Scottish Sanitary Survey Project

Sanitary Survey Report

Badcall Bay(HS 494)
Eddrachillis Bay (TBA)
April 2010

Cefas

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

Report Distribution – Badcall Bay

Date	Name	Agency*
	Linda Galbraith	Scottish Government
	Paul Shave	Scottish Government
	Ewan Gillespie	SEPA
	Douglas Sinclair	SEPA
	Sarah Gillman	Scottish Water
	Alex Adrian	Crown Estate
	Alan Yates	Highland Council
	Anne Grant	Highland Council
	Debasis Biswas	Loch Duart Ltd.

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

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

Table of Contents

1. General Description

Badcall Bay is a southwest-facing bay located on the northwest coast of mainland Scotland protected by a number of small islands which lie in its mouth. Eddrachillis Bay is about 4 km to the south of Badcall Bay, and is west facing and slightly more exposed. This sanitary survey was undertaken in response to an application for classification of this area for sea urchins (*Paracentrotus lividus*).

Figure 1.1 Location of Badcall and Eddrachillis Bays

2. Fishery

The urchin fishery at Badcall Bay (HS 494 911 22) and at Eddrachillis Bay was established to operate in co-production with salmon aquaculture in marine cages. Small urchin stock is purchased from a supplier in Ireland, then placed in racks and suspended below the walkways between cages stocked with salmon, at a depth of 1-2 m. Here, they graze on detritus falling from the cages. Their diet is supplemented with seaweed grown on ropes suspended from floats at a site within Eddrachillis Bay. The urchin production cycle is aligned with the salmon production cycle, with the sites stocked with, and then harvested of, both species at the same time. Urchins would generally be harvested in autumn when their roes are largest, as this is only part which is consumed.

At the time of shoreline survey, two cage sites were stocked with Urchins (A & B). The other two (C & D) will be stocked when salmon are placed on the site. One site lies within Badcall Bay (A), and the other three are within Eddrachillis Bay. Figure 2.1 shows the positions of the present and proposed urchin farms in Badcall and Eddrachillis Bays.

A provisional classification was issued by the FSAS on 13 November 2009, with production area boundaries described as the area bounded by lines drawn between NC 1520 4110 and NC 1580 4030. This only encompassed the Badcall Bay site (site A), which was harvested in the autumn of 2009. A provisional representative monitoring point (RMP) for *E. coli* monitoring was set at NC 1565 4075.

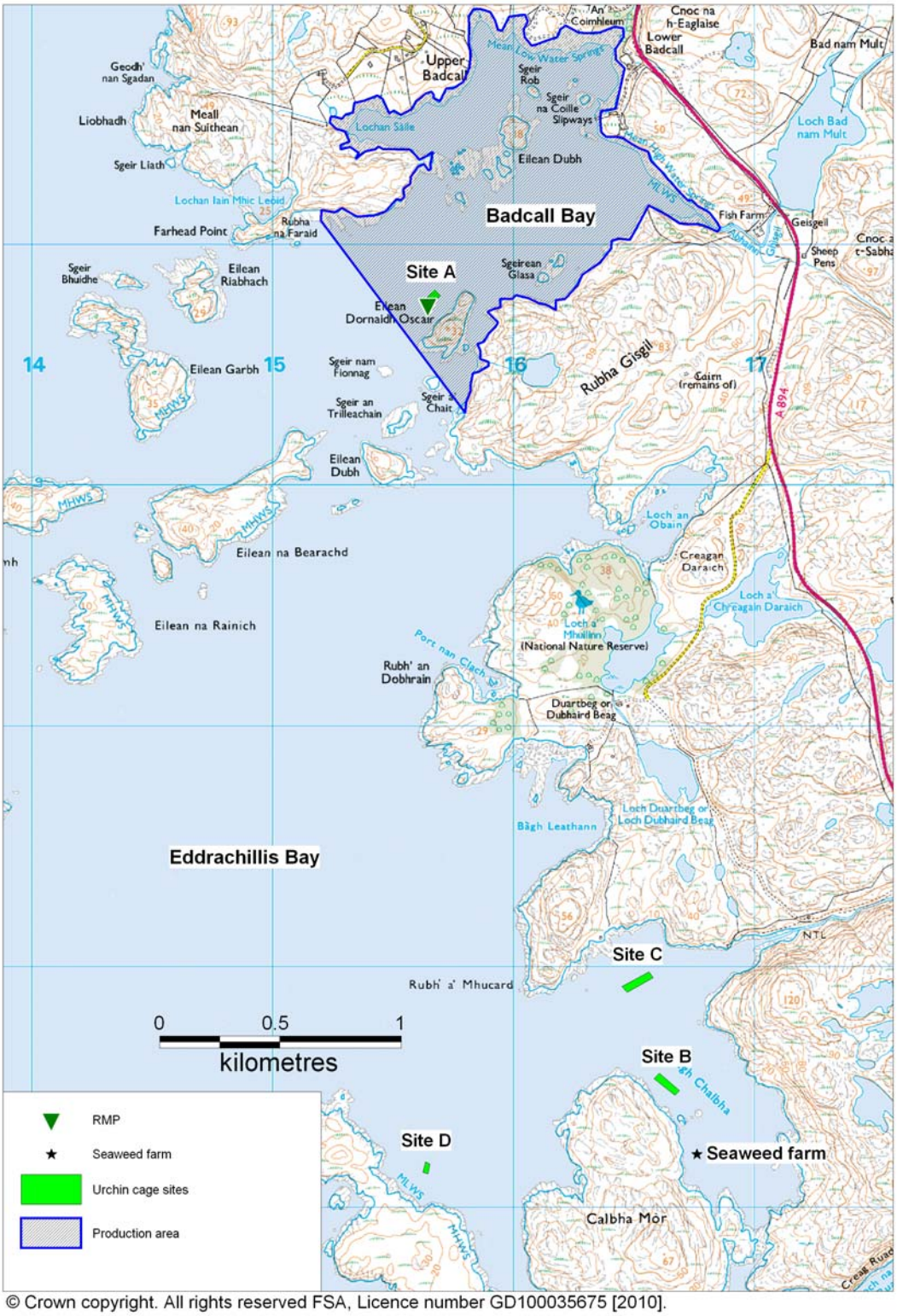

Figure 2.1 Badcall/Eddrachillis Bay fishery

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 Badcall Bay and Eddrachillis Bay at the time of the last census in 2001.

Figure 3.1 Human population surrounding Badcall/Eddrachillis Bay.

Population densities in the area are very low. There is one large population census area immediately adjacent to the fishery sites, with a total population of 83. There are only a few scattered dwellings on the shore of this area, most of which are located around the head of Badcall Bay. The small village

of Scourie lies about 4 km north of the nearest cage site. The population for the census area in which is lies was 139 in 2001. The area lies within the Northwest Highlands Geopark and draws some tourism during the summer months. A caravan park (75 pitches) is located on the south side of the bay at Scourie and there are hotels at both Scourie and at the head of Badcall Bay. Seasonal population in the area, therefore, is anticipated to be higher betweeen the months of April and October, peaking during the prime summer holidays months of July and August..

The impact from human habitation on microbiological contamination of the waters surrounding the fisheries is expected to be very low overall, with a peak during late summer.. The cage site in Badcall Bay (Site A) may be impacted slightly more than the other three sites due to is location nearer to populated areas.

4. Sewage Discharges

No Scottish Water discharges were identifies in the survey area. SEPA list 13 discharge consents in the area, details of which are presented in Table 4.1.

Table 4.1 Discharges identified by SEPA

	Ref No.	NGR of discharge	Discharge Type	Level of Treatment	Consented flow (DWF) m^3/d	Consented PE	Discharges to
1	CAR/R/1010264	NC 1131 3371	Domestic	Septic tank	-	5	Land
2	CAR/R/1013603	NC 1243 3286	Domestic	Septic tank, package treatment plant and constructed reed bed	-	15	Loch Ruighean An Aitinn
3	CAR/R/1016108	NC 1481 4441	Domestic	Septic tank	-	5	Land
4	CAR/R/1017116	NC 1565 4177	Domestic	Septic tank	-	5	Land via soakaway
5	CAR/R/1019755	NC 1137 3320	Domestic	Package treatment plant	-	5	Land via mound soakaway
6	CAR/R/1021317	NC 1479 4457	Domestic	Septic tank	-	5	Land via soakaway
7	CAR/R/1022782	NC 1299 3268	Domestic	Package treatment plant	-	5	Land via mound soakaway
8	CAR/R/1034208	NC 1545 4417	Domestic	Septic tank	-	5	Land via soakaway
9	CAR/R/1036927	NC 1940 3331	Domestic	Septic tank	-	5	Land via soakaway
10	CAR/R/1039555	NC 1558 4503	Domestic	Septic tank	-	8	Land via soakaway
11	CAR/R/1051802	NC 1632 4897	Domestic	Septic tank	-	5	Loch Dubh
12	WPC/N/0070278	NC 1635 4180	Sewage effluent	Septic tank	-	-	Badcall Bay
13	WPC/N/0070315	NC 1635 4185	Sewage effluent	Septic tank	-	-	Badcall Bay
14	WPC/N/53420	NC 152 438	Treated sewage effluent	Septic tank	9	50	Unnamed Burn
15	WPC/N/55584	NC 1540 4480	Treated sewage effluent	Septic tank	50	300	North Minch
16	T/B13/050/93(00)	NC 164 415	Sewage effluent	Unspecified	-	-	Badcall Bay

The locations of these discharges are mapped in Figure 4.1. Three of the above consents relate to discharges direct to Badcall Bay. Although no flow or PE information was provided on any of these discharges, the two septic tanks are associated with a hotel on the shore of the bay that has 11 rooms in addition to living quarters for staff so at maximum is likely to be used by approximately 30 people. The other discharge to the bay is associated with the salmon shore base itself, and it was not clear whether this discharged treated waste from a septic tank or untreated sewage as the permit did not specify. As there has not historically been a requirement to register septic systems in Scotland, this list is unlikely to cover all septic tanks in the area. A

physical survey the shoreline was undertaken and observations of septic tanks and/or outfalls present along the shoreline are presented in Table 4.2.

Table 4.2 Discharges and septic tanks observed during shoreline survey

No.	NGR	Observation	SEPA ref no.
1	NC 15512 44965	Pipe in seawall, concrete, dribbling, sewage fungus and smell	
2	NC 15501 44965	Iron pipe in seawall, no flow. Trickle of water through wall below pipe, with green algal growth	
3	NC 15529 44793	Scourie Village Septic Tank. SEPA sample point	WPC/N/55584
4	NC 15406 44760	Septic tank discharge pipe. End underwater at low tide, seawater sample BB 8 (>10000 *E. coli* cfu/100ml)	WPC/N/55584
5	NC 15440 44733	Large corrugated plastic pipe with water flowing out and down rocks.	

Observations 3 and 4 relate to discharge consent 15 in Table 4.1. During the shoreline survey, locations of the discharges from the hotel and the salmon facility were not confirmed visually.

The shoreline survey identified that small craft and salmon farm service boats operate in the area, with a number on moorings near the north end of the bay. The Clyde Cruising Club Sailing Directions for Ardnamurchan to Cape Wrath indicates suitable areas for yacht anchorages anywhere around the head of Badcall Bay, although it is not known how frequently these anchorages are used. There are no specific facilities for visiting yachts in the area .

The most significant potential sewage impacts to the area are all more likely to affect cage site A in Badcall Bay. These are the discharges from the the salmon shore base and the hotel, and any potential discharges from boats using the anchorage in the bay. At the other cage sites, sewage impacts are likely to be from boat traffic rather than land based sewage infrastructure. Yachts and salmon farm service barges may have on-board toilets and discharges from boats can occur in close proximity to any of the cage sites.

