Scottish Sanitary Survey Review

Sanitary Survey Review

Islay: Loch Gruinart Craigens

AB 094

September 2012

Cefas

Food Standards Agency
food.gov.uk

Report Distribution
Islay: Loch Gruinart Craigens

Name	**Agency**
Linda Galbraith	Scottish Government
David Denoon	SEPA
Douglas Sinclair	SEPA
Fiona Garner	Scottish Water
Alex Adrian	Crown Estate
Andy MacLeod	Argyll & Bute Council
Fraser Anderson	Argyll & Bute Council
Mr G. A. Archibald	Harvester

Review Specification

Sanitary surveys are used to demonstrate compliance with the requirements stated in Annex II (Chapter II Paragraph 6) of Regulation (EC) 854/2004, whereby if the competent authority decides in principle to classify a production or relay area it must:

- make an inventory of pollution sources of human/animal origin likely to be a contamination source for the production areas;
- examine the quantities of organic pollutants which are released during the different periods of the year, according to the seasonal variations of both human and animal populations in the catchment area, rainfall readings, wastewater treatment, etc.;
- determine the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal regime in the production area;
- establish a sampling programme of bivalve molluscs in the production area which is based on the examination of established data, and with a number of samples, a geographical distribution of the sampling points and a sampling frequency which must ensure that the results of the analysis are as representative as possible for the area considered.

The EURL Good Practice Guide (GPG) for the monitoring of bivalve molluscs harvesting areas requires the re-evaluation of sanitary surveys every six years. Location, extent and nature of fisheries and faecal pollution sources may change over time and the review is conducted to determine whether the sampling plan and/or production area boundaries remain appropriate and protective of public health.

As specified by the Food Standards Agency, the review comprises of a brief desktop search of publicly available information together with a shoreline survey. The review will determine significant changes in:

• Historic microbiological data.
• Sewage treatment and sewerage infrastructure.
• Housing and development.
• Harvester operations.

The output of the review will be in the form of a report identifying any new information that has been identified or whether major elements of the original sanitary survey can be regarded as essentially unchanged. The report should include an overall assessment as to whether the production area/classification zone boundaries and/or RMPs should be modified from those recommended in the original report and, if so provide: A description of the revised boundaries and a revised sampling plan with the boundaries and RMP(s) locations stated.

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Introduction

In 2007 a Sanitary Survey Report for Loch Gruinart Craigens was conducted to identify the location, extent and nature of the shellfishery and the potential faecal pollution sources contaminating the fishery.

The output of the Sanitary Survey included a recommended sampling plan for the fishery. These are listed overleaf alongside the sampling plan recommended following findings from this review.

Sampling Plan and Recommended Production Area

	2007	2012 review	Changes
PRODUCTION AREA	Islay	Islay	
SITE NAME	Loch GruinartCraigens	Loch GruinartCraigens	
SIN	AB 094-011-13	AB 094-011-13	
SPECIES	Pacific oysters	Pacific oysters	
TYPE OF FISHERY	Aquaculture, trestles	Aquaculture, trestles	
NGR OF RMP	NR 3024 7116	NR 3027 7114	Changed to account for movement of oyster trestles
EAST	130240	130270	
NORTH	671160	671140	
TOLERANCE (M)	10	10	
DEPTH (M)	N/A	N/A	
METHOD OF SAMPLING	Hand	Hand	
FREQUENCY OF SAMPLING	Monthly	Monthly	
LOCAL AUTHORITY	Argyll & Bute	Argyll and Bute	
AUTHORISED SAMPLER(S)	Christine McLachlan William McQuarrie Ewan McDougall Donald Campbell	Fraser Anderson Karen Goodchild William McQuarrie Ewan McDougall Allison Hardie	Change in staff
LOCAL AUTHORITY LIAISON OFFICER	Christine McLachlan	Fraser Anderson	Change in staff
RECOMMENDED PRODUCTION AREA	NR 29550 69350 to NR 29000 69350 to NR 29000 70000 to NR 30000 71470 to 30500 71470 extending to MHWS	NR 29550 69350 to NR 29000 69350 to NR 29000 70000 to NR 30000 71470 to 30500 71470 extending to MHWS	

1. Area Description

Loch Gruinart Craigens is a sea loch situated on the northwest coast of the Island of Islay, off the south west coast of mainland Scotland.

The loch is north-facing, 6.2 km long, 2 km wide and has a maximum depth of 8 m. The total flushing time for Loch Gruinart is one day.

