Agricultural census data to parish level was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the parish of Gigha and Cara, encompassing a land area of 14.86 km^2. Reported livestock populations for the parishes in 2008 and 2009 are listed in Table 7.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data. Any entries which relate to less than five holdings, or where two or fewer holdings account for 85% or more of the information, are replaced with an asterisk.

Table 7.1 Livestock numbers in the Gigha and Cara parish 2008 - 2009

	Gigha and Cara			
	2008		2009	
	Holdings	Numbers	Holdings	Numbers
Pigs	0	0	0	0
Poultry	5	86	5	93
Cattle	7	805	7	742
Sheep	*	*	*	*
Horses and ponies	0	0	0	0

* Data withheld for reasons of confidentiality

Census data report 4 km^2 in crops and grass and 8.6 km^2 in rough grazing, comprising 85% of the total land area of the island.

Cattle are reported in the largest numbers on the island, with an average of 50/km^2 of total land area. However, the number of sheep has not been provided, and they may also be present in significant numbers. Therefore, an accurate representation for the number of livestock on the shore surrounding the East Tarbert Bay production area is only available from observations made during the shoreline survey on the 8th September 2010 (see section 15 and Appendix 7). Only the area around East Tarbert Bay was surveyed, and the observations made were dependent upon the point of view of the observer. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 7.1.

During the shoreline survey approximately 30 cattle were observed in a field near the southern end of East Tarbert Bay. Another 4 horses and 10 sheep were observed in an adjacent field. At the northern end of East Tarbert Bay, a large amount of fresh cow manure was observed in a field next to the woodland and a farm with approximately 60 sheep and 15 cattle were seen at Kinerarach.

The area around much of the bay is likely to be used for grazing, with 75 animals noted to the north and 44 to the southwest of the oyster trestles. Watercourses draining land where animals are grazed is likely to carry faecal material from these areas to the bay. Impacts will be highest near where the watercourses enter the bay.

Figure 7.1 Livestock observations at East Tarbert Bay

8. Wildlife

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

Seals

Seals are present on the island and are reported to favour one of the beaches on the southern western shore. It is not known whether seals ever use the beach at East Tarbert Bay to haul out and no seals were observed during the shoreline survey. However, it should be presumed that they may be present in the area from time to time and could potentially contribute faecal indicator bacteria to waters of the bay. It is anticipated than any impact to the fishery would be minor and transient.

Whales/Dolphins

A variety of whales and dolphins are routinely observed off the west coast of Scotland. It is possible that some of the smaller species of cetaceans enter the area from time to time, although any impact of their presence is likely to be fleeting and unpredictable.

Birds

A number of bird species are found around the Isle of Gigha, but seabirds and waterfowl are most likely to occur around or near the fisheries.

A number of seabird species breed on the Isle of Gigha. These were the subject of a detailed census carried out in the late spring of 1999 and 2000 (Mitchell *et al.*, 2004). Total counts of all species recorded within 5 km of the production areas are presented in Table 8.1. Where counts were of sites/nests/territories occupied by breeding pairs actual numbers of birds breeding in the area will be higher.

The location of breeding sites nearest the fishery is thematically mapped in Figure 8.1

Table 8.1 Seabird counts within 5km of the site.

Common name	Species	Count	Method
Arctic Tern	*Sterna paradisaea*	4	Individuals on land/Occupied nests
Northern Fulmar	*Fulmarus glacialis*	116	Occupied sites
Herring Gull	*Larus argentatus*	554	Occupied territory or nests
Common Gull	*Larus canus*	306	Occupied territory or nests
Black Guillemot	*Cepphus grylle*	319	Individuals on land
Great Black-backed Gull	*Larus marinus*	32	Occupied territory or nests
Lesser Black-backed Gull	*Larus fuscus*	215	Individuals on land
Great Cormorant	*Phalacrocorax carbo*	18	Occupied nests
European Shag	*Phalacrocorax aristotelis*	240	Occupied nests

In addition to seabirds, Gigha hosts significant numbers of geese and in 2003/2004 joined the Kintyre Local Goose Management Group established to manage feeding

areas for overwintering Greenland White-fronted geese, under which farmers may receive payment for maintaining suitable fields for feeding. A small number of goose zones were identified on Gigha, and these are represented in Figure 8.1. Two of these fields lie close to the identified shellfishery. These may present a localised source of faecal contamination where large numbers of geese congregate and leave droppings which are subsequently washed into streams and watercourses by rainfall. It should be noted, however, that no correlation between high *E. coli* levels and the presence of overwintering geese was found at Loch Gruinart on Islay, which hosts many thousands of geese during the winter. Without sampling history from this specific area, it is not possible to investigate such an association.

Deer

There are no deer on the Isle of Gigha, though a report was found of one having swum to the island and taken up residence in the gardens.

Otters

No otters were observed during the course of the shoreline survey, and otters are not noted as present on the island.

Summary

Wildlife contributions to background levels of faecal contamination in waters around the fishery are expected to be minor. Any effects from the areas designated for feeding wild geese would be carried via watercourses or land drainage discharging to the shoreline west of the oyster trestles.

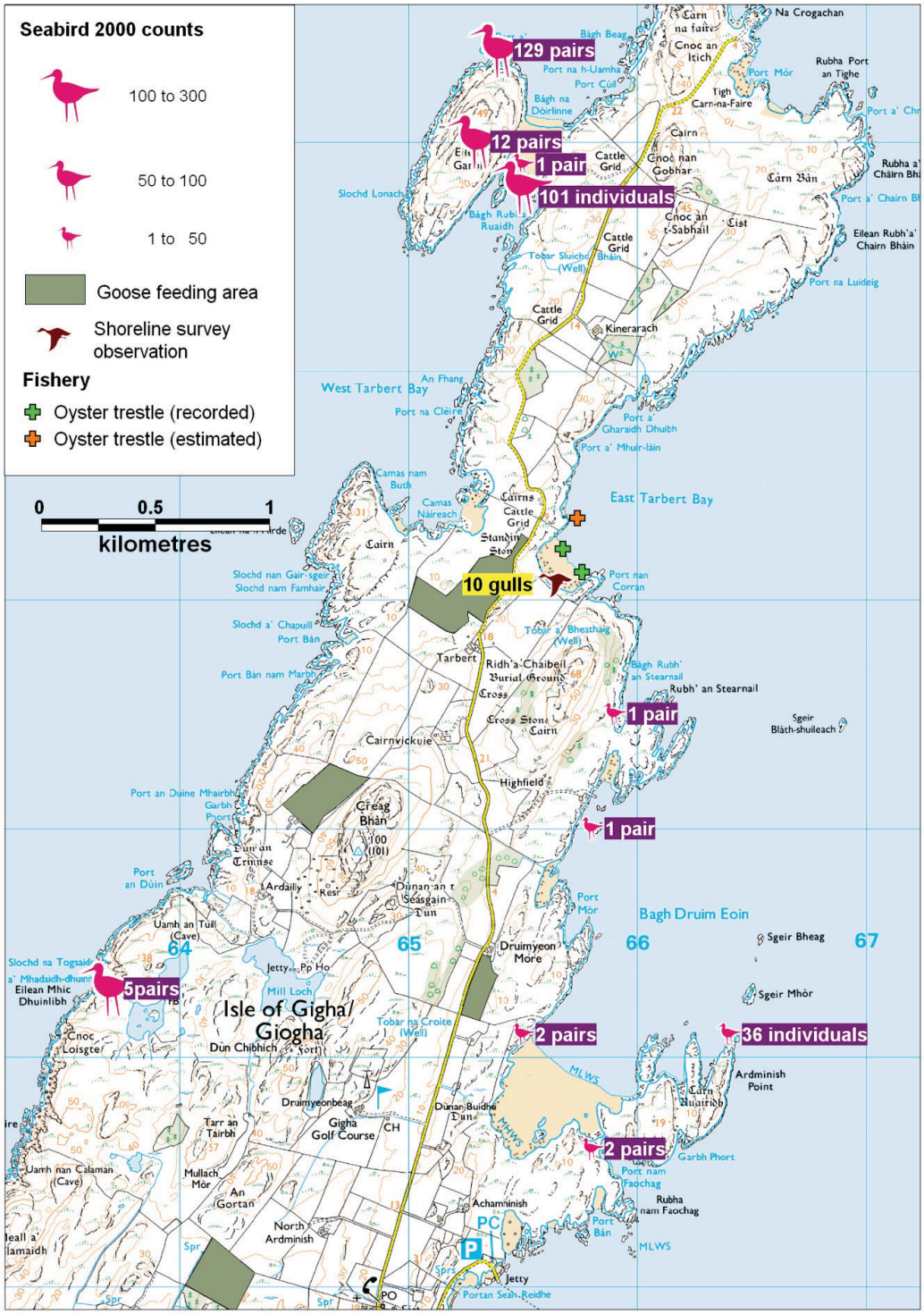


Figure 8.1 Map of wildlife observations and distributions

9. Meteorological data

The nearest weather station for which continuous records were available is located at Machrihanish, approximately 30 km to the south of East Tarbert Bay, for which uninterrupted rainfall data is available for 2003-2009 inclusive. Due to the distance between the locations, rainfall experienced within the catchment at East Tarbert Bay may vary significantly from that at Machrihanish.