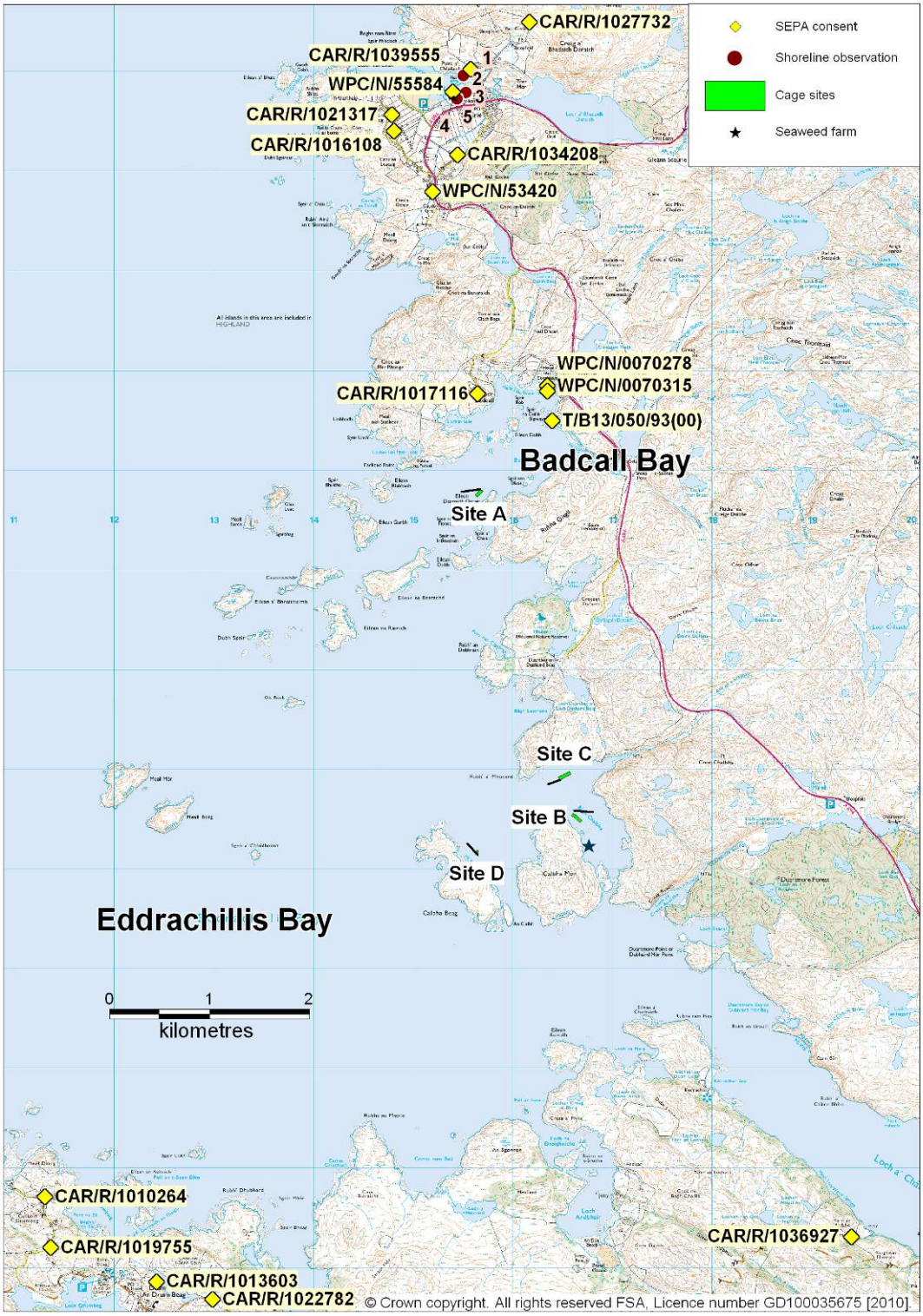

Figure 4.1 Sewage discharges at Badcall/Eddrachillis Bays

5. Geology and Soils

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

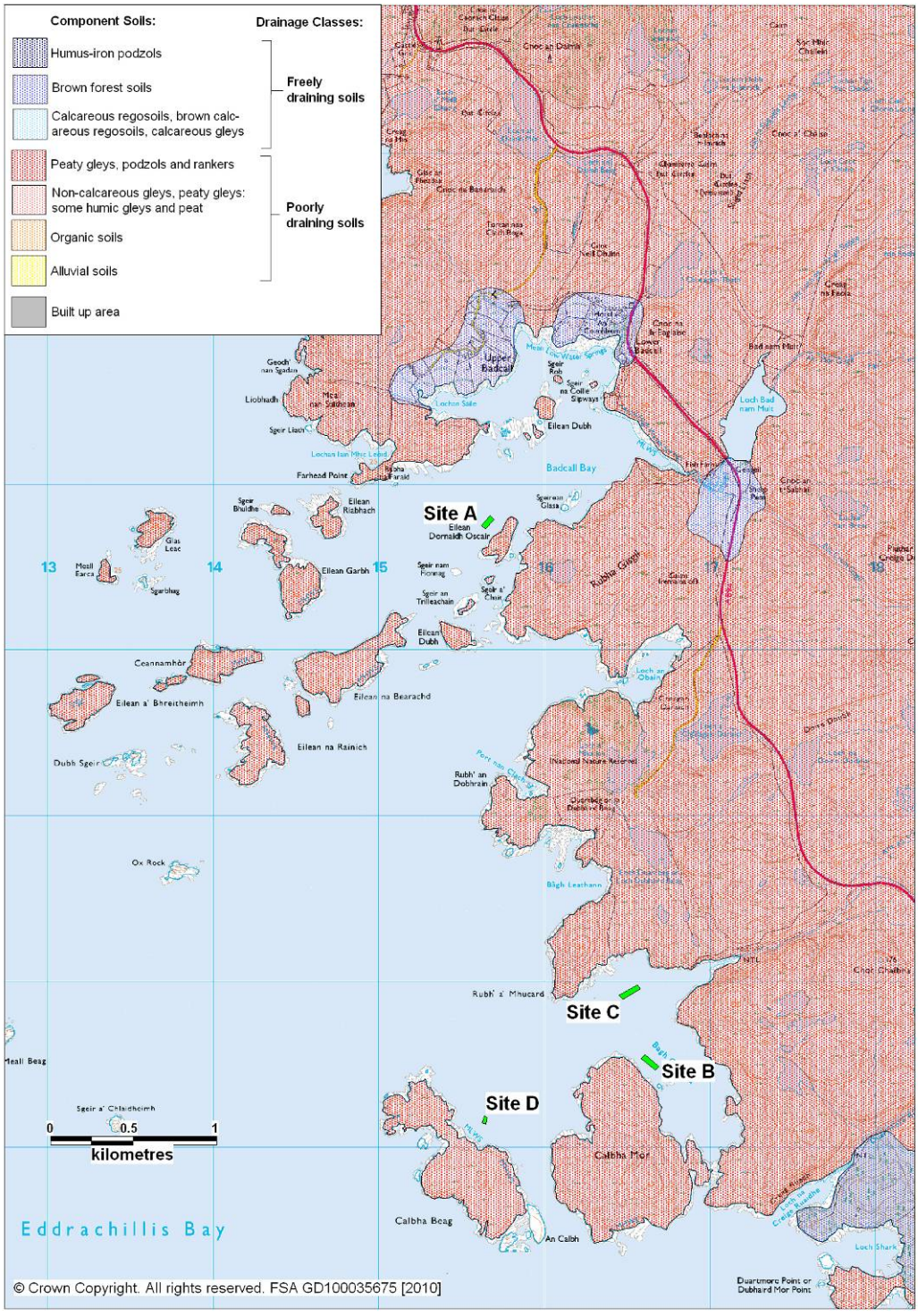

Figure 5.1 Component soils and drainage classes for Badcall/Eddrachillis Bay

Two types of component soils were identified in the area: peaty gleys, podzols and rankers and brown forest soils. The areas of brown forest soils are located around the north and east of Badcall Bay and also to the southeast of the sites located further south in Eddrachillis Bay. These soils are freely draining and therefore the potential for runoff due to soil structure is reduced in these areas. The peaty gleys, podzols and rankers are poorly draining; therefore the potential for runoff is increased.

Overall, the potential for runoff contaminated with *E. coli* from human and/or animal waste is high for most of the area, including all of the coastline directly adjacent to the fishery sites, as the component soils surrounding this remaining area are composed of poorly draining soils. An area surrounding the northern side of Badcall Bay had freely draining soils and so would be less likely than the remaining area to contribute high levels of runoff.

6. Land Cover

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

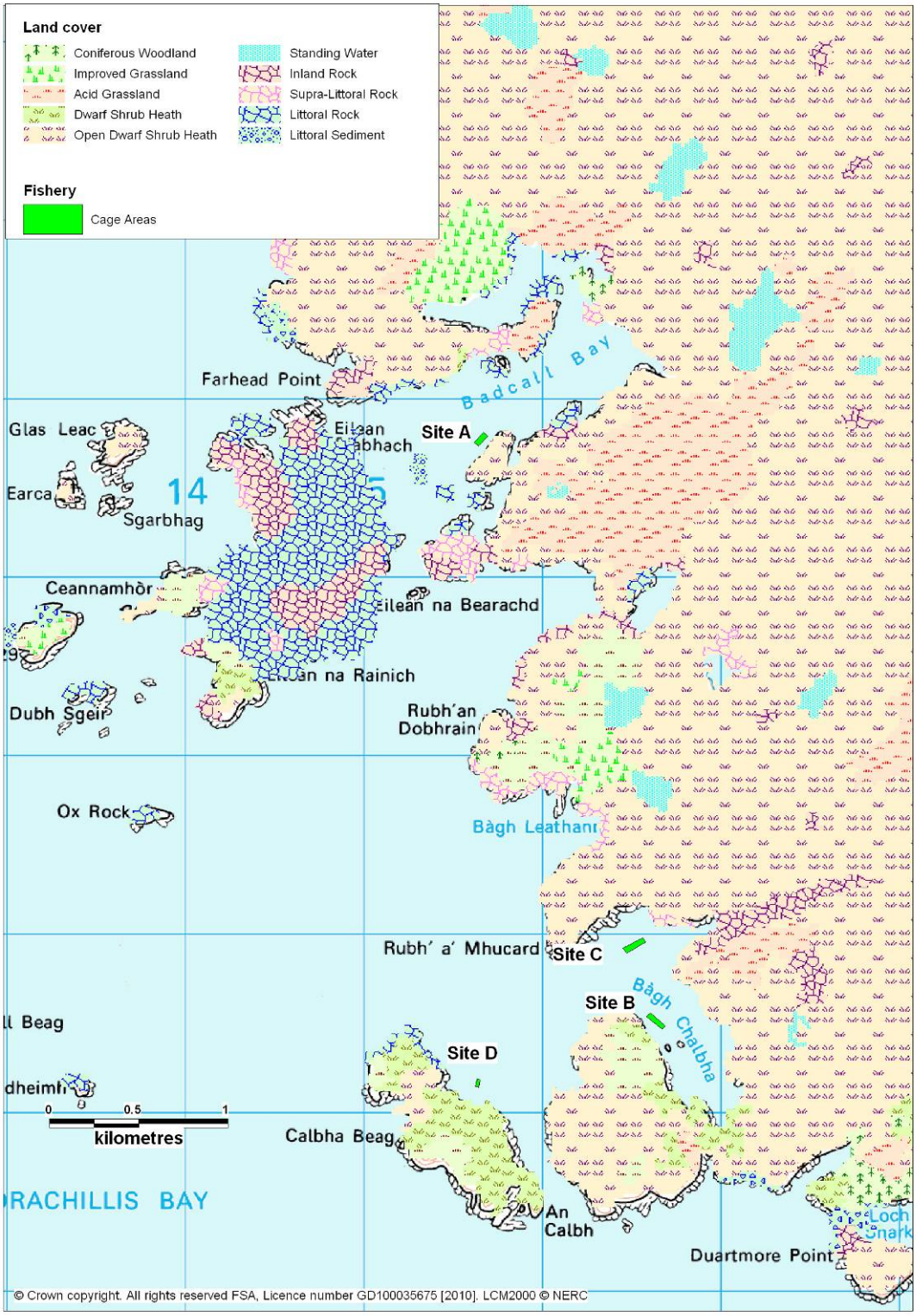

Figure 6.1 LCM2000 class land cover data for Badcall/Eddrachillis Bay

Land cover in the area is predominantly open heath and acid grassland. There significant patches of improved grassland around the north west shore of Badcall Bay and also on the shore between Site A and the southern sites, east of Rubh'an Dobharain. There is a small area of development (including buildings, drives and car parks) associated with the hotel and fish farm base on the northeast side of Badcall Bay that is not shown in the LCM2000 data.

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 being expected to be highest, at more than 100-fold, for the improved grassland.

Therefore, the overall predicted contribution of contaminated runoff from these land cover types would be low to intermediate around the site within Badcall Bay, and low around the sites within Eddrachillis Bay. However, the exceptions to this are the developed area around the northeastern shore of Badcall Bay and the area of improved grassland on the northwestern side of Badcall Bay. Relatively high contributions of contaminated runoff might be expected from the developed area while intermediate contributions could be expected from the improved grassland. The risk from the improved grassland would be expected to be mitigated somewhat by the underlying soil which was identified as predominantly freely draining in this area (Section 5). The impact from these two areas is most likely to affect Site A.

The contribution from all land cover types would be expected to increase significantly following heavy rainfall, but this effect would be greater for the improved grassland found in the north end of Badcall Bay .

7. Farm Animals

Parish level aricultural census data was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the parish of Eddrachillis, which encompasses the shoreline adjacent to the fishery. The parish encompasses a land area of 575 km^2, extending 45 km north to south and up to 23 km east to west. Reported livestock populations for the parishes 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. Any entries which relate to less than five holdings, or where two or fewer holdings account for 85% or more of the information, is replaced with an asterisk.

Table 7.1 Livestock numbers in Eddrachillis Parish 2007 - 2008

	2007		2008	
	Holdings	Numbers	Holdings	Numbers
Pigs	0	0	0	0
Poultry	8	328	6	110
Cattle	9	102	9	110
Sheep	44	6775	41	5522
Horses and ponies	*	*	5	9

* Data withheld for reasons of confidentiality

Sheep are the most common type of livestock kept in the Eddrachillis parish, with relatively low numbers of cattle and poultry provided. Substantial declines were reported in both poultry and sheep numbers from 2007 to 2008. Due to the large land area covered by the parish, this data does not provide sufficiently detailed information on the livestock population present near the fishery. The only significant source of local information was therefore the shoreline survey (see Appendix), which relates specifically to the time of the site visit on 12-13th August 2009. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 7.1. This information should be treated with caution, as it applies only to the survey dates and the point of view of the observer. Due to the large geographic area and rough terrain, many animals could have been obscured from view.

The shoreline survey confirmed that livestock in the area is predominantly sheep, with some cattle. A flock of 37 sheep was recorded on pastures by the north shore of Badcall Bay, with 11 rams seen about 1 km further north. Livestock was also observed in another two other locations; at Scourie and another site 2 km inland from Eddrachillis Bay. Livestock are likely to be grazed widely throughout the area and so their faeces may be present in land runoff from a much wider area than that represented by observations made during the shoreline survey. Diffuse pollution to stream runoff by livestock faeces is likely to affect background levels of contamination found within the areas of the bay nearest shore and the discharge points of watercourses. Based on this observation, the relative impact of faecal contamination from livestock sources is likely to be highest at Site A, and may potentially also

impact Site C depending on where livestock are allowed to graze within the area.

Based on the numbers and distribution of animals seen during the shoreline survey and overall farm census data for the parish, there relatively few animals located in the vicinity of the fishery and so the impact to bacteriological water quality in the area is likely to be low.