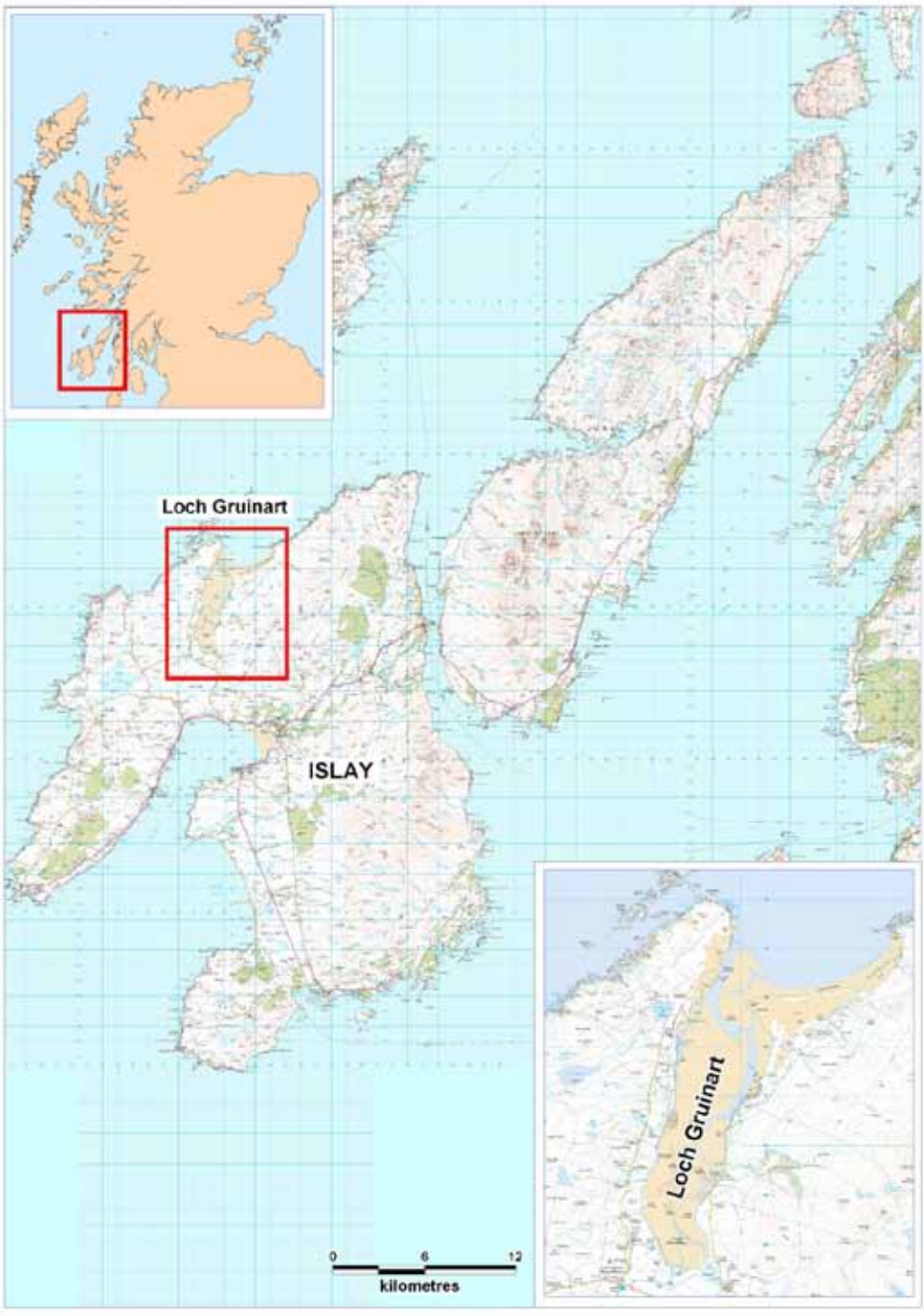

Figure 1.1 Location of Loch Gruinart Craigens, Island of Islay.

2. Fishery

The fishery at Loch Gruinart Craigens remains largely the same as it was in the 2007 Sanitary Survey Report, with one harvester (Mr Archibald) operating a Pacific oyster (*Crassostrea gigas*) farm. Details of the current classified production area according to FSA in Scotland are displayed in Table 2.1. Oysters are grown in triangular baskets, stacked in three rows of seven, which equates to 21 baskets per trestle. Trestles are easily transported from shore to shed, with baskets able to be individually removed for ease of collection.

The location of the oyster trestles at the time of the shoreline survey is shown in Figure 2.1, together with the production area boundary and the two RMPs that have been used by the FSAS. No reported Crown Estate Lease Area exists for Loch Gruinart, as the oysters are grown on foreshore adjacent to the harvester's own land. During discussions held with the harvester it was understood that he used two locations to grow oysters on trestles. The southern trestles were used for immature stock and trestles to the north were used for mature stock and were close to the processing shed.

Table 2.1 Current Pacific oyster fishery at Loch Gruinart Craigens (FSAS 2012-2013)

Site	SIN	Species	Local Authority	Production area boundaries	RMP
Loch Gruinart	AB 094 011 13	Pacific oyster	Argyll and Bute	NR 2955 6935 - NR 2900 6935 - NR 2899 7000 - NR 3000 7147 - NR 3050 7147	NR 3024 7114

During the 2007 shoreline survey the nominal RMP was recorded at NR 303 712. The reference RMP designated at the time by FSAS was designated at NR 3024 7116. Conclusions from the 2007 Sanitary Survey recommended the RMP should remain at NR 3024 7116 to facilitate sample collection.

During the most recent shoreline survey, the nominal RMP was recorded at NR 3024 7116. The current reference RMP designated by FSAS is located at NR 3024 7114, which plots 34.8 m southeast of the nominal RMP observed during the most recent shoreline survey. The RMP at NR 3024 7116 has been used by a sampling officer at FSAS over the past month, but sampling has since returned to the designated RMP at NR 3024 7114. This allows sampling to take place regardless of the tidal cycle.