The nearest weather station for which wind data is available is Prestwick: Gannet wind station, approximately 75 km to the southeast. While overall wind patterns may be broadly similar at Prestwick and East Tarbert Bay, local topography is likely to result in differences and conditions on any given day may differ due to the distance between them. This section aims to describe the local rain and wind patterns and how they may affect the bacterial quality of shellfish at East Tarbert Bay.

9.1 Rainfall

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

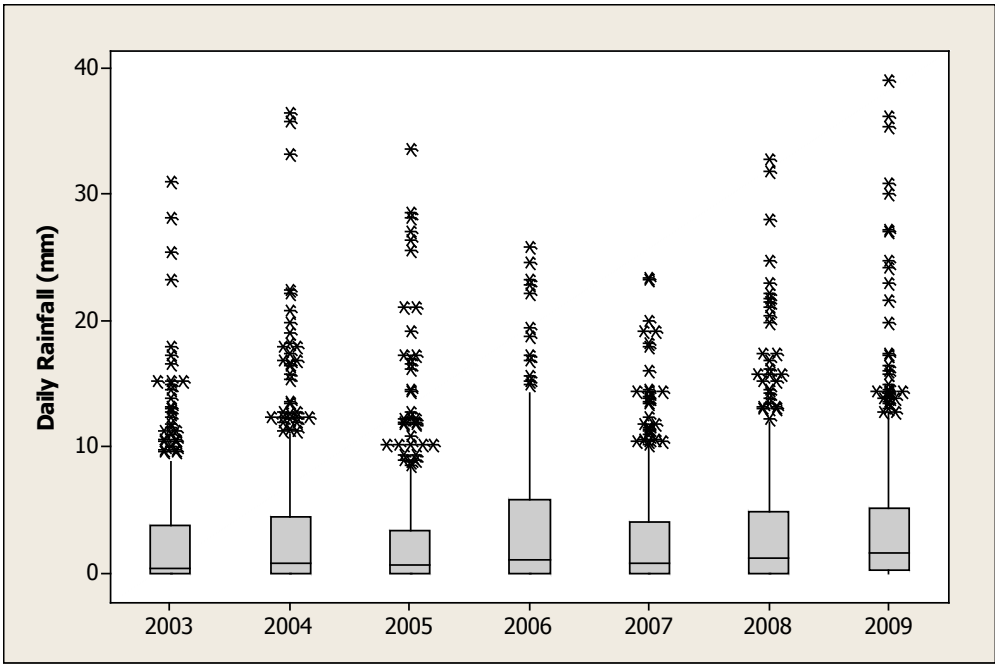


Figure 9.1 Box plot of daily rainfall values by year at Machrihanish, 2003-2009

Figure 9.1 shows some variation in rainfall is evident between the years presented here, with 2006 the wettest and 2005 the driest.

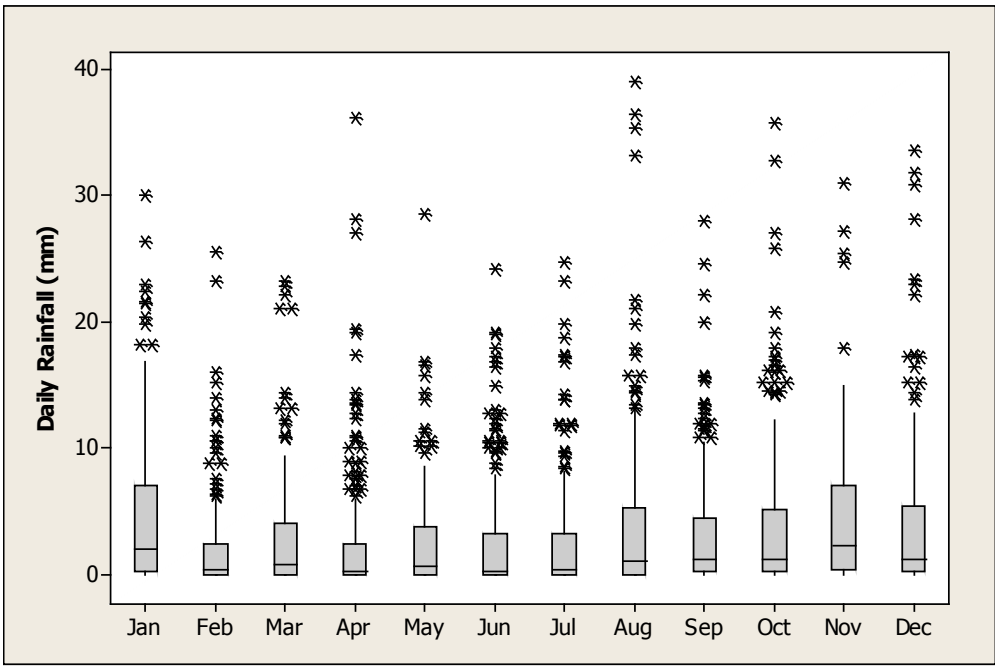


Figure 9.2 Box plot of daily rainfall values by month at Machrihanish, 2003-2009

Figure 9.2 shows wide variation in monthly rainfall. There appears to be a general tendency for higher rainfall from August to January. However, days with rainfall in excess of 20 mm occurred in all months. For the period considered here (2003-2009), 50% of days experienced rainfall less than 1 mm, and 10% of days experienced rainfall of 10 mm or more.

9.2 Wind

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

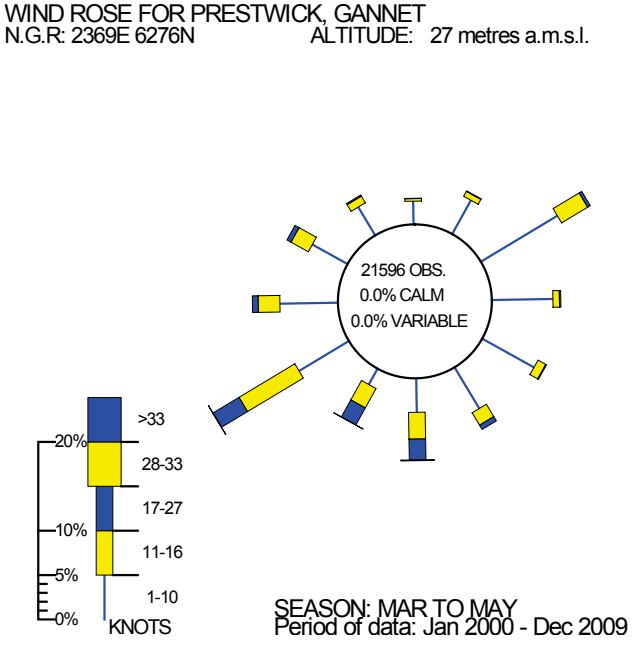


Figure 9.3 Wind rose for Prestwick: Gannet (March to May)

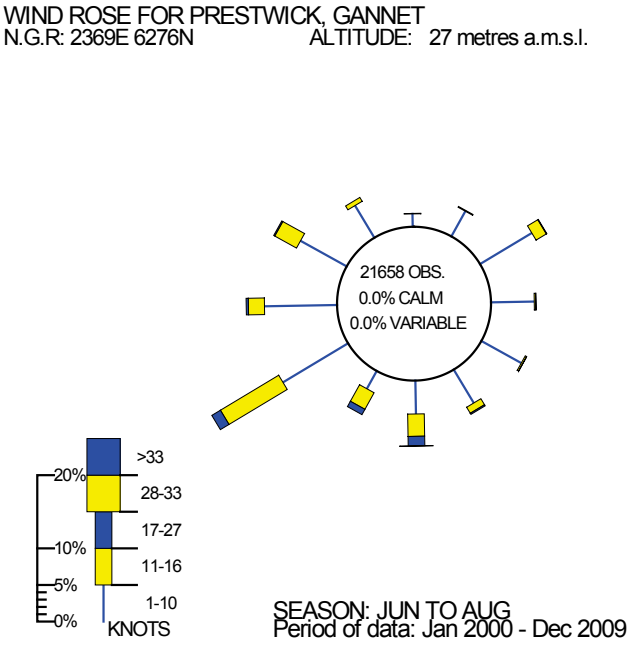


Figure 9.4 Wind rose for Prestwick: Gannet (June to August)

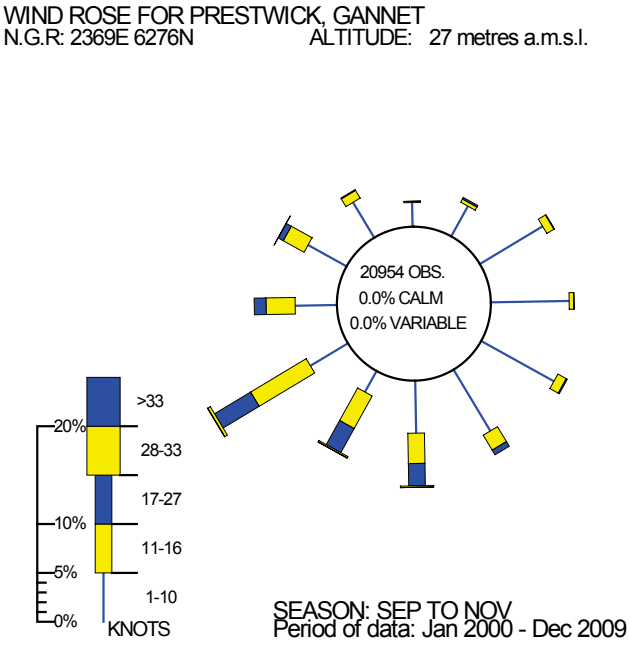


Figure 9.5 Wind rose for Prestwick: Gannet (September to November)