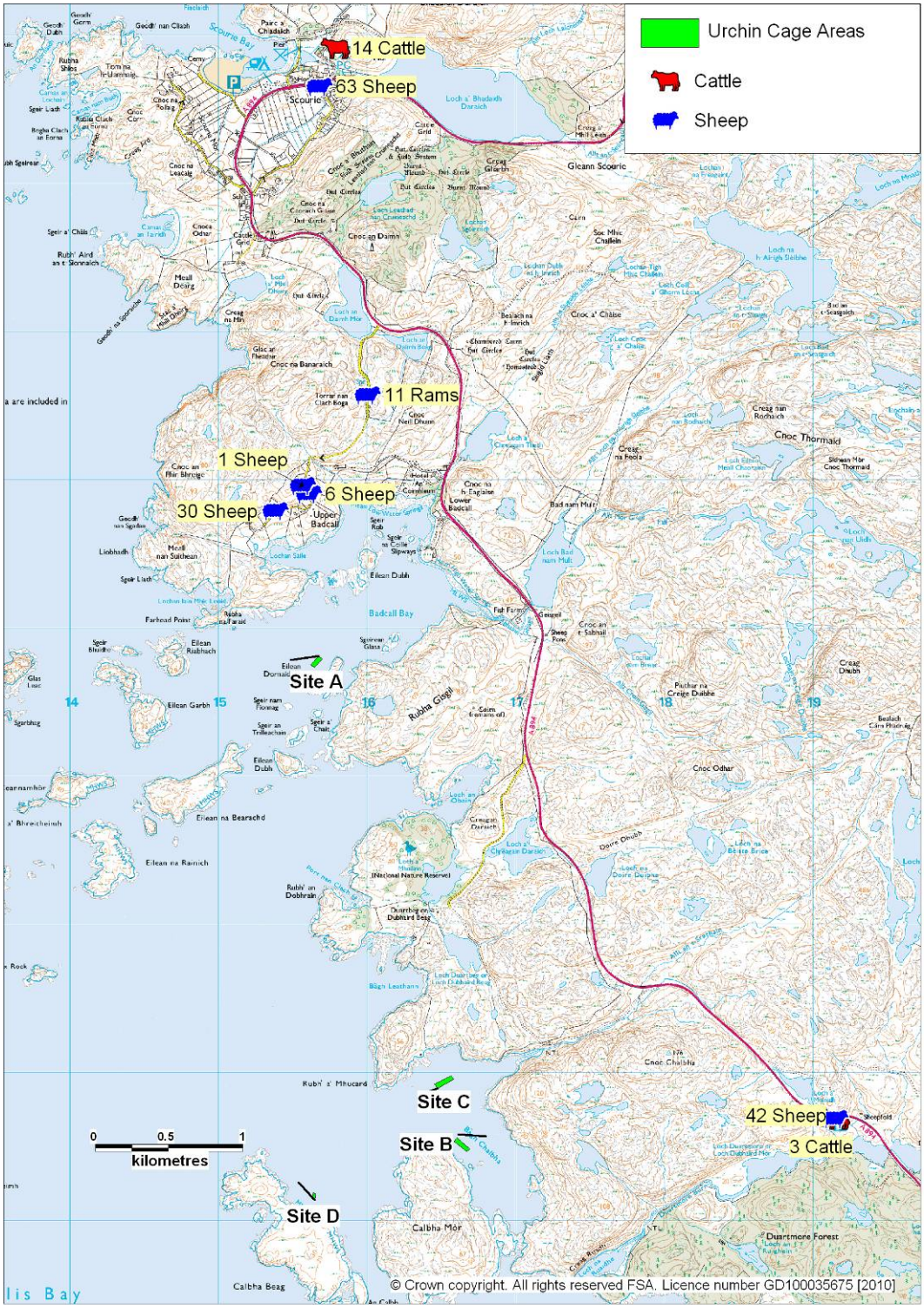

Figure 7.1 Livestock Observed during Shoreline Survey

8. Wildlife

General information related to potential risks to water quality by wildlife can be found in Appendix 4. The Loch a' Mhulinn nature reserve covers part of the coastline of Eddrachillis Bay, and hosts native oak woodlands. A number of wildlife species present or likely to be present around Badcall Bay and Eddrachillis Bay could potentially affect water quality around the fishery.

Seals

Two species of seal 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 2005 estimated a population of 4966 common seals from Cape Wrath to Appin (Sea Mammal Research Unit, 2007). There was no specific data on grey seals in this area. The exact locations of the common seal haulout sites were not specified so it is not known how many seals are likely to be resident in the area. They are likely to be attracted to the cage sites by the salmon housed there and so may frequently be present near the fishery. The shoreline survey identified that seals were present in the area.

Whales/Dolphins

A variety of whales and dolphins are routinely observed off the west coast of Scotland. Smaller species of cetaceans could potentially be present in the area from time to time, although any impact of their presence is likely to be fleeting and unpredictable.

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. In the 2006 count, a total of 296 red deer were recorded within a 5 km radius of the cage sites, so there is a considerable population in the area, although only one animal was recorded within 1 km of any of the cage sites. Roe and Sika deer are also present in the region. However, deer are fenced from the Loch a' Mhulinn nature reserve (encompassing the shoreline between Site A at Badcall Bay and the other 3 sites further south) to prevent damage to the small area of oak woodlands there. Faecal microorganisms originating from deer faeces are likely to be found in all the streams and burns in the area. No specific information is available on the spatial distribution of deer within the area.

Birds

A number of bird species are found around Badcall Bay and Eddrachillis Bay, but seabirds and waterfowl are most likely to occur around or near the fisheries. A number of seabird species breed in Sutherland. These were the subject of a detailed census carried out in the late spring of 1999, 2000 and 2001 (Mitchell *et al.*, 2004). Total counts of all species recorded within 5 km of the cage sites are presented in Table 8.1. Where counts were of sites/nests/territories occupied by breeding pairs actual numbers of birds in the area will be higher.

Table 8.1 Counts of breeding seabirds within 5 km of the cage sites

Common name	Species	Count	Method	Individual /pair
Northern Fulmar	*Fulmarus glacialis*	304	Occupied nests/sites	pairs
Great black-backed gull	*Larus marinus*	124	Occupied nest/territories	pairs
Herring gull	*Larus argentatus*	101	Occupied nest/territories	pairs
European shag	*Phalacrocorax aristotelis*	60	Occupied nests	pairs
Black Guillemot	*Cepphus grylle*	55	Individuals on land	indiv
Great cormorant	*Phalacrocorax carbo*	15	Occupied nests	pairs
Common gull	*Larus canus*	4	Occupied nests	pairs
Common tern	*Sterna hirundo*	2	Occupied nests	pairs

The location of breeding seabird pairs is thematically mapped in Figure 8.1, with each recorded pair counted as two individuals. They were mainly concentrated on the small islands around the mouth of Badcall Bay, with some also breeding on the small island next to site D. Contamination of the cage sites from these birds would be via direct deposition as they feed, and through runoff from streams draining the areas in which they nest, rest or roost. As sites A and D are closest to islands on which the birds nest, faecal contamination carried by land runoff from the nesting areas may be of more importance at these sites compared to the other two sites. Impacts from these species are expected to peak during the summer breeding season, although some species are likely to be resident year round. Significant numbers of gulls were recorded in the vicinity of sites A and C during the shoreline survey.

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 in Sutherland in small numbers. The presence of ducks was recorded at a pond in Scourie, although these are unlikely to be of relevance to any of the cage sites. Goose droppings were recorded by a stream at the head of Badcall Bay during the shoreline survey, suggesting there was a small presence of geese in the area at the time. Geese will tend to be found on areas of pasture, and there may be greater numbers present in the winter months if they overwinter in the area. Aside from an area at the head of Badcall Bay (where the goose droppings were recorded) there is little in the way of pasture within the survey area.

Figure 8.1 Breeding seabird counts within 5 km of the cage sites

Wading birds would be concentrated on intertidal areas, such as the area at the head of Badcall bay, although no aggregations were recorded during the shoreline survey.

There is reported to be a small heronry on cliffs within the Loch a' Mhulinn nature reserve, the exact location of which is uncertain.

Otters

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

Summary

In summary, the main wildlife species potentially impacting on the sites are deer, seals and seabirds. Contamination from deer will be carried into the production area by streams draining the surrounding hills and this will occur all year round. Seals are likely to be a minor year round presence, and will be attracted to any cage sites containing salmon. Given the locations of their nesting sites, impacts from breeding seabirds via direct deposition or land runoff may be higher at sites A and D.

9. Meteorological data

The nearest weather station is located at Kerrachar, approximately 6 km to the south of the site. Rainfall data was available for 2003-2008 inclusive apart from the months of October to December 2006 and March and December 2008. The nearest weather station for which wind data was available was Stornoway, approximately 71 km to the west of the fishery. Differences in local topography between Badcall Bay and Stornoway are likely to skew wind patterns in different ways, and conditions at any given time may differ due to the distance between them. This section aims to describe the local rain and wind patterns and how they may affect the bacterial quality of shellfish at Badcall 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 at the midline. The whiskers extend to the largest or smallest observations up to 1.5 times the box height above or below the box. Individual observations falling outside the box and whiskers are represented by the symbol *.

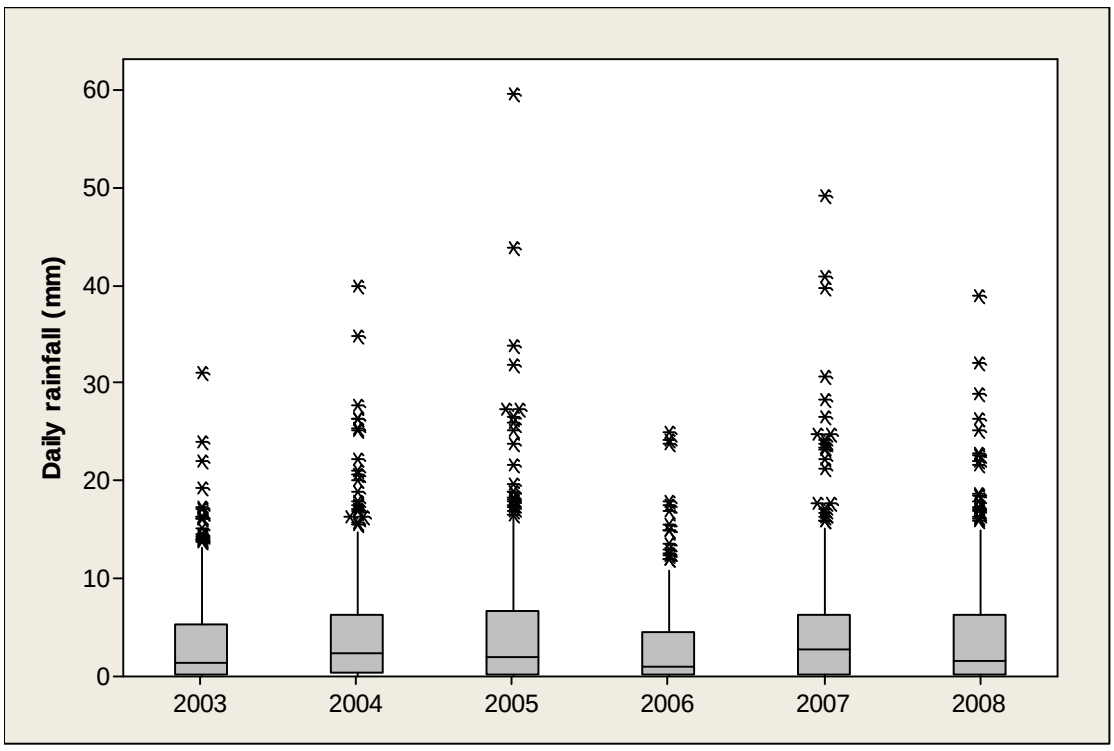

Figure 9.1 Box plot of daily rainfall values by year at Kerrachar, 2003-2008

Figure 9.1 shows that rainfall patterns varied year to year, although it must be noted that records for 2006 and 2008 were incomplete. As 3 months data were missing from 2006, this year cannot be compared with with others, however average daily rainfall did appear to be lower in 2003 than in subsequent years. Individual rainfall events of >30 mm in a day occurred in all years but 2006, however it must be noted that there were no rainfall records for the last quarter of that year. In the remaining years, 2005 and 2007 had espcially high individual events (>50 mm in a day).

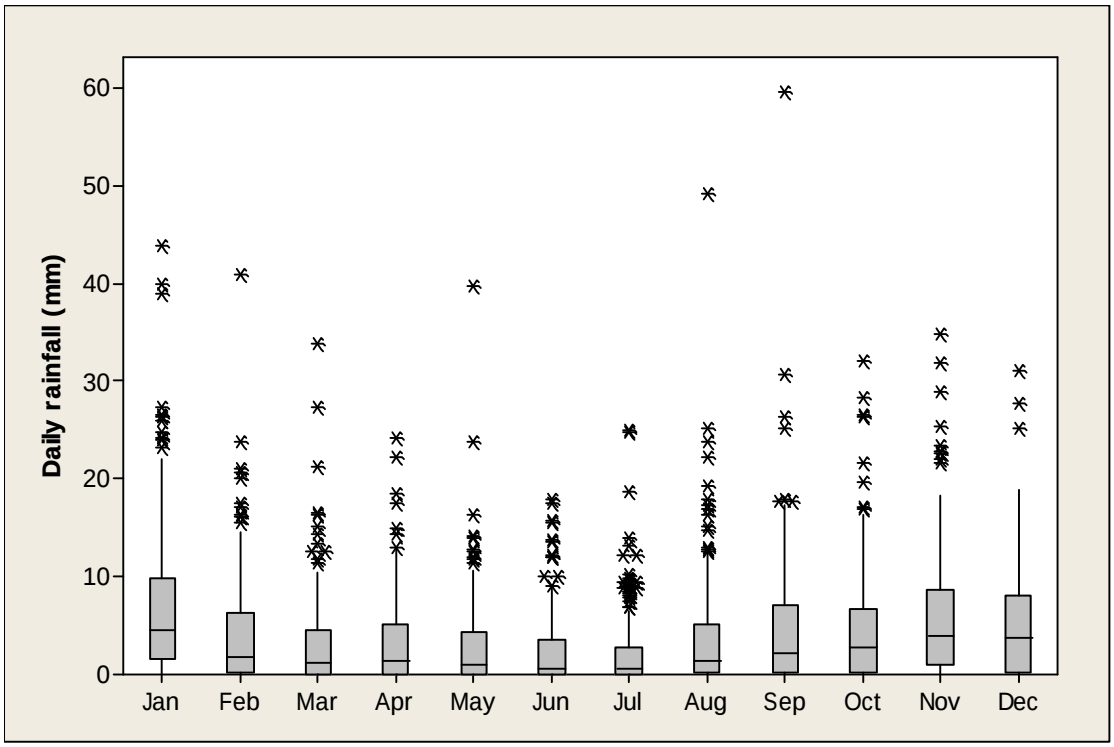

Figure 9.2 Box plot of daily rainfall by month at Kerrachar, 2003-2008

The wettest months were November, December and January. June and July were the driest months. Days with high rainfall occurred in all months of the year but these were lower in June. Extreme rainfall events of >30 mm in a day were recorded in all months except April, June and July. For the period considered here (2003-2008), 42% of days experienced rainfall less than 1 mm, and 12% of days experienced rainfall of 10 mm or more.