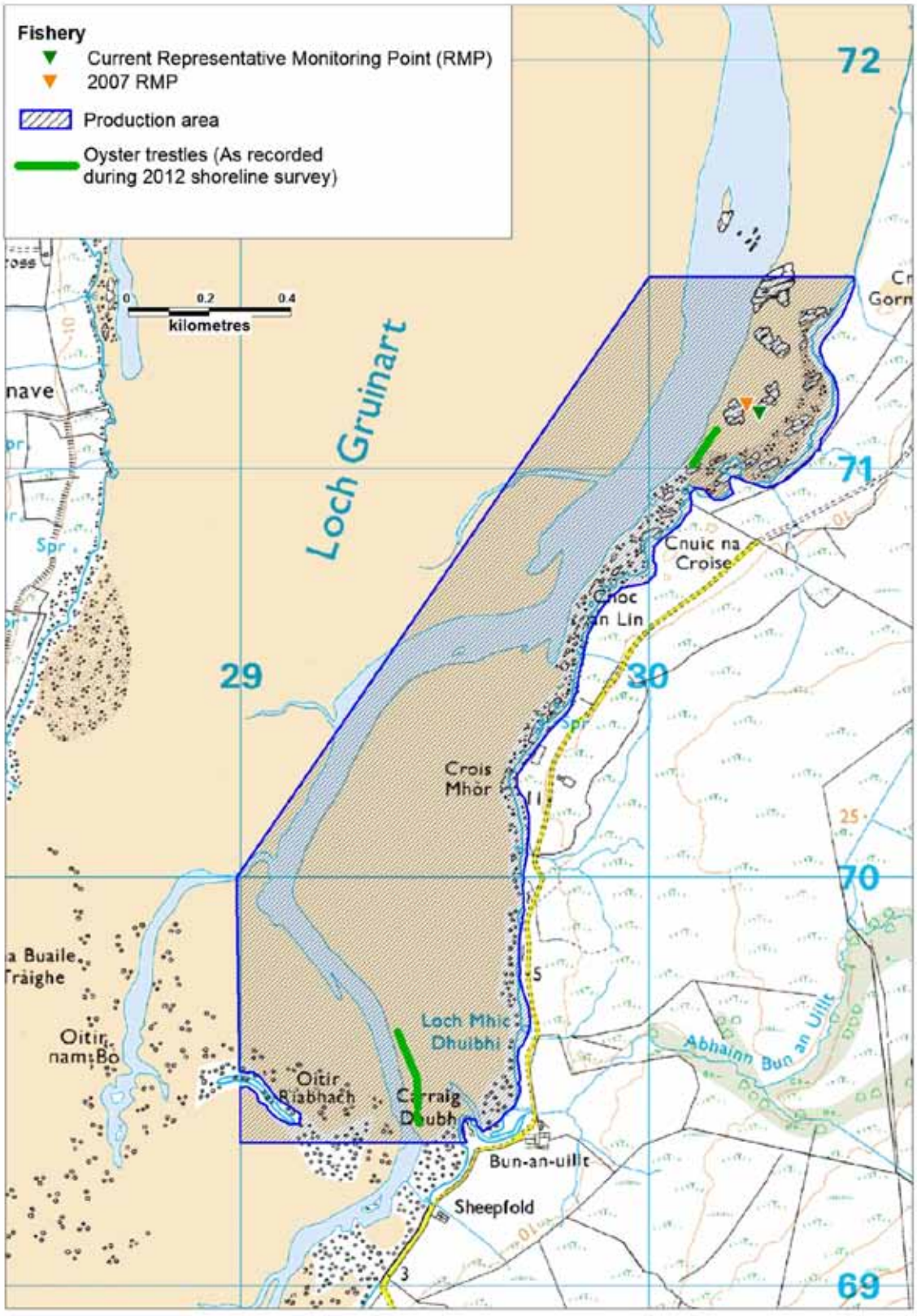

Figure 2.1 Loch Gruinart Craigens Fishery.

3. Population and Human Sewage Impacts

3.1 Population

The 2011 population census output from the General Register Office for Scotland was unavailable at the time of this Review. Population data from the 2001 Census is given for the two census output areas adjacent to Loch Gruinart, identified in the 2007 Report are as follows and are displayed in Figure 3.1.

Table 3.1 Local Population at 2001 Census

Census Output Area	Land Area (km^2)	Population
60QD000104	115	92
60QD000105	60	71

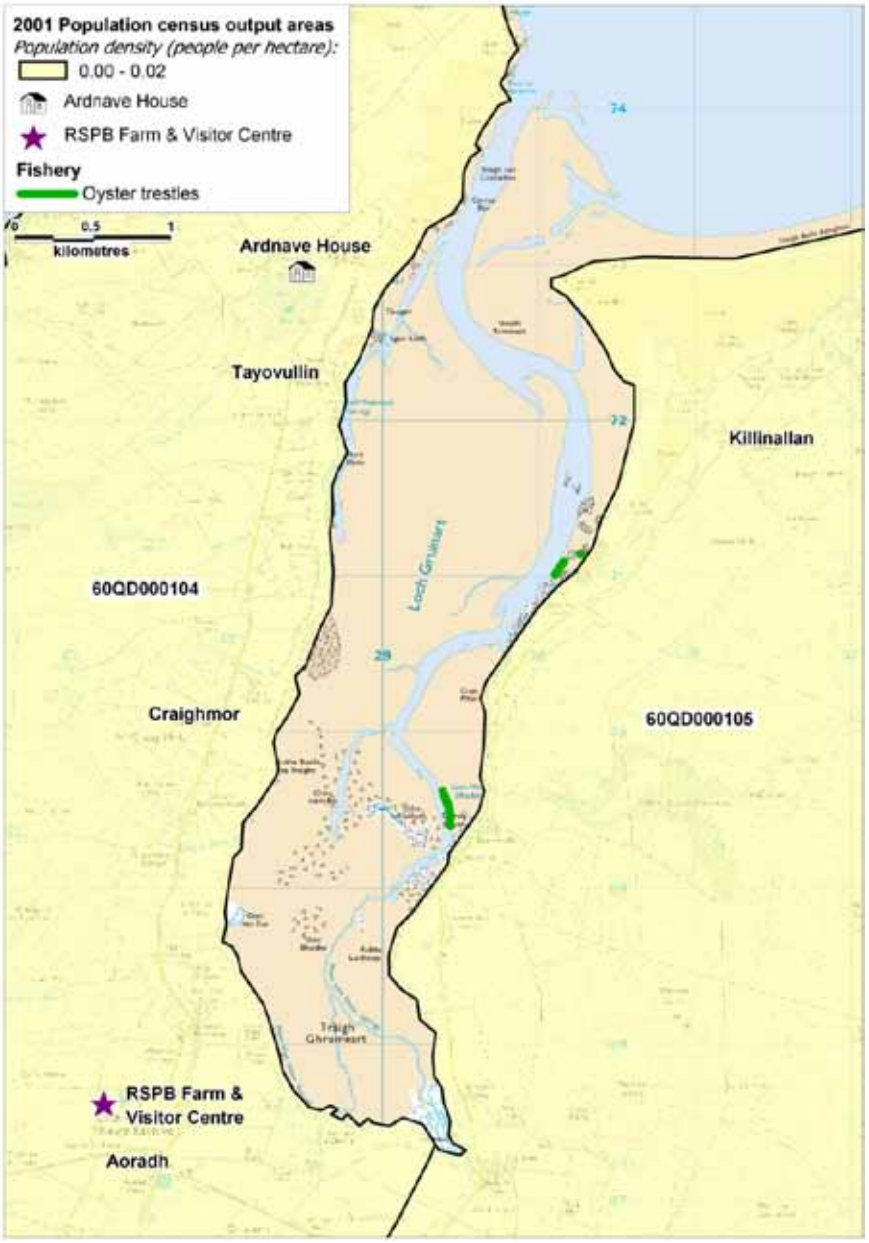

Figure 3.1 Map of human population distribution around Loch Gruinart Craigens.

One planning application has been made since the 2007 Report. This was to demolish an existing extension at Ardnave House (see Figure 3.1), then re-build and extend the dwelling house and out buildings. The application was granted approval. This house has an existing septic tank and no comments were submitted with the application to alter the sewage discharge consent. Ardnave House is located on the northwest side of the loch and is not expected to significantly alter the human population impact on the fishery at Loch Gruinart Craigens.

The majority of the population around Loch Gruinart Craigens is concentrated around its southern and western shorelines. The east side of the loch has 6 dwellings, three of which are associated with farm buildings. One of these, at Killinallan, is uninhabited. One of the two cottages south of Craigens Farm is a holiday let, and therefore not permanently occupied. Further dwellings are scattered along the western shore from Aoradh to Tayovullin, which lies 2.8 km southwest of the point.