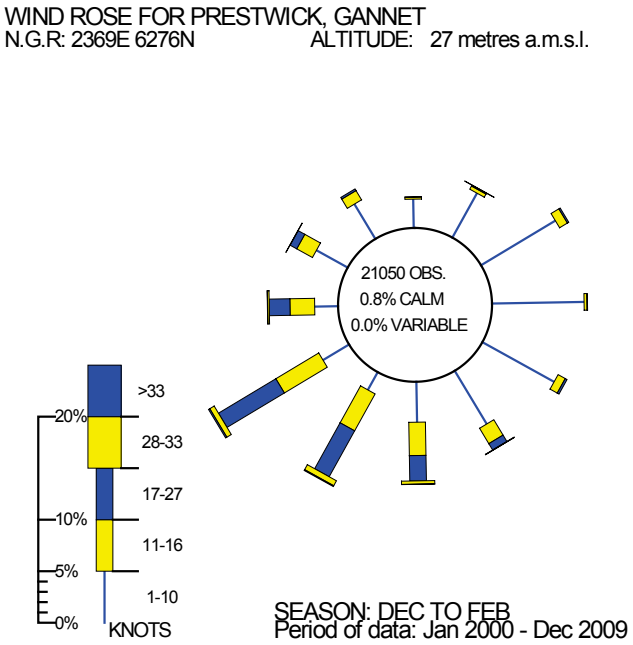


Figure 9.6 Wind rose for Prestwick: Gannet (December to February)

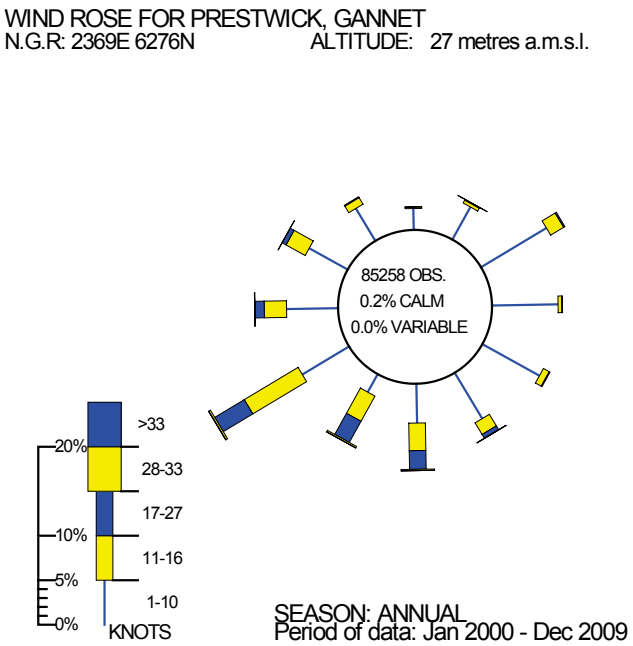


Figure 9.7 Wind rose for Prestwick: Gannet (All year)

The prevailing wind direction at Prestwick is from the south and west, but wind direction often changes markedly from day to day with the passage of weather systems. There is a higher occurrence of north easterly winds during the spring. Winds are generally lightest in the summer and strongest in the winter. The fishery lies on the east side of the Isle of Gigha and so will be exposed to easterly winds but will receive some protection from westerly winds from the island itself.

Winds typically drive surface water at about 3% of the wind speed (Brown, 1991) so a gale force wind (34 knots or 17.2 m/s) would drive a surface water current of about 1 knot or 0.5 m/s. Therefore strong winds may significantly alter the pattern of surface currents at East Tarbet Bay. Strong winds may affect tide height depending on wind direction and local hydrodynamics. A strong wind combined with a spring tide may result in higher than usual tides, which will carry accumulated faecal matter from livestock, in and above the normal high water mark, into the production area. A strong northerly wind will result in increased wave action at the site, which may resuspend any organic matter settled in the substrate.

10. Current and historical classification status

Isle of Gigha has not been previously classified.

11. Historical *E. coli* data

No monitoring history was available for the Isle of Gigha fishery.

12. Designated Shellfish Growing Waters Data

There are no designated Shellfish Growing Waters in the vicinity of the Pacific oyster fishery at Isle of Gigha.

13. River Flow

There are no gauging stations on watercourses along the Isle of Gigha coastline.

The streams listed in Table 13.1 were measured and sampled during the shoreline survey. The weather was dry at the time of the survey. The locations are shown on the map presented in Figure 13.1. Where the bacterial loading is labelled on the map, the scientific notation is written in digital format, as this is the only format recognised by the mapping software. So, where normal scientific notation for 1000 is 1 x 10^3, in digital format it is written as 1E+3.

Table 13.1 Stream loadings for the Isle of Gigha

No	Grid Reference	Description	Width (m)	Depth (m)	Flow (m/s)	Flow in m^3/day	*E.coli* (cfu/ 100ml)	Loading (*E.coli* per day)
1	NR 65591 52118	Stream	0.40	0.05	0.352	608	410	$2.5x10^9$
2	NR 65715 52028	Stream	0.20	0.02	0.011	4	110	$4.2x10^6$
3	NR 66035 52966	Stream	0.60	0.10	0.168	871	1100	$9.6x10^9$
4	NR 66063 52992	Stream	0.53	0.05	0.044	101	70	$7.1x10^7$

The calculated loadings for two of the four streams (numbers 1and 3) were moderately high while the loadings for the other two were low. Streams 1 and 2 would impact directly on the oyster trestles, predominantly on the two located within the small embayment at the southern end of East Tarbert Bay. Given that stream 1 had the higher loading, there is the potential for the trestle at the centre of that embayment to be affected to a greater extent.

Loadings from all of these watercourses would be expected to increase at least tenfold following heavy rain.

Figure 13.1 Map of river/stream loadings at Isle of Gigha

14. Bathymetry and Hydrodynamics

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

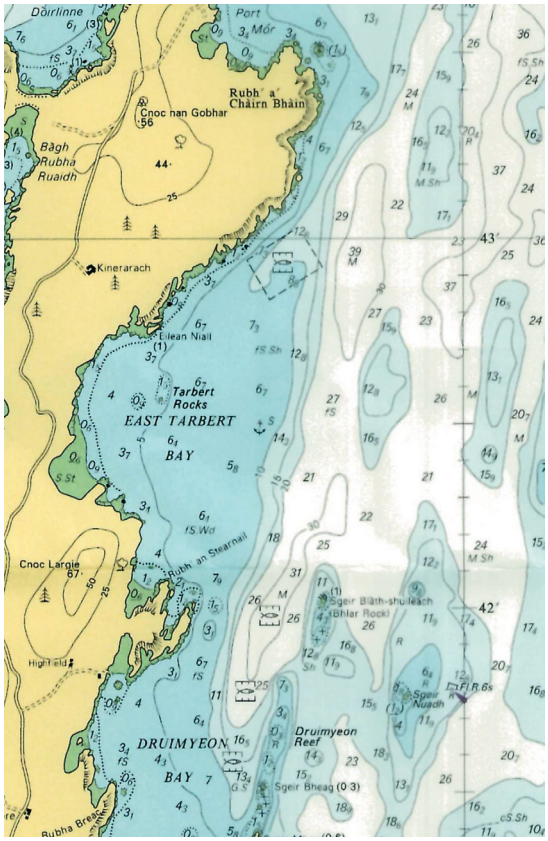


Figure 14.1 OS map of East Tarbert Bay
Figure 14.2 Bathymetry at East Tarbert Bay

East Tarbert Bay is located on the eastern side of the Isle of Gigha. The sound of Gigha lies between the Isle and the Mull of Kintyre. While there are deep areas within the main body of the sound, the maximum depth within East Tarbert Bay is approximately 6 m. There is a drying area around the edge of the bay, with a relatively extensive area within the embayment where the fishery is located. The seabed in the area does not shelve steeply.

14.1 Tidal Curve and Description

The two tidal curves below are for Sound of Gigha, approximately 3 km south of the oyster farm. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 BST on 08/09/10 and the second is for seven days beginning 00.00 BST on 15/09/10. Together they show the predicted tidal heights

over high/low water for a full neap/spring tidal cycle, including the dates of the shoreline survey.