Levels of rainfall-dependent faecal contamination entering the production area from these sources may be higher on average during the autumn and winter months. However, rainfall events substantially above the average can occur at any time of year, as can be seen in Figure 9.2. These events may result in a 'first flush' of highly contaminated runoff from pastures, resulting in poor water quality at the fishery. This effect may be particularly acute during the summer, when livestock numbers are likely to be highest and faecal matter may have built up on pastures. Therefore, rainfall driven runoff of faecal contamination is most likely to affect the fishery after heavy rainfall during the late summer to early autumn months.

9.2 Wind

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

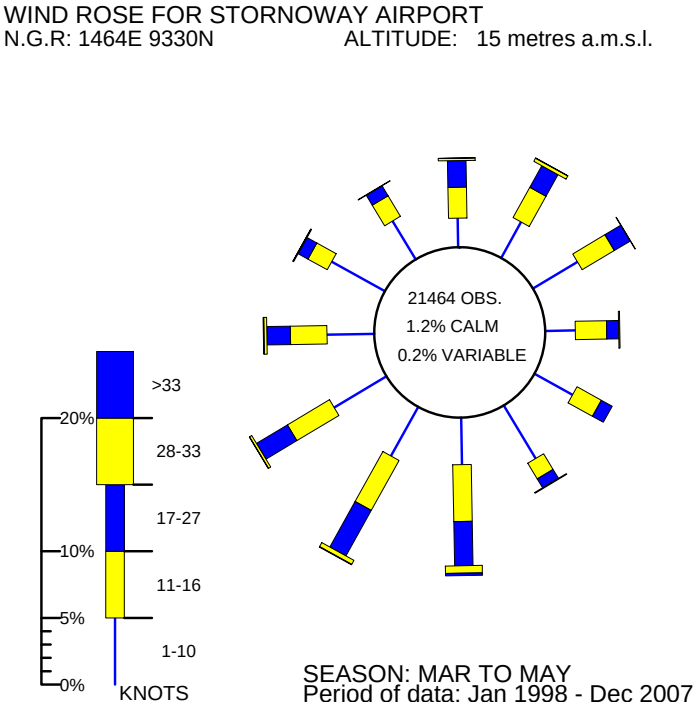

Figure reproduced under license from Meteorological Office. Crown Copyright 2010.

Figure 9.3 Wind rose for Stornoway (March to May)

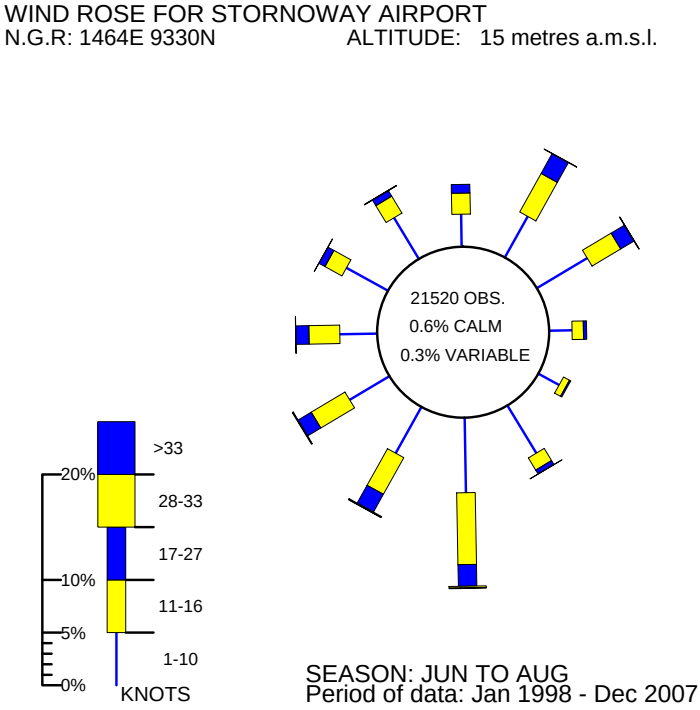

Figure reproduced under license from Meteorological Office. Crown Copyright 2010.

Figure 9.4 Wind rose for Stornoway (June to August)

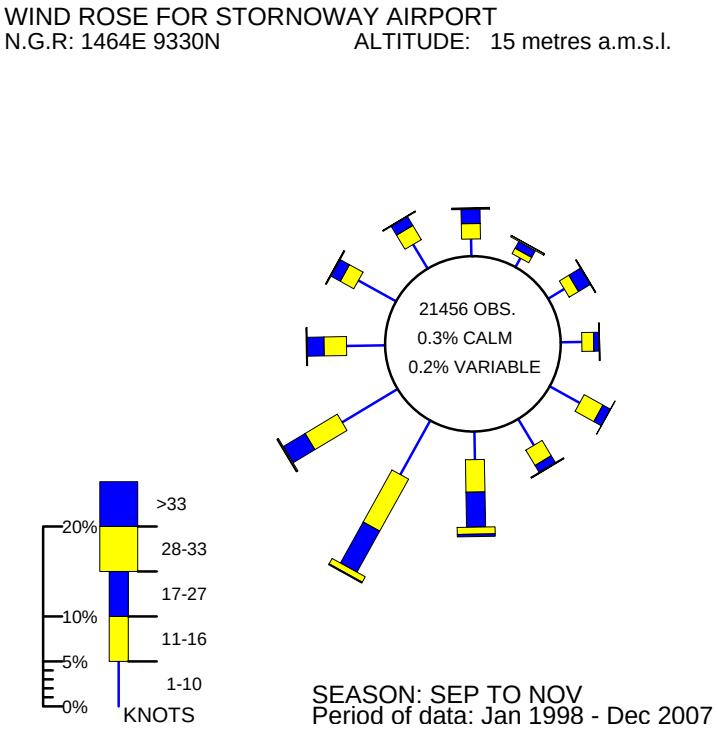

Figure 9.5 Wind rose for Stornoway (September to November)

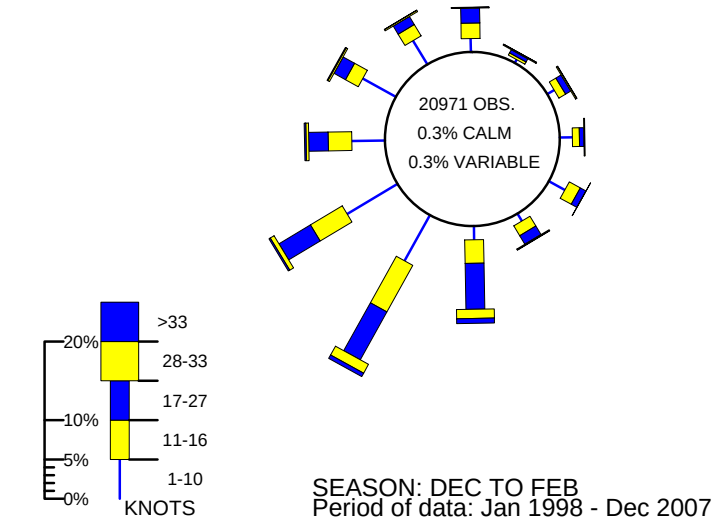

Figure 9.6 Wind rose for Stornoway (December to February)

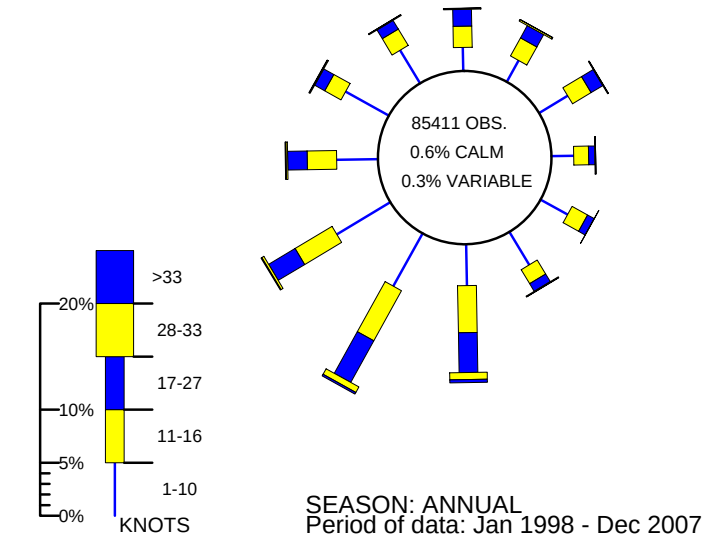

Figure 9.7 Wind rose for Stornoway (All year)

The prevailing wind direction at Stornoway is from the south and west. There is a higher occurence of north easterly winds during the spring and summer. Winds are generally lighter in the summer and stronger in the winter. The Stornoway weather station is located at Stornoway airport, which faces the sea to the north east, and is surrounded by low lying land in other directions. The fishery at Badcall (site A) lies within a southwest facing bay and so is most exposed to the southwest, but will receive some some shelter from rocky islands around its mouth. Therefore, overall wind patterns may be more skewed to the west at Badcall Bay. The other three sites are most exposed to the north west.

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 within Badcall Bay, subsequently affecting the movement of freshwater-associated contamination. 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. An onshore wind will result in increased wave action, which may resuspend any organic matter settled in the substrate.

10. Current and historical classification status

The Badcall Bay area (which only includes site A, see Figure 2.1) was assigned a provisional A classification for the period November 2009 to March 2010 inclusive. This is the only time the area has been classified for the harvest of shellfish.

11. Historical *E. coli* data

11.1 Validation of historical data

All shellfish samples taken from Badcall Bay up to 1st February 2010 were extracted from the SHS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. Three samples did not have valid test results (one in June 2009 and two in October 2009) and so could not be used in this analysis. All *E. coli* results are reported in most probable number (MPN) per 100g of flesh and intracoelomic fluid.

11.2 Summary of microbiological results

Individual sample details are presented in Table 11.1. All samples were collected in 2009, following the receipt of the application to classify the area, and were all taken from site A, in Badcall Bay.

Table 11.1 Individual sample results from Badcall Bay

Collection date	Production area	Site	SIN	Species	Grid reference	*E. coli* (MPN/100g)
26/05/2009	Badcall Bay	Badcall Bay Urchins	HS 494 911 22	Urchins	NC 15700 40750	3500
30/06/2009	Badcall Bay	Badcall Bay Urchins	HS 494 911 22	Urchins	NC 161 414	<20
21/07/2009	Badcall Bay	Badcall Bay Urchins	HS 494 911 22	Urchins	NC 15671 40773	<20
04/08/2009	Badcall Bay	Badcall Bay Urchins	HS 494 911 22	Urchins	NC 15695 40793	<20
29/09/2009	Badcall Bay	Badcall Bay Urchins	HS 494 911 22	Urchins	NC 15671 40773	80
17/11/2009	Badcall Bay	Badcall Bay Urchins	HS 494 911 22	Urchins	NC 16444 41476	<20

E. coli results for mussels ranged from <20 to 3500 *E. coli* MPN/100g. Only one of six samples contained over 230 *E. coli* MPN/100g, and four contained <20 *E. coli* MPN/100g. This shows there is the potential for significant levels of contamination to occur within this species at this site on occasion, although generally they had very low levels of contamination. The results are presented geographically in Figure 11.1. One sample was recorded at the shorebase. Another was recorded near the boat moorings in Badcall Bay. The sample with the highest result (3500 *E. coli* MPN/100 g) was recorded 30 m southeast of the recorded salmon farm. Given that the recorded sampling locations do not in all cases correspond with locations on the fishery, it is not possible to draw conclusions regarding potential geographic variation in results. There were insufficient data upon which to investigate the effects of season and environmental variables on *E. coli* levels in shellfish at Badcall Bay.

Figure 11.1 Monitoring results at Badcall/Eddrachillis Bay

12. Designated Shellfish Growing Waters Data

The survey area does not coincide with a designated shellfish growing water.

13. Rivers and streams

The following rivers and streams were measured and/or sampled during the shoreline survey. These represent the most significant freshwater inputs into the area. The shoreline survey was conducted on the 12-13th August 2009. Some rain fell on the 11th and 12th August. Samples collected on 12 August were delayed in arrival at the laboratory until 14 August. Therefore, these samples were voided and samples were retaken on 29 September. On that date, the sampling officer noted that the Abhainn Ghisgil, the largest watercourse at Badcall Bay, was not flowing. Therefore, a seawater sample was taken from near where it normally enters the bay. As a result, paired flow measurements and sample results were only available for two watercourses.

Table 13.1 Stream loadings for Badcall Bay

No.	Position	Description	Width (m)	Depth (m)	Flow (m/s)	Dis-charge (m^3/d)	*E. coli* (cfu/100 ml)	*E. coli* loading (cfu/day)
1	NC 15537 44864	Discharge from pond at Scourie	10.2	0.27	0.049	11659	300	3.5×10^{10}
2	NC 15625 42138	Stream-Upper Badcall	0.70	0.10	0.022	133	<100	$<1.3 \times 10^{8}$
3	NC 15213 41580	Stream-Lochan Saile	0.65	0.14	-	-	100	-
4	NC 16448 41880	Stream-Badcall	-	-	-	-	<100	
5	NC 17094 38111	Allt an t-Strathain	-	-	-	-	<100	
6	NC 16769 41132	Seawater near Abhainn Ghisgil	-	-	-	-	50	

None of the streams sampled were carrying high levels of contamination at the time. The one with the largest calculated loading discharges was at Scourie, which is about 7 km away from the nearest site by sea, so is unlikely to have any impact on the fisheries. *E. coli* levels in three of the streams sampled and measured were less than the limit of quantification for the test used. While the flow at Allt an t-Strathain was measured on 12 August, a valid sample was not obtained until 29 September and so these two readings cannot be linked.