Loch Gruinart RSPB Reserve maintains a farm and visitor centre southwest of the head of the loch (at Aoradh on Figure 3.1). It is a large tourist attraction, bringing in between 14,000-16,000 visitors annually (Mary McGregor, Senior Warden at RSPB Loch Gruinart Reserve). This has increased since 2008, when approximately 12000 people visited. These figures only include tourists to the RSPB Visitor Centre and therefore total number of visitors to the area is likely to be higher. Tourist numbers peak around summer when the weather is at its best.

No official camping/caravan sites are located around Loch Gruinart, but a caravan with an accompanying 4x4 vehicle was observed during the shoreline survey. This was observed parked adjacent to the fishery and on the same day (16/10/2012) a RIB/inflatable dingy was also observed on the shoreline, close to the aforementioned caravan. The OC sampling officer identified that people regularly camped at or near this location.

3.2 Sewage Impacts

Information received from SEPA on consented sewage discharges for the 2007 Report is shown in Table 3.1. Discharge volume is given in population equivalent (PE) and type (ST) is septic tank.

Table 3.2 SEPA discharge consents around Loch Gruinart Craigens from the 2007 Report.

Consent No.	NGR	Name	Type	Discharges to	PE
CAR/R/1012902	NR 2797 7009	Tigh an Arish	ST	Land	5
CAR/R/1013288	NR 2769 6924	Lek Gruinart Cottage	ST	Land	5
CAR/R/1014876	NR 2758 6852	Mullin Cottage	ST	Abhainn a Mhuillinn	5
CAR/R/1014875	NR 2774 6796	Woodside Cottage	ST	Land	5
CAR/R/1014862	NR 2776 6762	1&2 Bushmill Cottages	ST	Land	10
CAR/R/1014864	NR 2756 6716	Aroadh Bothy & Farmhouse	ST	Land	12
CAR/R/1014863	NR 2699 6679	Grainel Farm	ST	Land	5

All discharges shown in Table 3.1 are located on the western shoreline of Loch Gruinart (Figure 3.2). Only one [CAR/R/1014876] discharges into freshwater at

Abhainn a Mhuillinn, with the rest discharging to land soakaways. Following heavy rainfall these land soakaways may present a contamination risk to Loch Gruinart, through surface runoff.

The discharge for Loch Gruinart RSPB Reserve is not included in Table 3.1. From a report, reedbeds around the Reserve are used to treat effluent from the visitor facilities. The reedbed filtration system is designed to cope with 20,000 visitors per annum (SP Paper 362, 2001), which is greater than the total visitor numbers over the past two years and may therefore be considered to have sufficient capacity. These reedbeds were not observed during the recent shoreline survey and it is therefore unclear whether effluent from this system would enter into Loch Gruinart.

Due to the seasonality in tourists/visitors to Loch Gruinart, it is likely that there will be a seasonal trend in sewage discharges from the RSPB Reserve and surrounding dwellings that are used as holiday lets. Sewage discharge will therefore be a greater contamination risk during the summer, than winter months.

An additional discharge was observed during the shoreline survey, at a house near the shore at NR 29526 67650. Despite the OS map showing this site to be a well, its location (close to watercourse Allt a Ghil) and shape meant it was suggested as a septic tank. The location of this discharge is shown in Figure 3.2 highlighted in red as Discharge 3.

Two other septic tanks were observed during the current shoreline survey and are shown in Figure 3.2. These two discharges were also previously noted the 2007 Report.

Discharge 1: is used by three houses, located approximately 100 m from the shoreline on the eastern side of Loch Gruinart and was measured to discharge 1L/min.

Discharge 2: is located on the northwest side of Loch Gruinart and reportedly overflows into stream water. No flow data was recorded at this location.

There are no mains sewerage systems in the area. All occupied dwellings are therefore assumed to be on septic tanks. These will discharge to land soakaways or to watercourses. No information was found suggesting a change to the number and/or location of sewage discharges since the 2007 Report. The location of the oyster trestles are also shown in Figure 3.2.