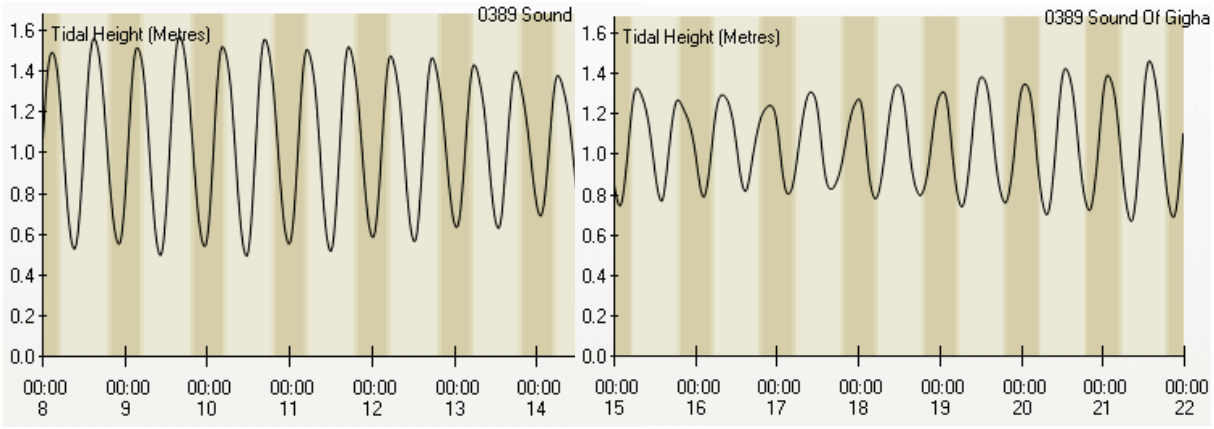


Figure 14.3 Tidal curves for Sound of Gigha

The following is the summary description for Sound of Gigha from TotalTide:

0389 Sound Of Gigha is a Secondary Non-Harmonic port.
The tide type is Semi-Diurnal.

HAT	1.6 m
MHWS	1.5 m
MHWN	1.3 m
MSL	0.93 m
MLWN	0.8 m
MLWS	0.6 m
LAT	0.4 m

Predicted heights are in metres above Chart Datum. The tidal range at spring tide is 0.9 m, and at neap tide 0.5 m, and so tidal ranges in the area are small.

14.2 Currents

Tidal stream information was available for one station in the Sound of Gigha. The location of this station, together with the tidal streams for peak flood and ebb tide, are presented in Figures 14.4 and 14.5, and the tidal diamond is presented in Table 14.1.

Figure 14.4 Spring flood tide in the Sound of Gigha

Table 14.1 Tidal streams for station SN039A (55°40.80'N 5°42.60'W) (Totaltide)

Time	Direction	Spring rate (m/s)	Neap rate (m/s)
-06h	000°	0.51	0.15
-05h	009°	0.62	0.21
-04h	012°	0.57	0.21
-03h	015°	0.41	0.15
-02h	011°	0.26	0.10
-01h	150°	0.05	0.00
HW	185°	0.41	0.10
+01h	193°	0.62	0.21
+02h	183°	0.67	0.21
+03h	174°	0.51	0.15
+04h	193°	0.31	0.10
+05h	312°	0.10	0.05
+06h	353°	0.51	0.15

It would therefore be expected that the tidal currents will flow directly up and down the Isle of Gigha, including past the mouth of East Tarbert Bay. It is likely that this movement will be modified within the bay itself and around the points at the southern end. Within the embayment, by the fishery, there will be tidal flow up and down the drying area.

Using a current speed of approximately 0.7 m/s as the peak flow during ebb or flood, contaminants would travel approximately 10 km over a tidal cycle, ignoring dilution and dispersion.

Given the shallow depths present in the bay, wind is likely to significantly affect water movement in the area.

14.3 Conclusions

Given the location of the oyster trestles on and near the drying area, and the restricted depths outside of this, contaminants from nearby sources will be subject to limited dilution. Contaminants from sources outside the main bay may not be taken far enough inside to impact at the oyster trestles but may tend to be taken past further offshore. Contaminants arising within the main bay will potentially affect the water quality at the trestle located north, and exterior to, the main embayment, on an ebb tide. Under such conditions, it is unlikely that effects would be seen within the small embayment itself. Contaminants arising at the south end of the bay will be likely to impact the exterior trestle, and potentially also the other trestles, on a flood tide. The effects on the trestles within the embayment are most likely to arise from within that area itself, and to impact on the ebbing, or at low, tide.

15. Shoreline Survey Overview

The shoreline survey was conducted on the 8th September 2010 under dry and calm weather conditions.

The fishery at East Tarbet Bay consisted of three oyster trestles one is roughly 20 m off the western point of the bay, a second is in the middle of the bay and a third is on the eastern side of the bay. At the time of the shoreline survey, the trestle on the western side of the bay was inaccessible due to tidal conditions. The harvester had plans to add another 10 – 20 trestles to the site, as a trial over the 2010/2011 winter period.

No septic tanks or sewage outfall pipes were observed during the shoreline survey.

Livestock were observed grazing on the land surrounding East Tarbet Bay. At the southern end of the bay, in a field fenced off from the shoreline, approximately 30 cattle were observed. Adjacent to this field on the other side of the road, were 4 horses and 10 sheep. On the north shoreline at Kinerarach there was a farm with approximately 60 sheep and 15 cattle. Approximately 10 sea gulls were observed on the shoreline of East Tarbert Bay.

Sea water samples, taken in the bay at the locations of the oyster samples, returned low levels of *E. coli,* with results of 10 and <10 *E. coli* cfu/100 ml. A third sea water sample taken at the northern end of the bay returned a significantly higher result of 120 *E. coli* cfu/100 ml. The salinity result for this sample was 30.3 g/L which indicated possible fresh water influence in the area at the time of the survey.

Freshwater samples and discharge measurements were taken at all streams draining into the survey area. These streams contained varying levels of contamination (70 – 1100 *E. coli* cfu/100ml). The stream with the highest *E. coli* loading per day of 9.6×10^9 was located at the north end of the bay. Most streams were small and drained areas of arable land and rough grassland.

An oyster sample was collected from each accessible trestle. The sample taken from the western trestle has a result of 20 *E. coli* MPN/100 g and the sample taken from the eastern trestle had a result of 490 *E. coli* MPN/100 g.

Post survey note: The sampling officer from Argyll & Bute identified that the harvester had installed the two additional sets of trestles. Both are located at the southern end of the bay, one further inshore and one further offshore than the southernmost trestle observed during the survey. The positions of the newly added trestles are included in Section 17, Figure 17.1.