The Abhainn Ghisgil receives water from Loch Bad nam Mult which lies just inland from Badcall Bay. The *E. coli* concentration found in the seawater sample taken from near Abhainn Ghisgil was relatively high for seawater at 50 cfu/100 ml and the salinity (17.9 g/l, Appendix 8) confirms freshwater influence at this point. This suggests that the Abhainn Ghisgil may carry higher levels of contamination than the other sampled streams around Badcall Bay. Depending on when it is discharging, flows from the Abhainn Ghisgil may also affect the hydrography within Badcall Bay. The streams discharging to Badcall Bay are likely to impact on site A and unlikely to impact the other sites.

Discharges from the Allt an t-Strathain will impact at sites C and B, and possibly to a lesser extent at site D. The catchment area for this stream is

poorly drained, therefore it may run in spate following heavy rainfall and may carry faecal contaminants from both wildlife and some livestock sources.

Stream loadings are expected to increase significantly following heavy rainfall events, particularly those with livestock within their catchment areas such as those on the north west shore of Badcall Bay.

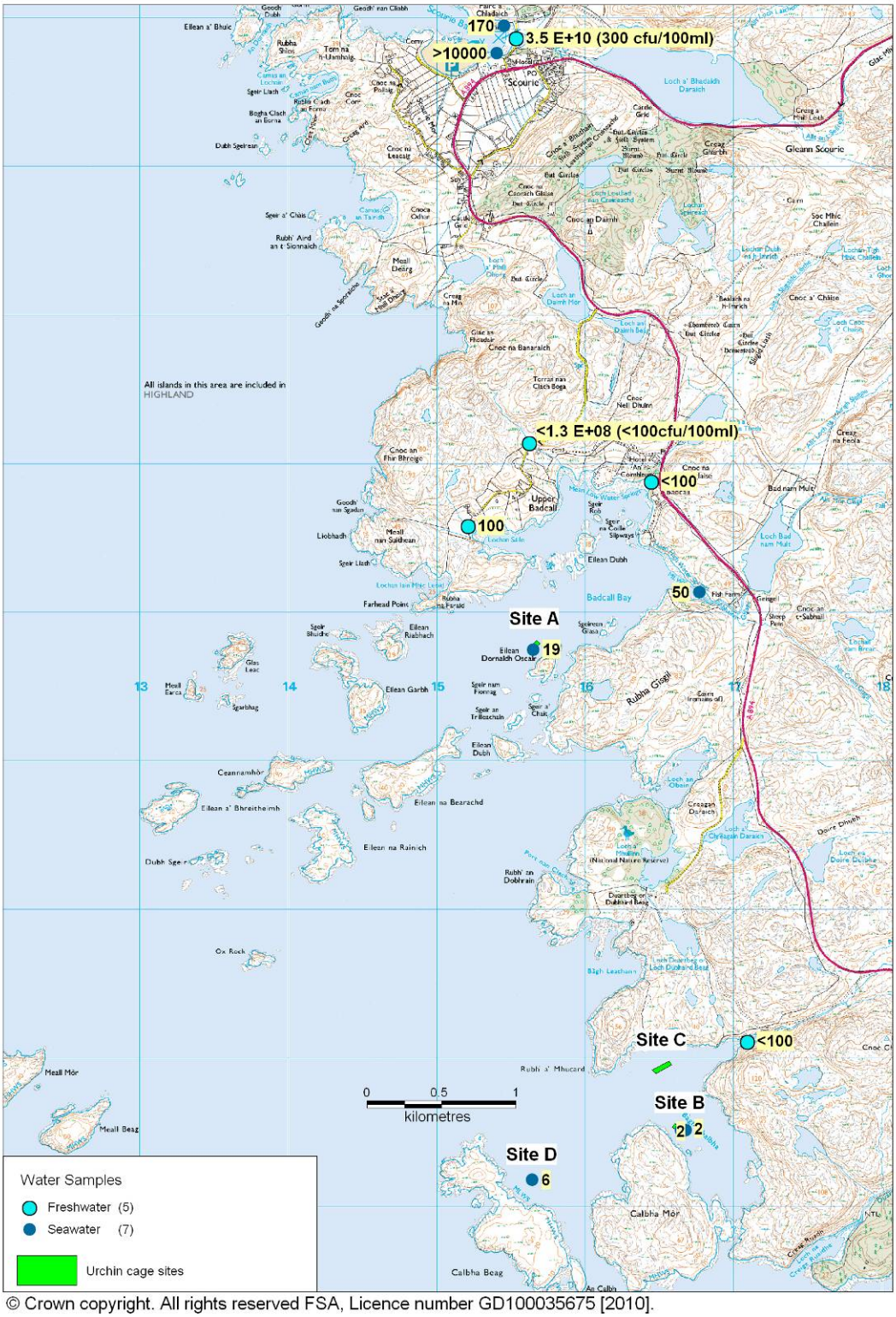

Figure 13.1 Water samples and stream loadings

14. Bathymetry and Hydrodynamics

Currents in coastal waters and estuaries are driven by a combination of tide, wind and freshwater inputs. This section aims to make a simple assessment of water movements around the area. Figure 14.1 shows the OS map of the eastern side of Eddrachillis Bay (which includes Badcall Bay) and Figure 14.2 shows the bathymetry of the same area.

Badcall Bay faces approximately southwest. At the southwestern end it joins Eddrachillis Bay. Badcall Bay is approximately 1.5 km long and 1 km wide. There are a number of islands around the edges of the bay and also outside it. The bay shelves fairly steeply and the depth exceeds 30 m in the outer part. There are intertidal areas all around the bay and also around the islands – at some states of the tide several of the islands are joined to the mainland. Chalbha Bay is approximately 1.5 km long and 0.5 km wide. It lies on the eastern side of Eddrachillis Bay, south of Badcall Bay. There are some intertidal areas around the bay.

Site A is located on the southern side of Badcall Bay in approximately 10 to 20 m of water. Sites B and C and the seaweed farm are located in Chalbha Bay, again in approximately 10-20 metres depth. Site D lies between Calbha Beag and Calbha Mór in approximately 30 m depth.

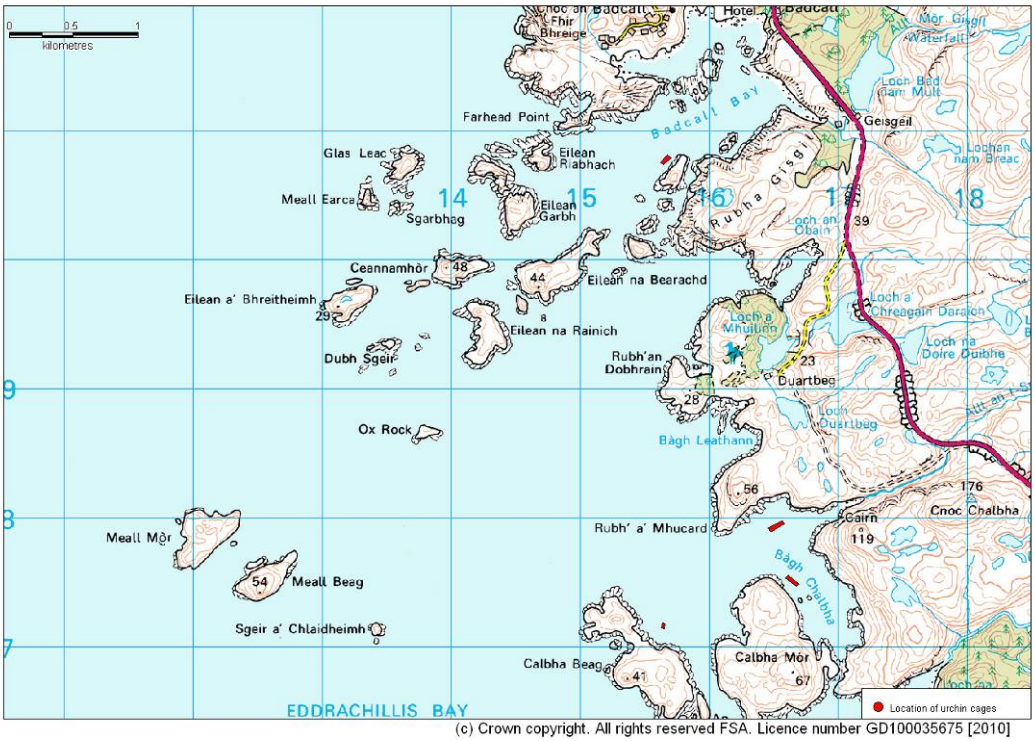

Figure 14.1 OS map of Eddrachillis Bay/Badcall Bay

Figure 14.2 Bathymetry of Eddrachillis Bay/ Badcall Bay

14.1 Tidal Curve and Description

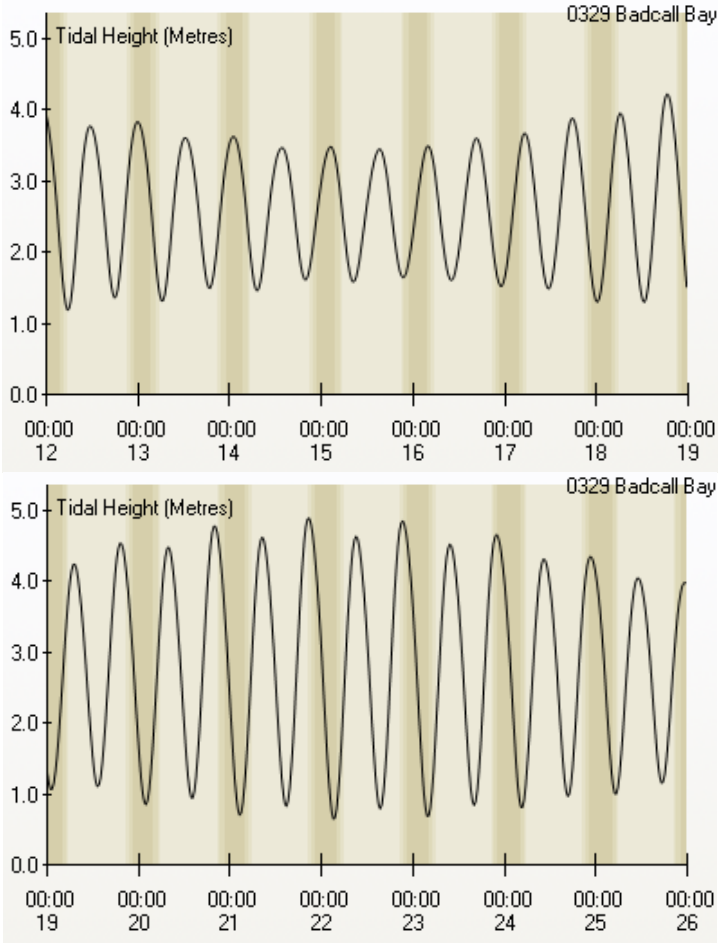

Figure 14.3 Tidal curves at Badcall Bay

The two tidal curves illustrated in Figure 14.3 are for Badcall Bay on the eastern side of Eddrachillis Bay. The tidal curves have been output from UKHO TotalTide. The first is for seven days beginning 00.00 BST on 12/08/09 and the second is for seven days beginning 00.00 BST on 19/08/09. This two-week period covers the date of the shoreline survey. Together they show the predicted tidal heights over high/low water for a full neap/spring tidal cycle.

The following is the summary description for Badcall Bay from TotalTide:

0329 Badcall Bay is a Secondary Non-Harmonic port.
The tide type is Semi-Diurnal.

HAT	5.1 m
MHWS	4.5 m
MHWN	3.4 m
MLWN	1.6 m
MLWS	0.9 m
LAT	0.5 m

14.2 Currents

Tidal stream information was available for one station in the extreme inner part of Eddrachillis Bay. 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 inner Eddrachillis Bay

Figure 14.5 Spring ebb tide in inner Eddrachillis Bay

Table 14.1 Tidal streams for station SN033B 58°15.37'N 5°01.47'W (taken from TotalTide)

Time	Direction	Spring rate m/s	Neap Rate m/s
-06h	241°	0.26	0.10
-05h	053°	0.46	0.21
-04h	055°	1.00	0.41
-03h	055°	1.30	0.51
-02h	056°	1.30	0.51
-01h	058°	0.93	0.36
HW	061°	0.46	0.21
+01h	231°	0.21	0.10
+02h	235°	0.77	0.31
+03h	237°	1.10	0.41
+04h	237°	1.20	0.51
+05h	239°	1.00	0.41
+06h	239°	0.41	0.15

The direction of the tidal stream at the depicted station is markedly constrained by the location within a narrow channel and this will also have the tendency to increase the speed. This means that the information is not very relevant to the situation at the location of the present and planned urchin nets.

SEPA provided summary information on currents that had been obtained in connection with fish farm assessments. These related to six sites. The locations of the sites are shown in Figure 14.6 and the summary information is presented in Table 14.2.

Figure 14.6 Fish farm current assessment sites

Given that the urchin nets are suspended under salmon cages, it is not surprising that the current data relates to locations where the urchin nets have been, or are going to be, established. The data is therefore directly relevant to the present sanitary survey. As expected, the measured currents are markedly lower than the tidal stream information presented above. The three sites in the vicinity of Badcall Bay were all regarded as moderately flushed at the surface while those in the vicinity of Calbha Bay were all regarded as highly quiescent at the surface. Apart from Eilean Riabhach, which was noted as weakly flushed, all sites were regarded as highly quiescent at the bottom. For the N. Eilean na Bearachd site, the residual current was given as approximately NNW. For the others, the direction of the residual current varied between SSE and SW. The residual currents in the vicinity of Badcall Bay were markedly higher than in the vicinity of Calbha Bay.