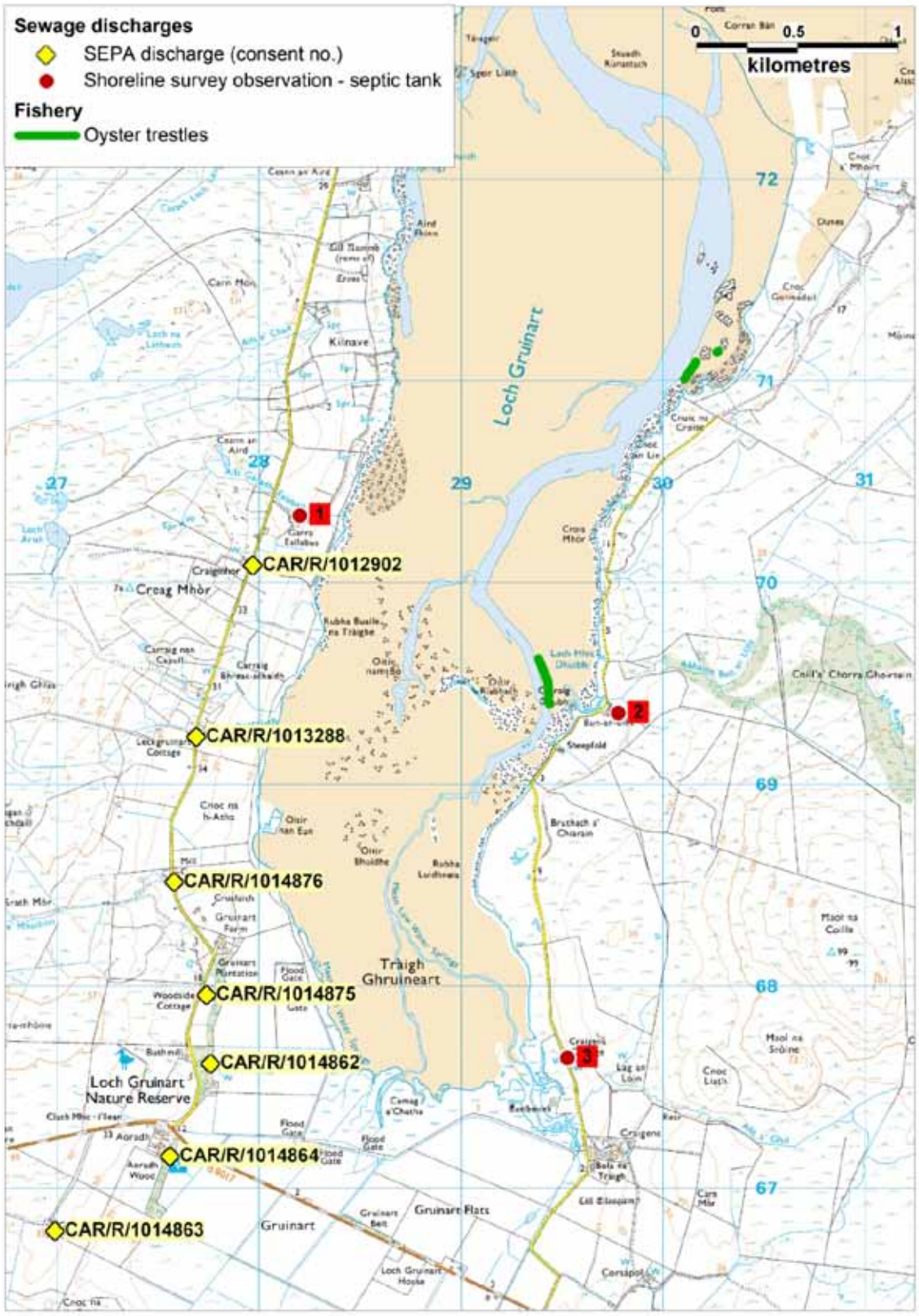

Figure 3.2 Map of identified SEPA sewage discharges and additional discharges observed during the 2012 shoreline survey, at Loch Gruinart Craigens.

4. Farm Animal Population and Agricultural Impacts

Agricultural census data was not sought for this review. Data on sources of farm pollution were obtained through the shoreline survey and discussions held with the harvester. The following data relates only to the time of the survey 16-17th October 2012. Spatial distribution of animals and agricultural land use observed during the shoreline survey is illustrated in Figure 4.1.

Agriculture remains the dominant land use around Loch Gruinart, with arable fields present around most of the Loch and the remaining area used extensively for grazing. There are large barns for housing both sheep and cattle during the winter. Three large farms operate around Loch Gruinart, though there may also be smaller ones in operation that were not obvious during the shoreline survey.

At the time of the shoreline survey, approximately 30 cattle (excluding those in a barn) and 450 sheep were counted at Craigens Farm. This differs from the 2007 Report where 200 cattle, 1100 ewes and 1200 lambs were counted during the shoreline survey. Similar differences are seen at Garra Eallabus, where approximately 30 cattle and 20 sheep were seen during the present shoreline survey, compared to 75-100 cattle and 200 sheep observed in the 2007 Report. At the RSPB Farm, no cattle were observed, though cattle were heard lowing in the nearby cattle shed. A plaque was observed at the RSPB visitor centre stating 250 cattle and 200 sheep were kept on the farm. This is a small difference since the 2007 Report where 200 cattle and 300 sheep observed in 2007 Report.

These differences may merely reflect the time of the year the shoreline surveys were conducted. The 2007 shoreline survey was carried out during July, just after lambing and calving season. The most recent shoreline survey was conducted in October, when it is likely that some livestock will have been moved to more sheltered grounds and into cattle sheds and sheep pens for the winter. Calves and lambs born in the spring may also have been moved or sold.

The majority of livestock were observed inland to the south of Loch Gruinart (Figure 4.1). Although set back from the shoreline, it is likely faecal pollution from these animals will wash into Loch Gruinart following heavy rainfall. It should also be noted that livestock counts taken during this shoreline survey are approximate. Overall it is likely that livestock counts will be under estimations due to practical limitations.

There was evidence that livestock had access to the majority of the shoreline and watercourses around Loch Gruinart, with droppings and poaching of river banks noted from the current shoreline survey. The 2007 shoreline survey also found livestock were free to roam the majority of the shoreline and particular concern was raised following sheep observed grazing on low lying wetland areas to the south. It was thought that faecal matter from the sheep would be carried over the oyster trestles during ebb tides. This shoreline survey illustrated that this wetlands area has since been re-developed to a reserve. This is managed by the RSPB for overwintering birds, though livestock are allowed on it at during parts of the year to help maintain sward height.

Land use was also noted during the shoreline survey. The RSPB farm manages an area to the south of Loch Gruinart, and grows spring-sown arable crops for the benefit of the birds and livestock. There was also an area of improved grassland to the southeast of the loch, near to Craigens Farm and a turnip field east of the loch (Figure 4.1).