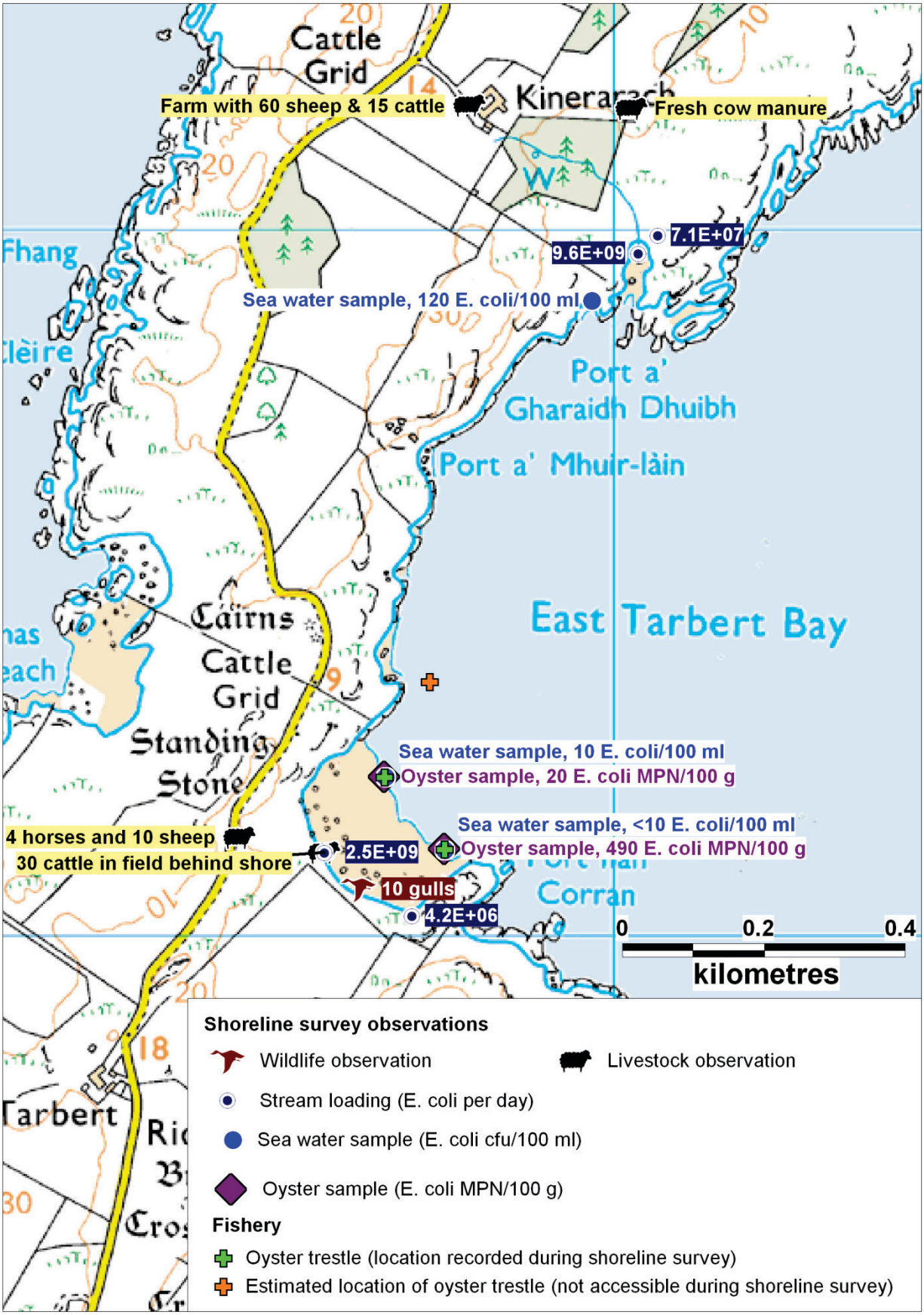


Figure 15.1 Summary of shoreline survey findings for East Tarbert Bay

16. Overall Assessment

Human sewage impacts

There is one septic tank discharge to the watercourse at the north end of East Tarbert Bay. The discharge lies approximately 1 km away from the northernmost trestle, and is from a single property; therefore it is likely to have been subject to significant dilution before reaching the fishery. Discharges from properties to the south could potentially affect water quality in East Tarbert Bay as they lie within approximately 4-5 km of the fishery and the predicted particle transport distance is up to 10 km on spring tides. The combined population equivalent of the known consented discharges to the eastern shore is just over 100 and is unlikely to include all discharges to this area. However, under most conditions these discharges are only likely to contribute to background levels of contamination at the fishery.

Agricultural impacts

Farm animals located around East Tarbert Bay are likely to pose a significant source of faecal contamination to the fishery. Animals in the area do not appear to have direct access to the shoreline, therefore faecal contaminants are most likely to be carried via streams and direct runoff from land. Part of the area where livestock were observed toward the north end of East Tarbert Bay lies within an area of poorly drained soils through which a stream passes. This is likely to constitute an important pathway for the runoff of livestock faecal wastes into the bay. Animals were also observed toward the south end of the bay, much nearer the fishery. Watercourses here are also likely to carry significant loadings of faecal bacteria and are likely to have a more acute effect on water quality around the oyster trestles.

Wildlife impacts

Little evidence was found of significant populations of wildlife in the vicinity of the fishery. Several fields to the west of the fishery have been identified as feeding areas for geese, and these are likely to be a source of faecal contamination from this source primarily during the overwintering period. A relatively small number of breeding seabirds are reported in the area, though no breeding sites were recorded within East Tarbert Bay itself. A few sites are located further south along the shore and a larger number along the north west shore of the island, and neither of these is anticipated to have a significant impact on water quality at the fishery. Seals or other sea mammals may be sporadically present, but these are also not expected to have a significant impact.

Seasonal variation

There is likely to be a seasonal increase in human population during the summer months as tourists visit the island during the peak summer holidays. There is likely to be some seasonal variation in numbers of sheep, as they are

normally have lambs in spring which are then shipped off in autumn. Cattle may not show the same seasonality as dairy cattle are often bred in rotation.

There was no clear seasonal variation in rainfall, and no *E. coli* monitoring history on which to base an assessment of seasonality in results.

Rivers and streams

Small streams discharging to East Tarbert Bay were found to contain sufficient loadings of *E. coli* to constitute a significant source of faecal contamination to the waters of the bay. Much of this is likely to be of livestock origin, however one of the streams at the north end of the bay also carries septic tank effluent from a nearby home. The two streams discharging to the small embayment where the oyster trestles are located will have the greatest impact on water quality at the fishery, and although the centremost of the three trestles lies nearest a stream, both trestles are likely to be impacted as water moves around the embayment.

Movement of contaminants

Tidal streams in the Sound of Gigha run more strongly southward than northward, therefore contaminants may be transported longer distances from the north than the south. The oyster trestles are located on the intertidal shore in a north-facing embayment, therefore will be most affected by contaminants arising from the streams discharging to the adjacent shoreline.

The northernmost trestle, however, lies further offshore and is more likely than the other two to be subject to contamination arising within other parts of West Tarbert Bay as well as those from the adjacent shore. Wind is likely to affect tidal heights if blowing from the southwest or northeast, thereby affecting the volume of water available for dilution and both movement and mixing of freshwater plumes arising from stream sources.

Temporal and geographical patterns of sampling results

As no monitoring history was available from this site, it is not possible to assess temporal patterns in results. Only two sample results were available to date for the site and these were both from the shoreline survey. Oyster samples were taken from the southern two trestles and results were substantially higher at the southernmost of these two. Seawater samples taken on the same date indicated much higher levels of contamination at the north end of the bay than at the south end. The stream discharging to the north end of the bay was found to contain much higher concentrations of *E. coli* (1100 cfu/100 ml, Appendix 8) and also the highest calculated loading per day to the bay. However, whilst the streams nearest the oyster trestles contributed a combined lower loading than the northern stream they discharge to waters immediately surrounding the trestles hence will have a greater effect on the bacteriological water quality at the fishery.

Conclusions

Human sewage input to the bay is very low and indirect. The largest source of faecal contamination to the bay is likely to be diffuse pollution from livestock that are kept on fields surrounding the bay. Bacterial concentrations observed in water samples taken from streams discharging to the bay indicated the presence of faecal contamination. Though one stream discharging to the north end of the bay was known to receive sewage from a single dwelling, it also flowed through pasture on which animals were kept.

Discharges nearest the oyster farm are most likely to affect the water quality there, and the nearest discharges are the streams discharging to the adjacent shore south of the trestles.

Too little is known about the fishery at present to determine whether *E. coli* monitoring results would vary significantly by season, however it is possible that there may be seasonal variation in background levels of contamination in the bay as well as sources of faecal contamination.

17. Recommendations

Production area

It is recommended that the production area be restricted to the southern end of the bay to avoid the more contaminated stream and domestic sewage discharge at the northern end. Therefore, the recommended boundaries are described by the area bounded by lines drawn between NR 6574 5260 and NR 6583 5210 extending to MHWS.

RMP

The RMP should be placed at the southern end of the fishery, which is affected most directly by both streams and had the higher result during the shoreline survey. Therefore, it is recommended that the RMP be established NR 6574 5210.

Frequency

As there is no monitoring history available at the site, monthly monitoring is recommended.

Tolerance

A sampling tolerance of 10 meters is recommended to allow for establishment of a sampling bag at a suitable point on the trestle.