Table 14.2. Summary current data for fish farm assessments undertaken in Eddrachillis Bay

						Residual					
		Speed (m/s)		Flushing/ quiescence		Surface		Bottom		Vector averaged	
Site Name	NGR	Surface	Bottom	Surface	Bottom	Speed (m/s)	Direction (degrees)	Speed (m/s)	Direction (degrees)	Speed (m/s)	Direction (degrees)
N. Eilean na Bearachd	NC1540 4060	0.08	0.026	Moderately flushed	Highly quiescent	0.03	13	0.019	41	0.024	23
N. Rubha Ghisgil	NC1570 4080	0.082	0.021	Moderately flushed	Highly quiescent	0.026	249	0.012	214	0.018	238
Eilean Riabhach	NC1483 4061	0.062	0.031	Moderately flushed	Weakly flushed	0.047	250	0.026	212	0.035	236
Calbha Beag	NC1570 3710	0.02	0.007	Highly quiescent	Highly quiescent	0.009	202	0.003	206	0.006	203
East Rubha Mhucard	NC1650 3790	0.005	0.012	Highly quiescent	Highly quiescent	0.002	154	0.009	241	0.005	228
North Calbha Bay	NC1660 3750	0.011	0.022	Highly quiescent	Highly quiescent	0.006	115	0.01	178	0.007	155

14.3 Conclusions

Information from the fish farm assessments indicates that the currents in the vicinity of the urchin nets will be relatively low, although greater at Badcall Bay than the other sites. Given the depth in the area, it is expected that any potential sources located away from the vicinity of the nets will be subject to significant dilution. Therefore, any impacting contamination is most likely to originate within the two bays and to be taken past the cages on the ebbing tide. Given the nature of the Eddrachillis Bay area, it is not anticipated that there will be any density-driven currents. For the site located between Calbha Beag and Calbha Mór (site D) any impacting contamination is likely to come from locations on the former island, given the depth and the low currents in the area. The topography means that westerly winds will have the greatest effect on currents within the two bays, increasing the flood rates and holding back the ebb.

15. Shoreline Survey Overview

The shoreline survey was conducted on the 12th-13th August 2009. Some rain fell on the 11th and 12th August. Water and shellfish samples taken on the 12th August did not reach the laboratory within the prescribed time and temperature limits, so another set of samples were taken from the same locations on a second visit on the 29th September 2009.

The urchin fishery at Badcall Bay operates alongside salmon aquaculture in marine cages. Small urchin stock is bought in then placed in racks suspended below the walkways between cages stocked with salmon, where they graze on falling detritus. Their diet is supplemented with seaweed grown on ropes suspended from floats at a site within Eddrachillis Bay. The urchin production cycle aligns with the salmon production cycle, with the sites stocked with and then harvested of both species at the same time. Harvesting occurs in the autumn when their roes are largest. At the time of shoreline survey, two cage sites were stocked with urchins (A & B). Site A has since been harvested. The other two (C & D) will be stocked with urchins when salmon are placed on those sites.

Discharges were recorded at Scourie, which is about 7 km from the nearest cage site by sea. It is likely that there is an increase in human population in the general area in summer, as there is a caravan site at Scourie, and there is hotel and B&B accommodation both in Scourie and at Badcall Bay. A number of salmon farm service boats and other smaller craft were observed in the area.

The majority of the surrounding land is rough scrub and grass with rocky outcrops, and is steeply sloped in most places. A flock of 37 sheep was recorded on pastures by the north shore of Badcall Bay, with 11 rams seen about 1 km further north. Livestock was also observed in another two clusters, one at Scourie, and one over 2 km inland from Eddrachillis Bay. Seals were observed in the area, and large numbers of gulls were recorded near sites A and C.

None was particularly large or carrying high levels of *E. coli* at the time (<100 to 300 cfu/100ml). Seawater samples taken at Scourie had highest levels of *E. coli* (170 and >10000 cfu/100ml). A seawater sample taken at site A contained 19 *E. coli* cfu/100 ml, and the salinity was 26.3 ppt. Two water samples taken at site B both contained 2 *E. coli* cfu/100ml, and salinities were 34.3 and 31.4 ppt. One taken at site D contained *E. coli* 6 cfu/100ml and had a salinity of 32.9 ppt. A final seawater sample was taken on the eastern shore of Badcall Bay, adjacent to where a stream discharges. This contained 50 *E. coli* cfu/100ml and had a salinity of 17.9 ppt. Shellfish samples were taken from the two sites where stock were present. A sample from site A contained 80 *E. coli* MPN/100g, and a sample from site B contained <20 *E. coli* MPN/100g. Therefore, at the time of survey, freshwater influence and levels of contamination in seawater and shellfish were slightly higher at Badcall Bay where site A is located compared to the other sites further south.

Figure 15.1 Summary of shoreline observations

16. Sea urchins in the sanitary context

Sea urchins are grazers, feeding mainly on a variety of marine plants. Their mouth is located in the middle of their ventral surface, and is made up of bony plates that rasp their food from the substrate. They are omnivores, but their preferred diet is macroalgae. Given their feeding mechanism, their uptake of bacterial contamination is likely to differ from bivalve molluscs, which filter suspended particles from seawater.

A study undertaken in Greece showed that the bacterial indicator content of sea urchins tended to reflect that of the surrounding seawater (Portocali, et al., 1997).

17. Overall Assessment

Human sewage impacts

The most significant potential sewage impacts to the area are all more likely to affect cage site A in Badcall Bay. These are the discharges from the the salmon shore base and the hotel, and any potential discharges from boats using the anchorage in the bay. At the other cage sites, sewage impacts are likely to be from boat traffic rather than land based sewage infrastructure. Yachts and salmon farm service barges may have on-board toilets and discharges from boats can occur in close proximity to any of the cage sites.

There is a small area of development (including buildings, drives and car parks) associated with the hotel and fish farm base on the northeast side of Badcall Bay that could contribute significant amounts a land runoff after heavy rainfall. This would impact Site A.

Agricultural impacts

There are significant patches of improved grassland around the north west shore of Badcall Bay and also on the shore between Site A and the southern sites, east of Rubh'an Dobharain. intermediate contributions could be expected from the improved grassland. The risk from the improved grassland would be expected to be mitigated somewhat by the underlying soil which was identified as predominantly freely draining in this area. The impact from these two areas is most likely to affect Site A.

As livestock are likely to be grazed widely throughout the area, their faeces may be present in land runoff from a much wider area than that represented by observations made during the shoreline survey. Diffuse pollution to stream runoff by livestock faeces is likely to affect background levels of contamination found within the areas of the bay nearest shore and the discharge points of watercourses. Based on this observation, the relative impact of faecal contamination from livestock sources is likely to be highest at Site A, and may potentially also impact Site C depending on where livestock are allowed to graze within the area.

Based on the numbers and distribution of animals seen during the shoreline survey and overall farm census data for the parish, there relatively few animals located in the vicinity of the fishery and so the impact to bacteriological water quality in the area is likely to be low.

Wildlife impacts

The main wildlife species potentially impacting on the sites are deer, seals and seabirds. There are significant numbers of deer in the region. Contamination from these will be carried into the production area by streams draining the surrounding hills and this will occur all year round.

Seals are likely to be a minor year round presence, and may defecate in close proximity to any of the cages sites, particularly as it is likely that they are attracted to cage sites containing stocks of salmon. Therefore, the potential exists for contamination of the seawater in the vicinity of the urchin cages by seals.

Impacts from breeding seabirds via direct deposition and land runoff may be higher at sites A and D as they nest closer to these two sites.

Seasonal variation

It is likely that there is an increase in human population in the general area in summer, as there is a caravan site at Scourie, and there is hotel and B&B accommodation in the area. A seasonal increase in visitors to the hotel at Badcall Bay is likely to have some effect on water quality within the bay, and may affect urchin sites A. It is quite likely that pleasure boat and yacht traffic increases during the summer, so this may result in an increase in overboard waste water discharges.

Livestock numbers will be higher in the summer, and they are likely to access watercourses to drink more frequently during warmer weather. Therefore, inputs from these may be higher during the summer, particularly following high rainfall events.

Seabird numbers are likely to be higher during the late spring and summer breeding season. Some gulls are likely to be present year round, while other seabird species will disperse outside of the breeding season.

There were insufficient *E. coli* classification monitoring results to investigate seasonal differences in levels of contamination within the shellfish.

Although there may be seasonality in levels of contamination, which suggests monthly monitoring should be applied, harvest is likely to be strongly targeted towards the autumn months.

Rivers and streams

The streams discharging to Badcall Bay are likely to impact on site A, though unlikely to impact the other sites. Results from a seawater sample taken near the Abhainn Ghisgil suggested that it may carry higher levels of contamination than the other sampled streams around Badcall Bay.

Discharges from the Allt an t-Strathain will impact at sites C and B, and possibly to a lesser extent at site D.

Stream loadings are expected to increase significantly following heavy rainfall events, particularly for those streams that have livestock within their catchment areas.

Meteorology, hydrography, and movement of contaminants

Circulation around the area will be driven by tide, winds, and possibly freshwater inputs at times. Information from the fish farm assessments indicates that the currents in the vicinity of the urchin cages will be relatively low, although greater at site A than the other sites. Therefore, any contamination in particulate form, the form that will be accumulated most effectively, will tend to settle out of the water column in close proximity to its source. As currents at site A were greater, it is likely to be impacted by contamination arising from a wider area than for the other sites.

Any impacting contamination is most likely to originate within the two bays and be taken past the cages on the ebbing tide.

The topography means that westerly winds will have the greatest effect on currents within the two bays, increasing the flood rates at the surface, and holding back the ebb.

Temporal and geographical patterns of sampling results

Historical *E. coli* monitoring results were available for 6 samples taken during 2009, all from site A. Due to discrepancies in the reported sampling locations, it was not possible to conduct a meaningful analysis of geographic patterns in sampling results. There was insufficient monitoring historey to permit analysis of temporal variation in results.

Shoreline survey sampling results were the only available information on spatial patterns of levels of contamination across the four cage sites. An urchin and a seawater sample taken at site A contained higher levels of *E. coli* (80MPN/100g and 19 cfu/100ml) than urchin and seawater samples taken at site B (<20 MPN/100g and 2 samples at 2 cfu/100ml). A seawater sample taken at site D contained 6 *E. coli* cfu/100ml. This tentatively suggests that levels of contamination may be higher at site A, although further sampling would be necessary to confirm this.

Overall conclusions

The sites fall into two distinct areas, with site A on its own in Badcall Bay, and the other three sites and the seaweed farm located in a cluster about 3 km south. There are more breeding seabirds, freshwater inputs, and possibly more visiting yachts within Badcall Bay. On the other hand, there are significant numbers of breeding seabirds by the latter cluster of sites. Samples taken on the shoreline survey tentatively support the supposition that there may be higher levels of contamination at site A, although this is based on very low numbers of samples.

Within the southern cluster, there is little to suggest that the sites would be subjected to noticeably differing levels of contamination. The only static source of contamination here is a small stream discharging by site C, which

may also impact on site B and the seaweed farm. Site D is located within a less enclosed area than the other sites.

Site A should be classified separately from the other sites as there appears to be a higher potential for contamination. The other sites should be classified together in one area.

There is no evidence to suggest that there are consistent differences in levels of contamination in urchins within site A, however the most significant sources of contamination to the site are located within Badcall Bay therefore monitoring should be undertaken on the northeastern end of the site.

18. Recommendations

Badcall Bay

Production Area

Recommended production area boundaries are lines drawn between NC 1580 4080 and NC 1543 4112 and between NC 1543 4112 and NC 1510 4099 and between NC 1510 4099 and NC 1562 4060 extending to MHWS along the western shore of the island Eilean Dornaidh Oscair. This excludes the inner part of Badcall Bay, where there are septic discharges.

RMP

There is no evidence to suggest that there are consistent differences in levels of contamination in urchins within site A, however the most significant sources of contamination to the site are located within Badcall Bay therefore monitoring should be undertaken on the northeastern end of the site at NC 1568 4080.

Tolerance

The recommended sampling tolerance is 10 m as it is an aquaculture site and it should be possible to access stock of sufficient size within this tolerance. Should a problem arise with regard to sampling within this tolerance, placement of a dedicated sampling basket at the RMP should be considered. The standard advice for shellfish is to ensure that stock are in situ for a minimum of two weeks prior to sampling in order to ensure that they take on the microbiological characteristics of the surrounding water. While sea urchins are not bivalves and are likely to take less time to equilabrate with surrounding water, little is known about how long they should be left in this context. Therefore, as a precaution it is recommended that the full two week placement be followed.

Depth

All stock is held at a similar depth (1-2 m) so this should be the sampling depth.

Frequency

There is likely to be an element of seasonality to some sources of contamination, although it is uncertain whether this will result in a seasonal effect on the levels of contamination found in the urchins. Until this is established, this production area should be sampled on a monthly basis.

Eddrachillis Bay

Production Area

Recommended production area boundaries are lines drawn between NC 1528 3741 and NC 1606 3790 and between NC 1666 3808 and NC 1680 3776 and between NC 1705 3685 and NC 1702 3686 and between NC 1568 3701 and NC 1618 3730 extending to MHWS.

RMP

It is recommended that the RMP be located at NC 1657 3796 as this is the site (Site C) closest to the nearest where the Allt an t-Strathain discharges into the bay.

Tolerance

The recommended sampling tolerance is 10 m as it is an aquaculture site and As this site is not currently stocked, placement of a dedicated sampling basket at the RMP should be considered. The standard advice for shellfish is to ensure that stock are in situ for a minimum of two weeks prior to sampling in order to ensure that they take on the microbiological characteristics of the surrounding water. While sea urchins are not bivalves and are likely to take less time to equilabrate with surrounding water, little is known about how long they should be left in this context. Therefore, as a precaution it is recommended that the full two week placement be followed.

Depth

All stock is held at a similar depth (1-2 m) so this should be the sampling depth.

Frequency

There is likely to be an element of seasonality to some sources of contamination, although it is uncertain whether this will result in a seasonal effect on the levels of contamination found in the urchins. Until this is established, the production area should be sampled on a monthly basis.