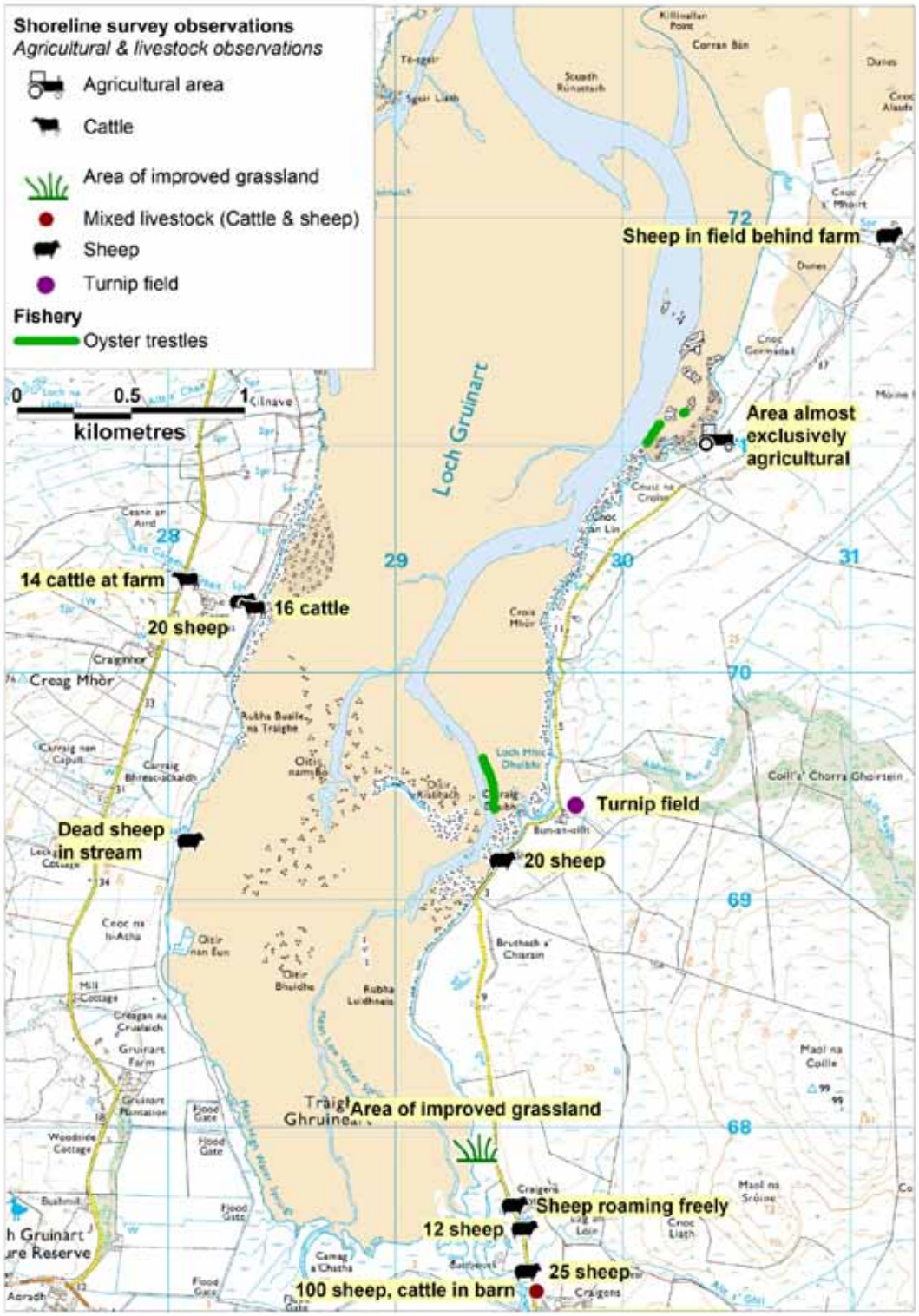

Figure 4.1 Map of livestock and crop concentration and distribution observed during the 2012 shoreline survey around Loch Gruinart Craigens.

5. Wildlife

Information on pollution sources from wildlife has been obtained through the shoreline survey, discussions held with the harvester and through a desk based web search. Information relates only to the time of the survey 16-17th October 2012. The desk based web search was conducted to obtain more realistic information relating to wildlife in the area. Wildlife observations recorded during the shoreline survey are displayed in Figure 5.1.

Pinnipeds

Both the Grey seal *(Halichoerus grypus)* and Common/Harbour seal *(Phoca vitulina)* are commonly reported hauled out in Loch Gruinart. Nave Island to the northwest of Loch Gruinart hosts a large colony of grey seals (http://www.argyllmarinesac.org/DS_s-eislayskerries.htm), and despite no common seal colony reported nearby, both species will use the area to forage and will haul out on the sand flats.

No seals were observed during the most recent shoreline survey. Through discussions with the harvester, it is noted that seals regularly haul out around the trestles. This was noted as having become less frequent since the 2007 shoreline survey, though numbers hauled out had increased.

Birds

Loch Gruinart hosts significant populations of waterfowl and is an important area for migratory birds. During the recent shoreline survey, evidence of geese around the mudflats and grassland was prevalent.

During the desk based study, no official updates have been made to the RSPB Census data for Loch Gruinart Craigens since the 2006 census. The data listed in Table 5.1 therefore corresponds to the 2006 RSPB census as stated during the 2007 Report.

Table 5.1 Significant populations of birds near the fishery (RSPB Census 2006).

Common name	Latin name	Months present	Peak month	Peak numbers
Barnacle goose	*Branta leucopsis*	Sept-Apr	Oct	25942
White-fronted goose	*Anser albifrons*	Oct-Apr	Oct	741
Greylag goose	*Anser anser*	Apr-Jun, Aug-Dec	Sep	814
Teal	*Anas crecca*	All year	Jan	1511
Dunlin	*Calidris alpina*	Nov-May, Aug-Sep	Dec	682
Golden plover	*Pluvaialis apricaria*	Oct-Mar	Nov	631
Wigeon	*Anas penelope*	Sep-May	Feb	386

Populations of individual species have however been reported as having increased. Significant numbers of Barnacle geese (*Branta leucopsis*) were reported at Loch Gruinart in 2010 and 2011, with approximately 30,000 Barnacle geese present over the past two years, a population increase of approximately 5,000 since the 2006 data (www.rspb.org). The Greylag goose population has also increased since the 2006 census, with 1500 reported over the last two years (www.rspb.org). It is likely that other bird populations at Loch Gruinart have also varied since the 2006 census thought the level of variation is unable to be quantified due to the lack of up to date population counts at the time of this review.

During the shoreline survey, large flocks of geese were observed around grazing areas, with droppings found along the shoreline and around standing bodies of water. From Figure 5.1, the majority of the geese were observed on the southeast of Loch Gruinart, with all geese observed on mudflats and some observed to the southwest of the loch. Due to the distance between the observers and the geese, as well as the high number, it was not possible to differentiate which species of geese were present. It should also be noted that geese counted in the recent shoreline survey are likely to be under estimated, with the high coverage of geese and close proximity to one another, making differentiating whilst counting very difficult. Despite these birds being present for only the winter months, it is likely that they will impact the contamination loading to the fishery, particularly those present to the south of the oyster trestles. Wading birds were also observed during the shoreline survey, to the southeast of Loch Gruinart. Although present in much lower numbers than the geese, their presence throughout much of the year is also likely to have an impact on the fishery.

Deer

There are anecdotal reports of Red deer (*Cervus elaphus*) around the wetland intertidal areas and surrounding farmland at Loch Gruinart. Roe deer (*Capreolus capreolus*) are also said to raise their young amongst the rushes in the wetlands (http://www.islayinfo.com/islay_rspb_loch_gruinart.html). No population data for red or roe deer was available at the time of this review. No deer were observed during the shoreline survey, however as they are most active during dusk and dawn, they would not be expected to be seen during the shoreline survey which takes place during daylight hours.

Otters

The Eurasian otter (*Lutra lutra*) is common along the shallows of Loch Gruinart, preying on the chicks of several species of waders (http://www.islayinfo.com/islay_rspb_loch_gruinart.html). No population data was available at the time of this review. No otters were observed during the shoreline survey, though due to their shy nature, they were not expected to be observed during the shoreline survey.