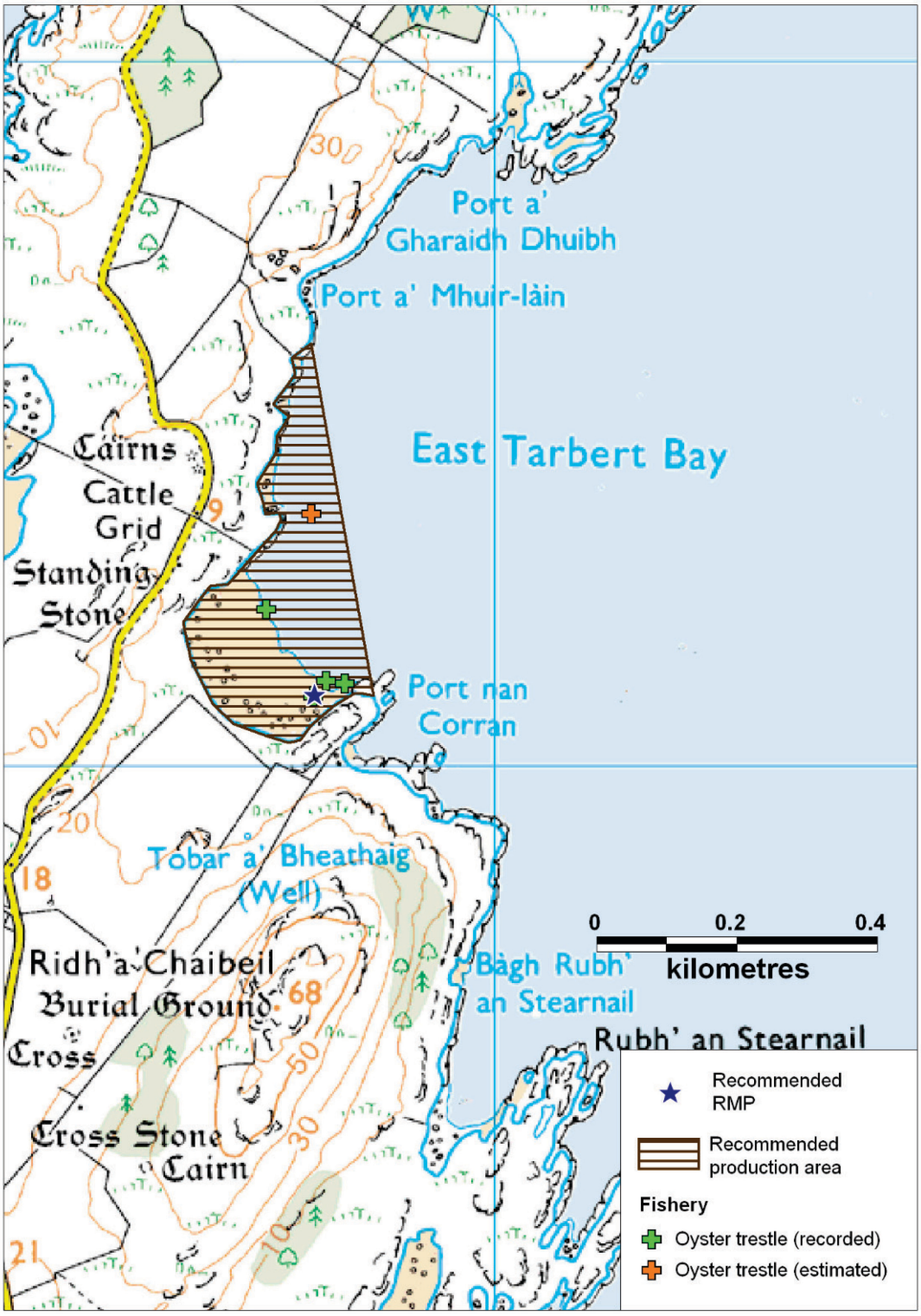


Figure 17.1 Map of recommendations at Isle of Gigha

18. References

Kay, D, Crowther, J., Stapleton, C.M., Wyer, M.D., Fewtrell, L., Anthony, S.G., Bradford, M., Edwards, A., Francis, C.A., Hopkins, M. Kay, C., McDonald, A.T., Watkins, J., Wilkinson, J. (2008). Faecal indicator organism concentrations and catchment export coefficients in the UK. *Water Research* 42, 2649-2661.

Lee, R.J., Morgan, O.C. (2003). Environmental factors influencing the microbial contamination of commercially harvested shellfish. *Water Science and Technology* 47, 65-70.

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

Mallin, M.A., Ensign, S.H., McIver, M.R., Shank, G.C., Fowler, P.K. (2001). Demographic, landscape, and meteorological factors controlling the microbial pollution of coastal waters. *Hydrobiologia* 460, 185-193.

Mitchell, P. Ian, S. F. Newton, N. Ratcliffe & T. E. Dunn. 2004. Seabird Populations of Britain and Ireland, Results of the Seabird 2000 Census (1998-2002). T&AD Poyser, London.

Scottish Environment Protection Agency. Bathing Waters Report 2001. A study of bathing waters compliance with EC Driective 76/160/EEC: The relationship between exceedence of standards and antecedent rainfall.

Ross, J (2006-10-13). "Island of opportunity welcomes a population explosion".TheScotsman(Edinburgh). http://thescotsman.scotsman.com/scotlandspopulation/Island-of-opportunity-welcomes-a.2818002.jp. Retrieved 2011-01-28.

19. List of Figures and Tables

Appendices

1. **Sampling Plan**
2. **Table of Proposed Boundaries and RMPs**
3. **Geology and Soils Information**
4. **General Information on Wildlife Impacts**
5. **Tables of Typical Faecal Bacteria Concentrations**
6. **Hydrographic Methods**
7. **Shoreline Survey Report**
8. **Norovirus Testing Summary**

Sampling Plan for Isle of Gigha

PRODUCTION AREA	Isle of Gigha
SITE NAME	East Tarbert Bay
SIN	AB 541 972 13
SPECIES	Pacific oyster
TYPE OF FISHERY	Trestle aquaculture
NGR OF RMP	NR 6574 5210
EAST	165760
NORTH	652120
TOLERANCE (M)	10
DEPTH (M)	Not applicable
METHOD OF SAMPLING	Hand
FREQUENCY OF SAMPLING	Monthly
LOCAL AUTHORITY	Argyll & Bute Council
AUTHORISED SAMPLER(S)	Christine McLachlan William MacQuarrie Ewan McDougall Donald Campbell
LOCAL AUTHORITY LIAISON OFFICER	Christine McLachlan

Table of Proposed Boundaries and RMPs

PRODUCTION AREA	Isle of Gigha
SPECIES	Pacific oyster
SIN	AB 541 972 13
EXISTING BOUNDARY	not established
EXISTING RMP	not established
RECOMMENDED BOUNDARY	The area bounded by lines drawn between NR 6574 5260 and NR 6583 5210 extending to MHWS
RECOMMENDED RMP	NR 6574 5210
COMMENTS	North end of bay excluded, RMP at southernmost trestle

Geology and Soils Assessment

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

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

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

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

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

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

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

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

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

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

Glossary of Soil Terminology

Calcareous: Containing free calcium carbonate.

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

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

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

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

General Information on Wildlife Impacts

Pinnipeds

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

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

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

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

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

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

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

Cetaceans

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

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

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

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

Birds

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

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

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

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

Deer

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

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

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

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

Other

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

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

References:

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

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

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

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

Tables of Typical Faecal Bacteria Concentrations

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

Indicator organism	Base-flow conditions				High-flow conditions			
Treatment levels and specific types: Faecal coliforms	n^c	Geometric mean	Lower 95% CI	Upper 95% CI	n^c	Geometric mean	Lower 95% CI	Upper 95% CI
Untreated	252	1.7×10^{7} * (+)	1.4×10^{7}	2.0×10^{7}	282	2.8×10^{6} * (-)	2.3×10^{6}	3.2×10^{6}
Crude sewage discharges	252	1.7×10^{7} * (+)	1.4×10^{7}	2.0×10^{7}	79	3.5×10^{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	1.0×10^{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	3.3×10^{5} * (-)	2.9×10^{5}	3.7×10^{5}	184	5.0×10^{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	2.8×10^{5} * (-)	2.2×10^{5}	3.5×10^{5}	93	5.1×10^{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

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

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

Background processes

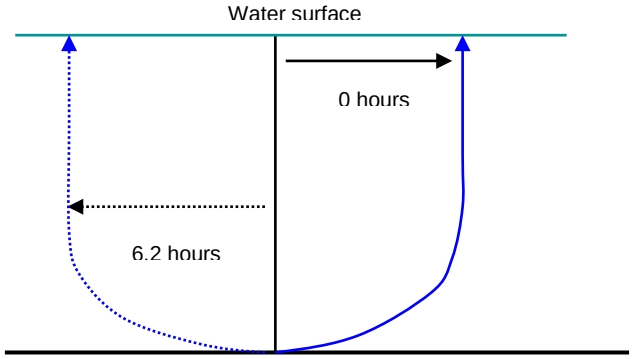
Currents in estuarine and coastal waters are generally driven by one of three mechanisms: 1) Tides, 2) Winds, 3) Density differences.

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

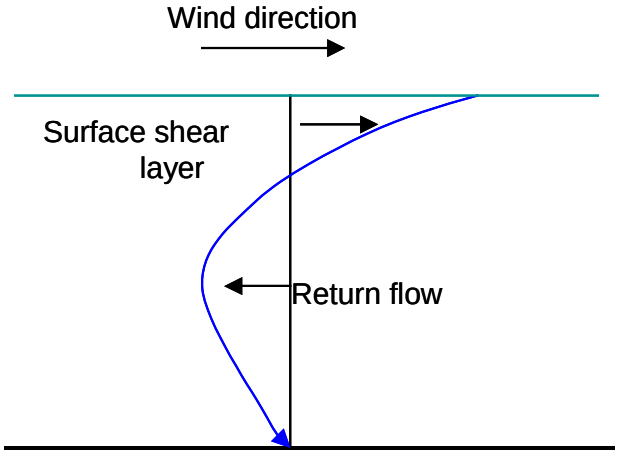
Wind and density driven current also lead to persistent movement of water and are particular important in regions of relatively low tidal velocities characteristic of many of the water bodies in Scottish waters. Whilst tidal flows generally move material in more or less the same direction at all depths,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

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

a)



b)



c)

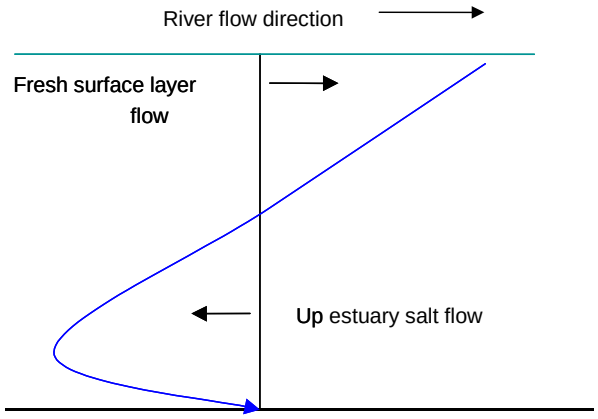


Figure 1. Typical vertical profiles for water currents. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction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