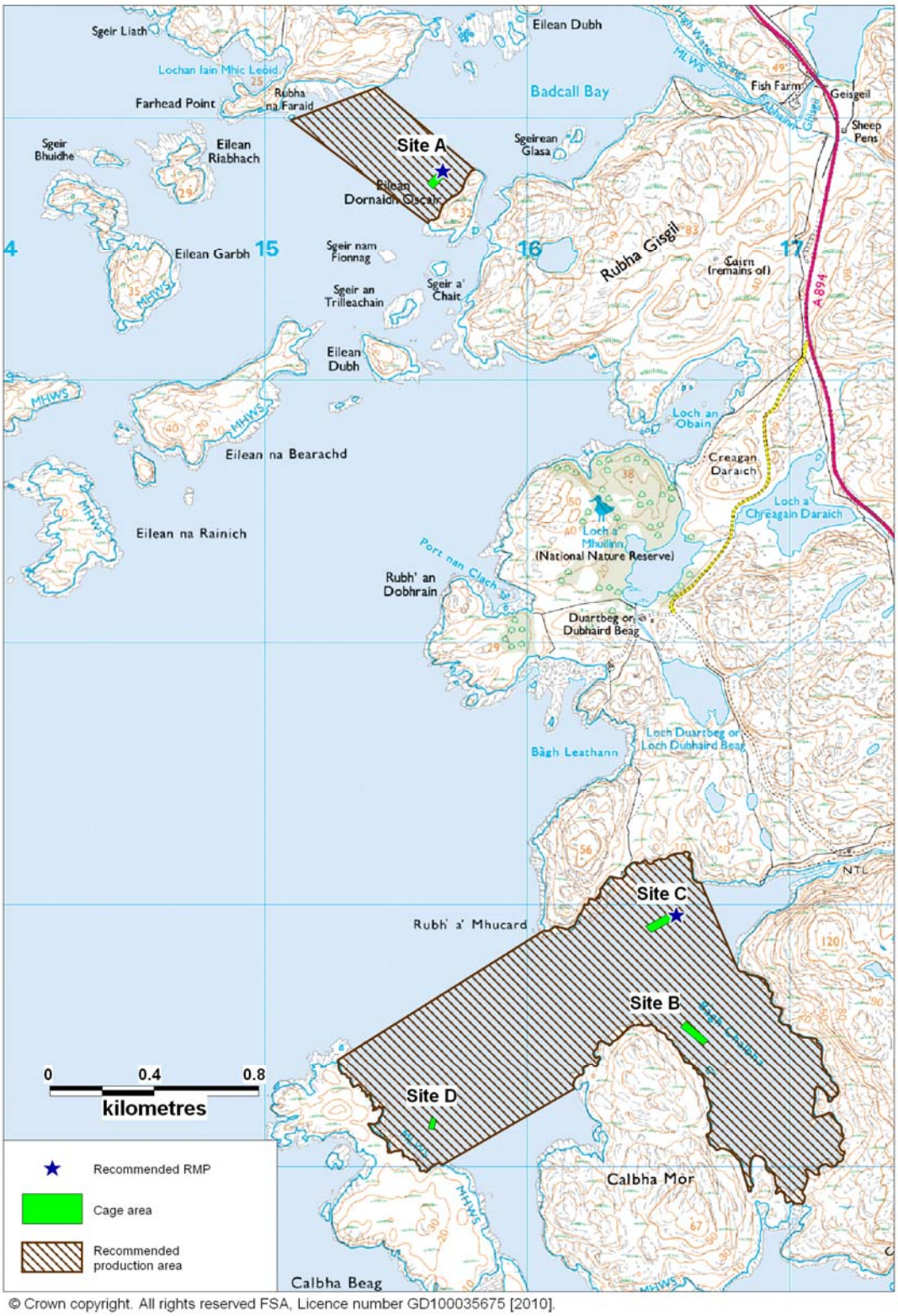

Figure 18.1 Recommendations for Badcall Bay

19. References

Brown J. (1991). The final voyage of the Rapaiti. A measure of surface drift velocity in relation to the surface wind. Marine Pollution Bulletin 22, 37-40.

Kay, D., Crowther, J., Stapleton, C.M., Wyler, 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, 442-454.

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.

Portocali, Ph., Iliopoulou-Georgudaki, J., Catsiki, V.A. and Papapetropoulou, M. (1997). The role of echinoderms as bioindicators of seawater pollution: a case study from Patraicos and Corinthiacos gulf, N. Peloponnesus, Greece. Toxicological and Environmental Chemistry 59, 293-303.

Sea Mammal Research Unit (2007). The status of British common seal populations. Special Committee on Seals Briefing paper 07/3.

20. List of Tables and Figures

List of Tables

List of Figures

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**

Sampling Plan for Badcall Bay & Eddrachillis Bay

PRODUC-TION AREA	SITE NAME	SIN	SPECIES	TYPE OF FISHERY	NGR OF RMP	EAST	NORTH	TOLER-ANCE (M)	DEPTH (M)	METHOD OF SAMPLING	FREQ OF SAMPLING	LOCAL AUTHORITY	AUTHORISED SAMPLER(S)	LOCAL AUTHORITY LIAISON OFFICER
Badcall Bay	Badcall Bay Urchins	HS 494 911 22	Sea urchins (*P. lividus*)	Suspended cages	NC 1565 4075	215650	940750	10	1-2	Hand	Monthly	Highland Council (Sutherland)	Anne Grant	Anne Grant
Eddrachillis Bay	Sites B, C and D	HS xxx xxx 22	Sea urchins (*P. lividus*)	Suspended cages	NC 1662 3573	216620	937530	10	1-2	Hand	Monthly	Highland Council (Sutherland)	Anne Grant	Anne Grant

Table of Proposed Boundaries and RMPs - Badcall and Eddrachillis Bays

Production Area	Species	SIN	Existing Boundary	Existing RMP	New Boundary	New RMP	Comments
Badcall Bay	Sea urchins (*P. lividus*)	HS 494 911 22	Area bounded by lines drawn between NC 1520 4110 and NC 1580 4030	NC 1565 4075	Area bounded by lines drawn between NC 1580 4080 and NC 1543 4112 and between NC 1543 4112 and NC 1510 4099 and between NC 1510 4099 and NC 1562 4060 extending to MHWS	NC 1565 4080	Area reduced, RMP remains the same
Eddrachillis Bay	Sea urchins (*P. lividus*)	HS xxx xxx 22	None	None	Area bounded by lines drawn between NC 1528 3741 and NC 1606 3790 and between NC 1666 3808 and NC 1680 3776 and between NC 1705 3685 and NC 1702 3686 and between NC 1568 3701 and NC 1618 3730 extending to MHWS.	NC 1657 3796	New area, RMP recommended Site C.

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.

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.

Poppe, C., Smart, N., Khakhria, R., Johnson, W., Spika, J., and Prescott, J. (1998). Salmonella typhimurium DT104: A virulent drug-resistant pathogen. Canadian Veterinary Journal, 39:559-565.

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

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

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.

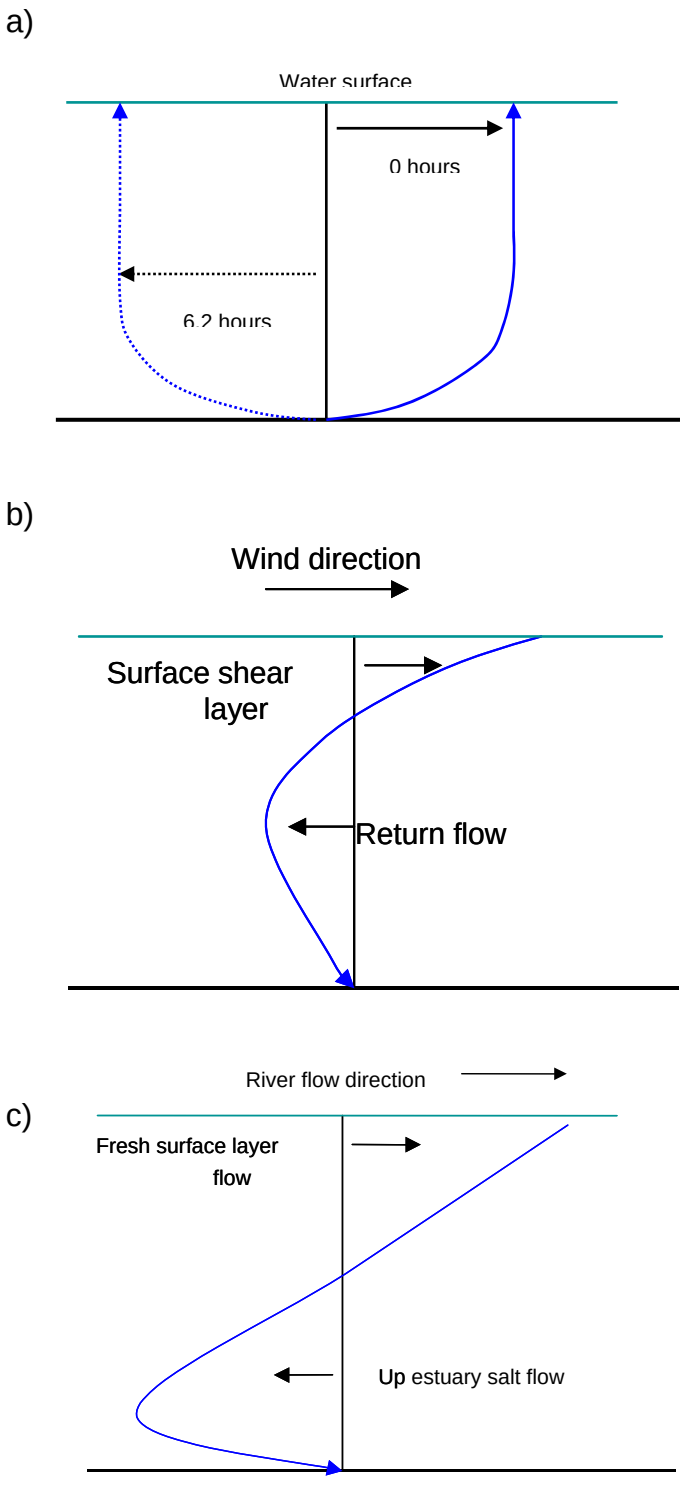

Figure 1. Typical vertical profiles for water currents. The black vertical line indicates zero velocity so portions of the profile to the left and right indicate flow moving in opposite directions. a) Peak tidal flow profiles. Profiles are shown 6.2 hours apart as the main tidal current reverses direction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

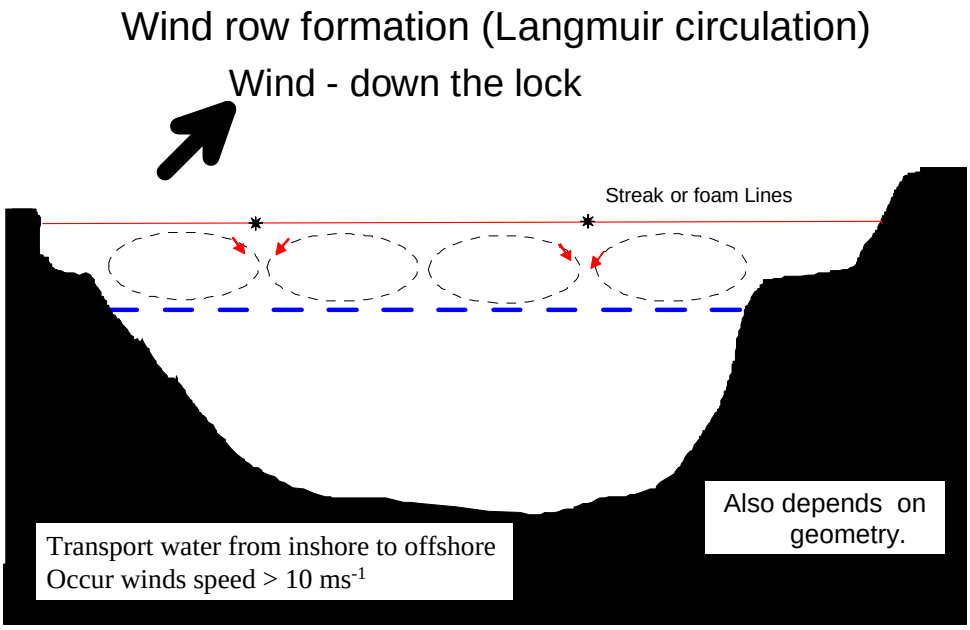

Figure 2. Schematic of wind driven 'wind row' currents. The dotted blue line indicates the depth of the surface fresh(er) water layer usually found in sea lochs.

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

Badcall Bay/Edrachilles Bay
HS 494

Scottish Sanitary Survey Project

Shoreline Survey Report

Prod. area:	Badcall Bay
Site name:	Badcall Bay Urchins (HS 494 911 22)
Species:	Sea urchins
Harvester:	Loch Duart, Ltd., Debasis Biswas
Local Authority:	Highland Council - Sutherland
Status:	New area
Date Surveyed:	12-13 August 2009
Surveyed by:	M. Price-Hayward, A. Grant
Existing RMP:	Not yet assigned
Area Surveyed:	Scourie, Badcall Bay and Edrachilles Bay

Weather observations

12 August - Overcast with scattered showers. Rain overnight and previous day. Wind SW Force 3-4. Air temperature 14C.
13 August - Partly cloudy, winds calm to Force 1. Air temperature 11C.

Fishery

The urchin fishery at Badcall Bay was established to operate in co-production with salmon aquaculture in marine cages. Small urchin stock is purchased from a supplier in Ireland, then placed in racks and suspended below the walkways between sea cages stocked with salmon. Currently, three sites are being considered, with two already stocked. The third will be stocked when salmon are placed on the site. The intent is to harvest in rotation at the same time as the salmon, with the first set of cages due to be harvested in autumn 2009. Harvest would generally take place in autumn when the urchin roes are at their largest size relative to the rest of the animal.

Sewage/Faecal Sources

The nearest village is Scourie, which lies 4 km north of the site in Badcall Bay. There are septic tanks and other discharges here, though these are not large. There is a hotel on Badcall Bay. Due to heavy scrub and rough terrain it was not possible to directly observe the shoreline below the hotel. However, the bay was observed by boat and no obvious discharge pipes were found.

The shore base for the salmon fishery has toilets and waste is discharged ?.

Other sources of faecal contamination are livestock. Sheep and some cattle are grazed extensively in the area. A number of streams are present in the area and those that were accessible were sampled.