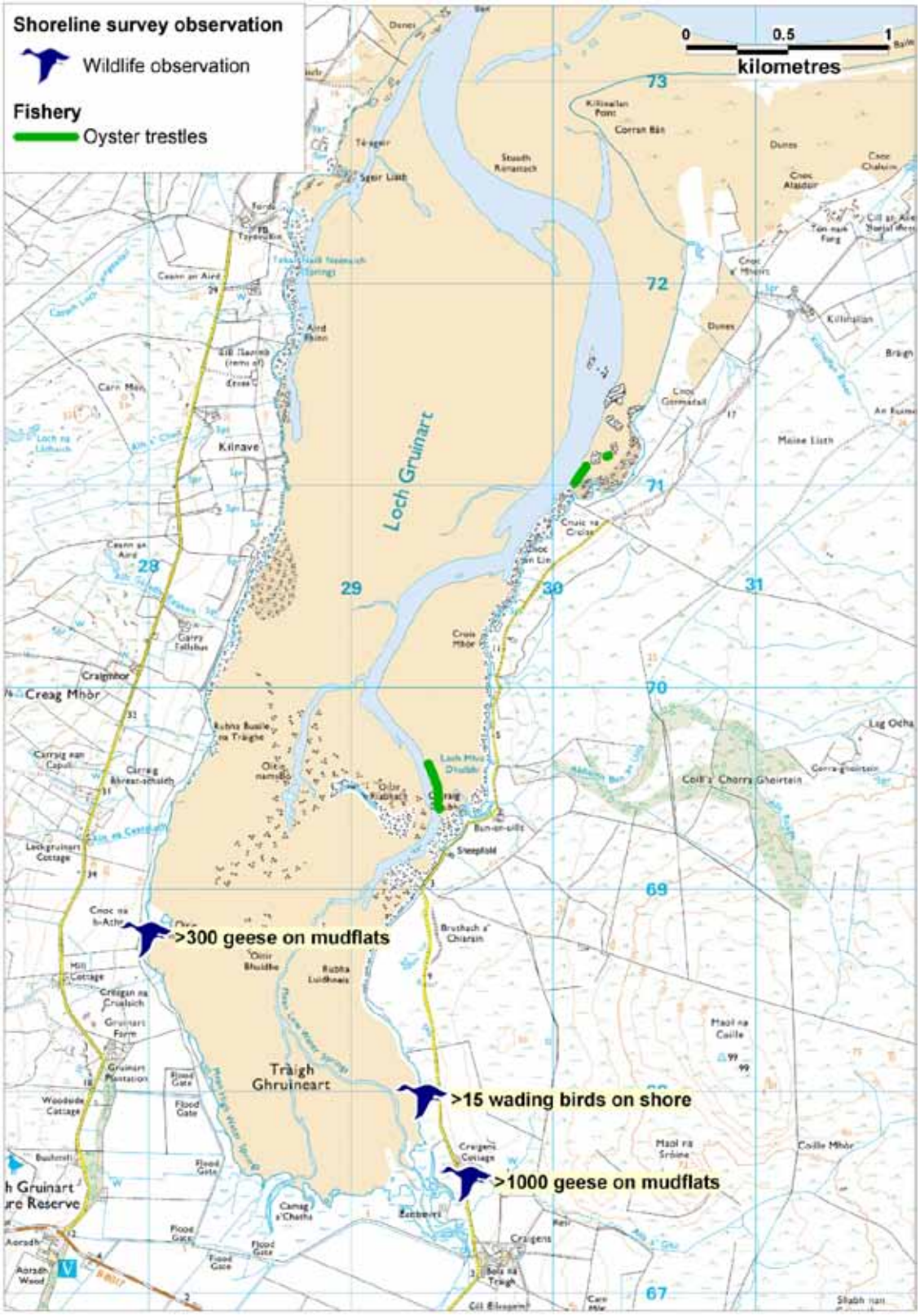

Figure 5.1 Wildlife observations made during the shoreline survey, Loch Gruinart Craigens.

6. Watercourses

There are no gauging stations on watercourses feeding into Loch Gruinart. During the shoreline survey for this review twelve major watercourses were sampled in October, with results displayed in Table 6.1.

Table 6.1 Watercourse flows and loadings to Loch Gruinart from the 2012 shoreline survey

No.	NGR	Description	Width (m)	Depth (m)	Meas. Flow (m/s)	Flow (m^3/d)	*E. coli* (cfu/ 100 ml)	Loading (E. coli/ day)
1	NR 29583 67360	Stream	1.85	0.20	0.120	3840	100	$3.8x10^9$
2	NR 30974 71962	Killinallan River	1.20	0.35	0.037	1340	100	$1.3x10^9$
3	NR 30307 70957	Stream	0.55	0.10	0.124	589	<100*	$5.9x10^8$
4	NR 30416 71040	Stream	0.80	0.30	0.465	9640	<100*	$9.6x10^9$
5	NR 29814 69429	Abhainn Bun an Uillt	2.00	0.30	0.256	13300	100	$1.3x10^{10}$
6	NR 29480 69198	Water flowing through pipes	0.45#	-	0.022	475	100	$4.8x10^8$
7			0.45#	-	0.011	167	100	$1.7x10^8$
8	NR 29267 67626	River	4.00	0.55	0.254	48300	2100	$1.0x10^{12}$
9	NR 28371 70281	Allt Garadh Eallabus	0.53	9.50	0.503	219000	900	$2.0x10^{12}$
10	NR 28110 69386	Stream	0.60	0.19	0.017	167	1900	$3.2x10^9$
11	NR 28095 69289	Stream	0.70	8.50	0.155	79700	2000	$1.6x10^{12}$
12	NR 28002 68597	Stream	0.20	0.25	0.326	1410	2700	$3.8x10^{10}$

*A nominal assumed value of 100 cfu *E. coli*/100 ml was used for calculation loading.

The wetted flow was estimated for the two pipes found at NR 29480 69198, where the diameter of the pipes was used to calculate the circumference before estimations of wetted flow were estimated from photographs given in Appendix 1 in Figures 7 and 8.

All twelve watercourses sampled during the present shoreline survey discharge into Loch Gruinart from both the east and west sides of Loch Gruinart and are shown in Figure 6.1. To compare measured flow rates and loadings between surveys, data on river loadings from the 2007 Report are displayed in Table 6.2. In the 2007 Report, only three watercourses were sampled, with two sets of measurements (July and November) taken for the larger streams: Killinallan River and Abhainn Bun an Uillt. All three watercourses sampled in 2007, were also sampled for this review.