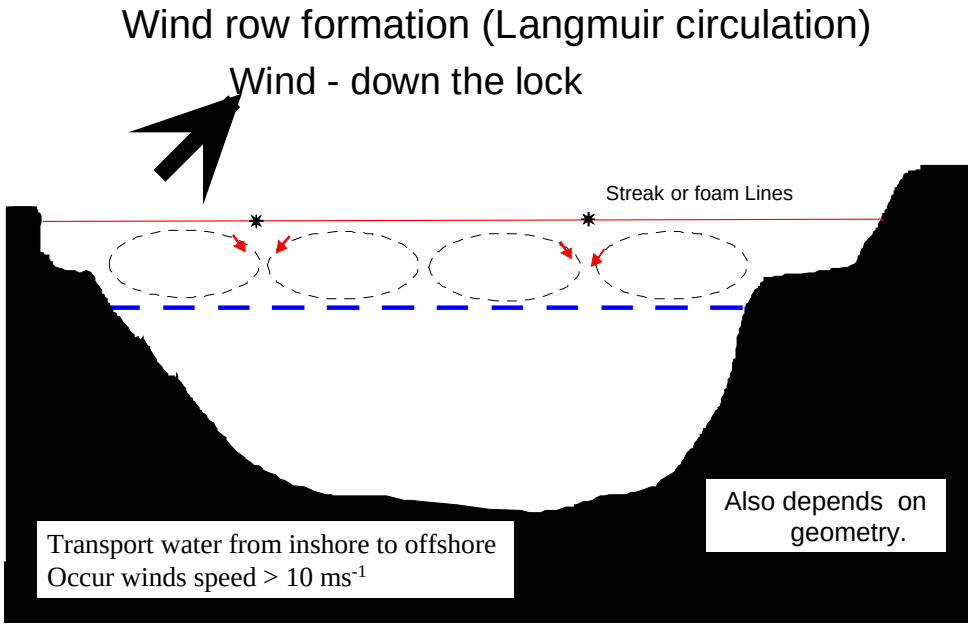


Figure 2. Schematic of wind driven 'wind row' currents. The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

Non-modelling Assessment

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

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

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

The catalogue of Scottish Sea Loch produced by the SMBA is used to quantify sills, volume fluxes and likely flow velocities. Because the flow is so constrained by the rapidly varying bathymetry, care has to be used in the extrapolation of direct measurements of current flow. Mean flow velocities can be estimated at the sills by using estimates of the sill area and the volume change through a tidal cycle. This in turn can be used to estimate the

maximum distance travelled in a tidal cycle in the sill area. Away from the sill area, tidal velocities are general low and transport events are dominated by wind or density effects. Sea Lochs generally have a surface layer of fresher water; the extent of this depends on freshwater input, sill depth and quantity of mixing.

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

References

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

Glossary

The following technical terms may appear in the hydrographic assessment.

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

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

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

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

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

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

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

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

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

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

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

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

Shoreline Survey Report

Production area:	Isle of Gigha	
Site name:	East Tarbert Bay (AB 541 972 13)	
Species:	Pacific oysters	
Harvester:	Anthony Walker	
Local Authority:	Argyll & Bute Council	
Status:	New	
Date Surveyed:	8th September 2010	
Surveyed by:	Jessica Larkham	Cefas
	Christine McLachlan	Argyll & Bute Council
Existing RMP:	NA	
Area Surveyed:	See Figure 1.	

Weather observations

08/09/2010 – Sunny with some clouds, 13˚C, F3 Gentle breeze (wind speeds of between 8-18.6 km/hr)

Fishery

There are currently three oyster trestles installed at East Tarbert Bay, located in and around the small embayment north-west of Port nan Corran. One is roughly 20 m off the north-western point of the embayment, a second is in the middle of the embayment and a third is on the south-eastern side of the embayment. At the time of the shoreline survey, the northernmost trestle was inaccessible due to tidal conditions. The harvester has plans to add another 10 – 20 trestles to the site, as a trial over the 2010/2011 winter season.

Sewage/Faecal Sources

No septic tanks or sewage outfall pipes were observed during the shoreline survey.

Seasonal Population

There is a daily car ferry from Tayinloan to the Isle of Gigha. There are tourist facilities - cafe/restaurant close to the ferry pier. There is one hotel and five self catering apartments on the island.

Boats/Shipping

There is a daily car ferry to the island from Tayinloan on the mainland and there were several boats moored close to the ferry pier at the time of the shoreline survey.

Land Use

The land cover immediately surrounding East Tarbert Bay is mainly arable land, rough grassland and heather. North of East Tarbert Bay there is areas of dense woodland, reeds and more rough grassland and heather.

Wildlife/Birds

Approximately 10 sea gulls were observed on the shoreline of East Tarbert Bay during the shoreline survey.

Livestock

At the time of the shoreline survey, there were approximately 30 cattle fenced off in a field at the southern end of the bay. Adjacent to this field on the other side of the road, near the standing stones were 4 horses and 10 sheep. On the north shoreline at Kinerarach there was a farm with approximately 60 sheep and 15 cattle.

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 bay.

Figure 1. Shoreline observations at East Tarbert Bay

Table 1. Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	08/09/2010	08:51	NR 65762 52122	165762	652122		GIGHA SW1	Location of sea water sample 1 (GIGHA SW1)
2	08/09/2010	08:56	NR 65591 52118	165591	652118	Figures 4 & 5	GIGHA FW1	Stream, W 0.40 m, D 0.05 m, Flow 0.352/0.342 m/s. Location of fresh water sample 1 (GIGHA FW1). Approximately, 30 cattle in field behind shoreline fenced in. 3 houses in background. Cockle and mussel shells on the shoreline.
3	08/09/2010	09:22	NR 65640 52066	165640	652066			Lots of live cockles and empty shells in intertidal area of shoreline. Also, a large number of native oyster and razor clam shells. Approximately 10 sea gulls on the shoreline of East Tarbert Bay.
4	08/09/2010	09:25	NR 65715 52028	165715	652028	Figures 6 & 7	GIGHA FW2	Stream, W 0.20 m, D 0.02 m, Flow 0.011/0.013 m/s. Location of fresh water sample 2 (GIGHA FW2). Live periwinkles and cockles all over the bay.
5	08/09/2010	09:34	NR 65761 52123	165761	652123	Figure 8	GIGHA OYSTER1, GIGHA NORO1	Location of oyster sample 1 (GIGHA OYSTER1) and norovirus sample (GIGHA NORO)
6	08/09/2010	09:57	NR 65676 52225	165676	652225	Figure 9	GIGHA OYSTER2	Location of oyster sample 2 (GIGHA OYSTER2)
7	08/09/2010	10:09	NR 65678 52225	165678	652225		GIGHA SW2	Location of sea water sample 2 (GIGHA SW2)
8	08/09/2010	10:44	NR 65471 52139	165471	652139			4 horses and 10 sheep in a field on the other side of the road behind the bay
9	08/09/2010	11:04	NR 65681 52357	165681	652357	Figure 10		Photograph of bay next to East Tarbert Bay
10	08/09/2010	11:06	NR 65678 52420	165678	652420			Field drain
11	08/09/2010	11:10	NR 65706 52563	165706	652563			Field drain
12	08/09/2010	11:20	NR 65855 52805	165855	652805			Field drain
13	08/09/2010	11:27	NR 65970 52900	165970	652900		GIGHA SW3	Location of sea water sample 3 (GIGHA SW3)
14	08/09/2010	11:33	NR 66035 52966	166035	652966	Figure 11	GIGHA FW3	Stream, W 0.60 m, D 0.10 m, Flow 0.168/0.176 m/s. Location of fresh water sample 3 (GIGHA FW3)
15	08/09/2010	11:42	NR 66063 52992	166063	652992	Figures 12 & 13	GIGHA FW4	Stream, W 0.53 m, D 0.05 m, Flow 0.044/0.043 m/s. Location of fresh water sample 4 (GIGHA FW4). Photograph showing example of land cover surrounding the bay, shows rough grassland, reed beds, woodland and heather.
16	08/09/2010	11:59	NR 66026 53171	166026	653171	Figure 14		Fresh cow manure, next to woodland, no cattle visible. Farm and house behind woodland.
17	08/09/2010	12:05	NR 65797 53176	165797	653176	Figures 15 & 16		Approximately, 60 sheep in field next to farm and 15 cattle in the adjacent field

Photos referenced in the table can be found attached as Figures 4-16.