Seasonal Population

There is likely to be a significant increase in human population during the summer months. A large caravan site was observed at Scourie and there is hotel and B&B accomodation in the area.

Boats/Shipping
No ships were observed. A number of boats serve the salmon farm and some smaller boats were observed in the area.

Land Use
Land in the area is predominantly used for rough grazing. Much of the area belongs to the Scourie Estate. The terrain is rough scrub, grass, and rocky outcrops and is steeply sloped in most places.

Wildlife/Birds
Seals were observed in the area and are likely to be drawn to the salmon cages. Seabirds, mostly gulls and shags, were observed roosting in large numbers on rocky islands in the bay.

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.

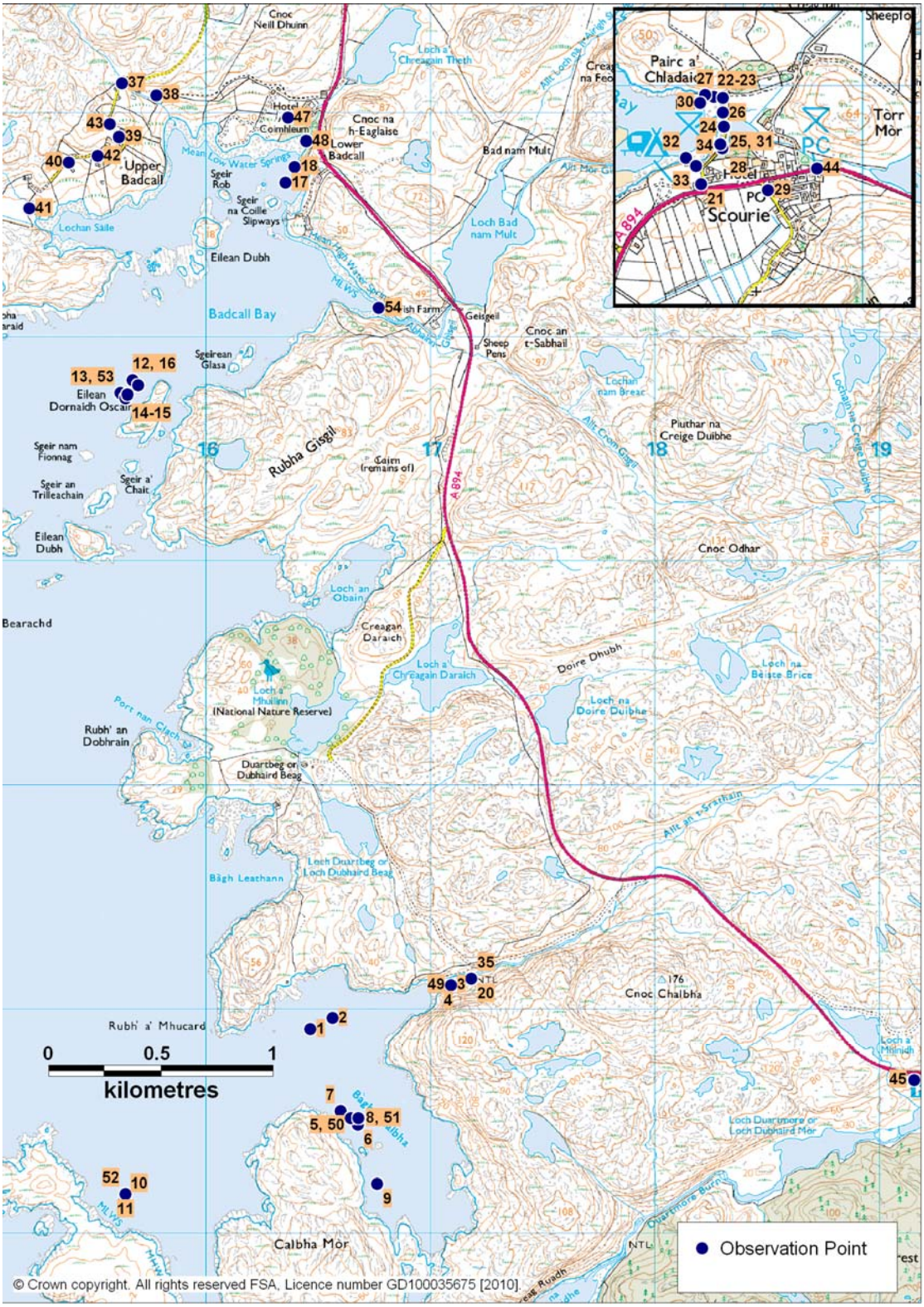

Figure 1. Map of Shoreline Observations

Table 1. Shoreline Observations

Obs No.	Waypt	Date	Time	Grid Ref	East	North	Associated Photograph	Observation
1	170	12-Aug-09	10:18:59	NC 16465 37913	216465	937913		End of urchin cages
2	171	12-Aug-09	10:20:55	NC 16565 37963	216565	937963	Figure 4	Other end of urchin cages, service barge, 74 gulls
3	172	12-Aug-09	10:42:14	NC 17094 38111	217094	938111		Water sample 1
4	173	12-Aug-09	10:42:59	NC 17081 38108	217081	938108		Stream entering bay, salinity 5 ppt at surface, 33 ppt at 2 m
5	174	12-Aug-09	10:54:30	NC 16646 37513	216646	937513		Water sample 2
6	175	12-Aug-09	10:55:41	NC 16677 37484	216677	937484		End of urchin cages
7	176	12-Aug-09	10:57:10	NC 16600 37545	216600	937545		End of urchin cages
8	177	12-Aug-09	10:59:57	NC 16680 37513	216680	937513		Water sample 3, urchin sample 2
9	178	12-Aug-09	11:03:31	NC 16763 37223	216763	937223	Figure 5	Seaweed farm
10	179	12-Aug-09	11:14:27	NC 15637 37153	215637	937153		Empty salmon farm, stock and urchins to go in in October
11	180	12-Aug-09	11:16:37	NC 15642 37177	215642	937177		Salinity 30 ppt, 0-5 m, Water sample 4
12	181	12-Aug-09	11:35:18	NC 15672 40811	215672	940811		Corner of cage area
13	182	12-Aug-09	11:36:46	NC 15619 40753	215619	940753		Corner of cage area
14	183	12-Aug-09	11:37:14	NC 15642 40732	215642	940732		Corner of cage area
15	184	12-Aug-09	11:37:42	NC 15650 40747	215650	940747	Figure 6	Water sample 5, urchin sample 1
16	185	12-Aug-09	11:42:28	NC 15697 40788	215697	940788		Corner of cage area, salinity 34.7 0-5 m, 150 gulls on island
17	186	12-Aug-09	11:53:42	NC 16355 41695	216355	941695		5 fishing boats and 3 open skiffs
18	187	12-Aug-09	11:54:57	NC 16396 41766	216396	941766		Salinity 10 ppt at surface, small stream at shore
19	188	12-Aug-09	11:56:58	NC 16448 41880	216448	941880	Figure 7	Stream. Water sample 5, remarked as 11.
20	189	12-Aug-09	12:59:14	NC 17183 38139	217183	938139		Nothing recorded for this waypoint
21	190	12-Aug-09	14:27:19	NC 15458 44671	215458	944671	Figure 8	Café and campground, at least 3 static pitches, 6 mobile caravans and 6 tents, toilets
22	191	12-Aug-09	14:48:23	NC 15512 44965	215512	944965	Figure 9	Pipe in seawall, concrete, dribbling, sewage fungus and smell
23	192	12-Aug-09	14:50:07	NC 15501 44965	215501	944965	Figure 10	Iron pipe in seawall, no flow. Trickle of water through wall below pipe, with green algal growth
24	193	12-Aug-09	14:54:43	NC 15532 44912	215532	944912		Picnic area and dog waste bins
25	194	12-Aug-09	14:56:07	NC 15534 44864	215534	944864		Culvert, water from pond drains to bay through this. 28 ducks
26	195	12-Aug-09	15:02:56	NC 15532 44962	215532	944962		Large home or lodge

Obs No.	Waypt	Date	Time	Grid Ref	East	North	Associated Photograph	Observation
27	196	12-Aug-09	15:03:29	NC 15471 44972	215471	944972		Scourie Jetty, 2 small boats
28	197	12-Aug-09	15:10:15	NC 15529 44793	215529	944793	Figure 11	Scourie Village Septic Tank. SEPA sample point
29	198	12-Aug-09	15:16:08	NC 15684 44651	215684	944651		Scourie village, 63 sheep
30	199	13-Aug-09	06:41:22	NC 15454 44945	215454	944945		Water sample 6, Scourie jetty
31	200	13-Aug-09	06:48:53	NC 15537 44864	215537	944864		Water sample 7, pond discharge. Width 10.2 m. Depth 27 cm, flow 0.049m/s
32	201	13-Aug-09	07:14:25	NC 15406 44760	215406	944760	Figure 12	Discharge pipe across shore below campground. End of pipe underwater at low tide, Water sample 8
33	202	13-Aug-09	07:27:54	NC 15440 44733	215440	944733	Figure 13	Large corrugated plastic pipe with water flowing out and down rocks
34	203	13-Aug-09	07:40:00	NC 15523 44806	215523	944806		Cattle on hillside in distance NE of this point. 14 cattle
35	204	13-Aug-09	10:33:42	NC 17184 38140	217184	938140	Figure 14	Stream sampled yesterday, width 2.1 m, depth 11 cm, 0.2m/s. Photograph viewing west along north shore of Badcall Bay
36	205	13-Aug-09	11:25:03	NC 16009 42568	216009	942568		11 rams
37	206	13-Aug-09	11:33:02	NC 15625 42138	215625	942138	Figure 15	Stream, width 70 cm, depth 10 cm, flow 0.022m/s. Water sample 9. Photograph looking southeast toward Loch Duart shore base
38	207	13-Aug-09	11:42:55	NC 15778 42084	215778	942084		House, no visible pipes on shore looking sw of this point
39	208	13-Aug-09	11:49:33	NC 15612 41899	215612	941899		House, 6 sheep
40	209	13-Aug-09	11:52:01	NC 15388 41786	215388	941786		House, 30 sheep
41	210	13-Aug-09	12:03:04	NC 15213 41580	215213	941580		Stream, width 65 cm, depth 14 cm, flow too slow to detect. Water sample 10. Goose droppings
42	211	13-Aug-09	12:22:09	NC 15518 41814	215518	941814		3 houses
43	212	13-Aug-09	12:23:58	NC 15571 41955	215571	941955		2 houses, 1 sheep
44	213	13-Aug-09	17:12:13	NC 15849 44725	215849	944725		Public toilets, dog waste bin, picnic area
45	214	13-Aug-09	17:39:18	NC 19158 37684	219158	937684		Crofts, 3 cattle, 42 sheep
46	215	13-Aug-09	17:57:48	NC 16363 41984	216363	941984	Figure 16	View point of weirs and ponds, upper Duartmore Burn.
47	216	13-Aug-09	17:58:24	NC 16365 41984	216365	941984		Edrachilles hotel plus cottage, small home, and static caravan
48	na	29-Sep-09	na	NC 16448 41880	216448	941880		Water sample BB1A, stream at Badcall
49	na	29-Sep-09	na	NC 17094 38111	217094	938111		Water sample BB2A, Allt an t-Strathain
50	na	29-Sep-09	na	NC 16646 37513	216646	937513		Seawater sample BB3A
51	na	29-Sep-09	na	NC 16680 37513	216680	937513		Seawater sample BB4A

Obs No.	Waypt	Date	Time	Grid Ref	East	North	Associated Photograph	Observation
52	na	29-Sep-09	na	NC 15642 37177	215642	937177		Seawater sample BB5A
53	na	29-Sep-09	na	NC 15650 40747	215650	940747		Seawater sample BB6A
54	na	29-Sep-09	na	NC 16769 41132	216769	941132		Seawater sample BB7A, near Abhainn Ghisgil (not flowing at time of sampling)
-								

Photographs 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. The samples collected on the 12 August did not arrive at the laboratory until 14 August and were above the maximum permitted temperature of 8ºC. Therefore, these samples were voided and a second set were retaken on 29 September. This second set of samples were given numbers BB1A to BB7A.

Samples of seawater were tested for salinity by the Glasgow Scientific Services. 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	13/08/09	BB6	NC 15454 44945	Seawater	170	34.9
2	13/08/09	BB7	NC 15537 44864	Freshwater	300	
3	13/08/09	BB8	NC 15406 44760	Seawater	>10000	31.6
4	13/08/09	BB9	NC 15625 42138	Freshwater	<100	
5	13/08/09	BB10	NC 15213 41580	Freshwater	100	
6	29/09/09	BB1A	NC 16448 41880	Freshwater	<100	
7	29/09/09	BB2A	NC 17094 38111	Freshwater	<100	
8	29/09/09	BB3A	NC 16646 37513	Seawater	2	34.3
9	29/09/09	BB4A	NC 16680 37513	Seawater	2	31.4
10	29/09/09	BB5A	NC 15642 37177	Seawater	6	32.9
11	29/09/09	BB6A	NC 15650 40747	Seawater	19	26.3
12	29/09/09	BB7A	NC 16769 41132	Seawater	50	17.9

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (mpn/100g)
1	29/09/09	Urchin 1A	NC 15650 40747	Sea urchin	80
2	29/09/09	Urchin 1B	NC 16680 37513	Sea urchin	<20

Figure 2. Water sample results map

Figure 3. Shellfish sample results map

Photographs

Figure 4. Salmon farm with urchin cages suspended beneath walkways

Figure 5. Seaweed culture at Bàgh Chalbha

Figure 6. Sampling from urchin cages

Figure 7. Stream at Lower Badcall

Figure 8. Campground at Scourie

Figure 9. Concrete pipe in jetty wall, Scourie

Figure 10. Iron pipe in seawall, Scourie

Figure 11. Septic tank at Scourie village

Figure 12. Discharge pipe at shore below campground

Figure 13. Flow through corrugated pipe in hillside below campground

Figure 14. Looking west along Badcall Bay shoreline

Figure 15. Looking southeast across Badcall Bay to Loch Duart shore base

Figure 16. Looking down over Duartmore Burn