Sampling

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

Samples of seawater were tested for salinity by the laboratory using a salinity meter under 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 sampled	Sample	Grid Ref	Type	E. coli (cfu/100 ml)	Salinity (g/L)
1	08/09/2010	GIGHA SW1	NR 65762 52122	Sea water	<10	35.2
2	08/09/2010	GIGHA SW2	NR 65678 52225	Sea water	10	34.7
3	08/09/2010	GIGHA SW3	NR 65970 52900	Sea water	120	30.3
4	08/09/2010	GIGHA FW1	NR 65591 52118	Fresh water	410	
5	08/09/2010	GIGHA FW2	NR 65715 52028	Fresh water	110	
6	08/09/2010	GIGHA FW3	NR 66035 52966	Fresh water	1100	
7	08/09/2010	GIGHA FW4	NR 66063 52992	Fresh water	70	

Table 3. Shellfish Sample Results

No.	Date sampled	Sample	Grid Ref	Type	E. coli (MPN/100 g)
1	08/09/2010	GIGHA OYSTER1	NR 65761 52123	Pacific oysters	490
2	08/09/2010	GIGHA OYSTER2	NR 65676 52225	Pacific oysters	20

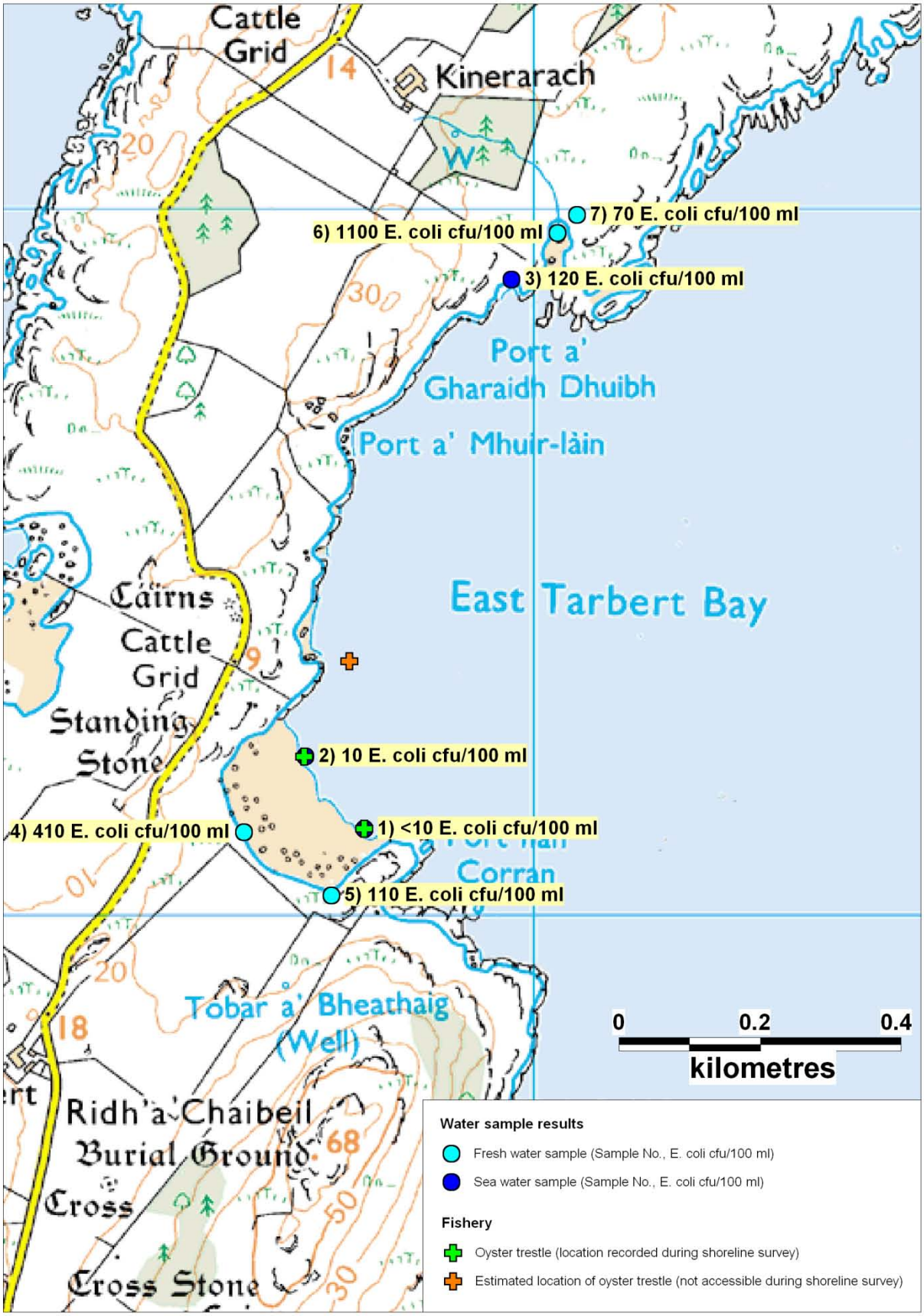


Figure 2. Water sample results

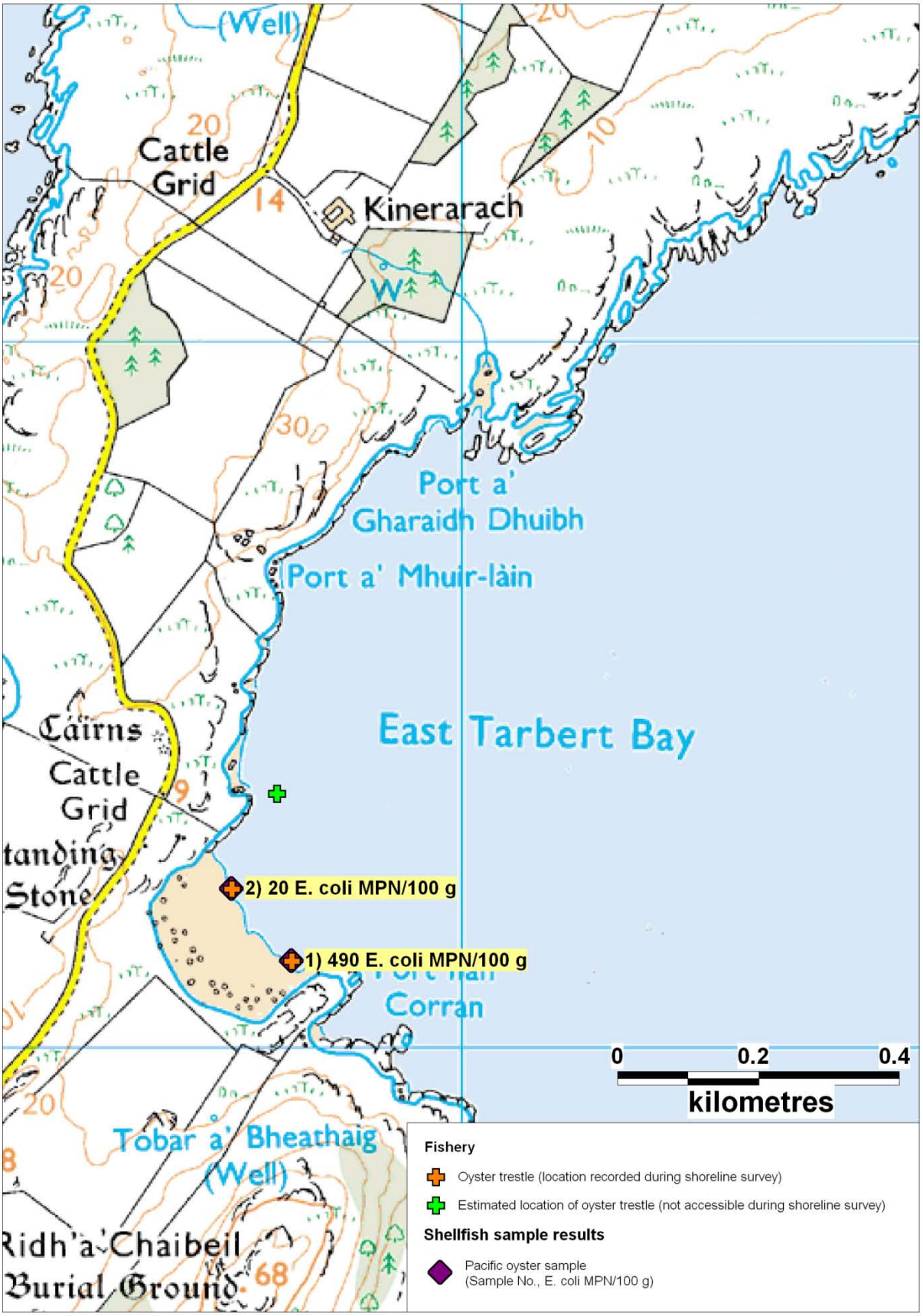


Figure 3. Shellfish sample results

Photographs

Figure 4. Stream and location of fresh water sample 1 (GIGHA FW1)

Figure 5. Approximately 30 cattle in field behind shoreline, fenced in. Also three houses in background.

Figure 6. Stream and location of fresh water sample 2 (GIGHA FW2)

Figure 7. Live periwinkles and cockles found around the bay

Figure 8. Oyster sample 1 (GIGHA OYSTER1)

Figure 9. Location of sea water sample 2 (GIGHA SW2) & oyster sample 2 (GIGHA OYSTER2)

Figure 10. Bay next to East Tarbert Bay

Figure 11. Stream and location of fresh water sample 3 (GIGHA FW3)

Figure 12. Stream and location of fresh water sample 4 (GIGHA FW4)

Figure 13. Example of land cover surrounding East Tarbert Bay

Figure 14. Farm and house located behind woodland

Figure 15. Approximately 60 sheep in field adjacent to farm

Figure 16. Approximately 15 cattle in field adjacent to farm

Norovirus Testing Summary

Isle of Gigha: East Tarbert Bay

Oyster samples taken from the oyster trestles at Isle of Gigha: East Tarbert Bay were submitted for Norovirus analysis quarterly from September 2010. Results to date are summarised in the table below. Sample results for June 2011 were not available at time of reporting.

Ref No.	Date	NGR	GI	GII
10/399	08/09/2010	NR 6576 5212	Not detected	Not detected
10/518	22/11/2010	NR 6576 5213	Not detected	Not detected
11/756	23/03/2011	NR 6574 5210	Not detected	Not detected