Table 6.2 Watercourse flows and loadings into Loch Gruinart from the 2007 shoreline survey

No.	NGR	Description	Width (m)	Depth (m)	Meas. Flow (m/s)	Flow (m^3/d)	*E. coli* (cfu/100 ml)	Loading (*E. coli*/ day)
1	NR 28325 70301	Stream	0.40	0.03	0.10	100	260	2.7×10^8
2	NR 29714 69413	Abhainn Bun an Uillt (Jul)	1.30	0.08	0.30	2700	>10000*	4.0×10^{11}*
3	NR 30707 72153	Killinallan River (Jul)	2.00	0.03	0.10	500	5200	2.7×10^{10}
4	NR 29704 69399	Abhainn Bun an Uillt (Nov)	3.30	0.22	0.87	55000	200	1.1×10^{11}
5	NR 30980 71941	Killinallan River (Nov)	0.89	0.12	1.22	11000	300	3.4×10^{10}

*A nominal assumed value of 15000 cfu *E. coli*/100 ml was used to calculate loading.

In 2007, watercourses measured in both July and November had higher flow rates in the latter month (resultant of higher rainfall levels). This appeared to result in a dilution of *E. coli* concentrations (Table 6.2) although overall loadings were approximately the same in both months.

Watercourse 10 [NR 28110 69386] discharges into Loch Gruinart from the western side. The sample taken in this shoreline survey had a relatively small flow rate slightly greater than that reported in the 2007 sample, but a much larger *E. coli* level. This may be explained by the intermittent showers falling whilst conducting the sampling, though it is likely that it reflects changes in land use or the spatial distribution of animals or wildlife. During the recent survey a dead sheep was found further upstream, and >300 geese were observed on the mudflats close to the watercourse, which are likely to have also used the river to wash themselves.

The Killinallan River discharges into the northeast of Loch Gruinart. At the time of the 2012 shoreline survey, the *E. coli* loading was less than both estimates from 2007.

Abhainn Bun an Uillt showed an exceptionally high *E. coli* concentration at the time of the 2007 July sample. This was reflected in the estimated *E. coli* loading, which was greater than in November. The remaining watercourses sampled during the 2012 shoreline survey vary in size, flow and *E. coli* concentrations. The greatest *E. coli* loading (2.0×10^{12} *E. coli*/day) was measured at Watercourse 9 (Allt Garadh Eallabus), located mid way along the west coast of Loch Gruinart. The farm Garra Eallabus lies adjacent to this watercourse and at the time of this survey livestock were observed close to the stream.

The Killinallan River and Abhainn Bun an Uillt represented the greatest sources of contamination to the fishery during both ebb and flow tides in the 2007 Report. This is expected to remain the case for the identified shellfishery location. In addition, watercourses 3 and 4 (north) and watercourses 6 and 7 (south) will also contribute to contaminants entering the fishery, and will similarly increase contamination on flood and ebb tides.

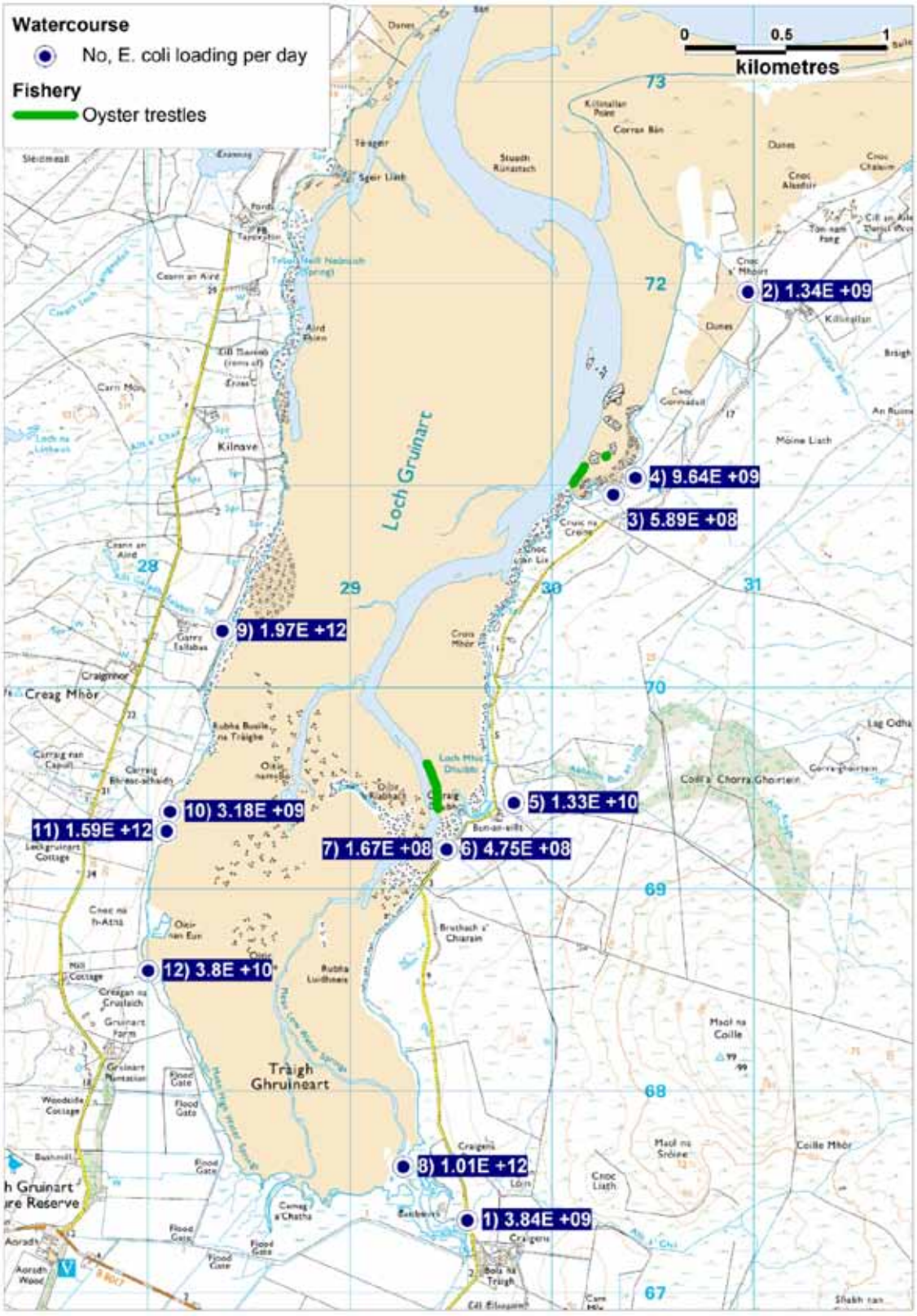

Figure 6.1 Watercourse loadings into Loch Gruinart, measured during the 2012 Shoreline Survey Report.

Where the bacterial loading is labelled on the map, the scientific notation is written in digital format, as this is the only format recognised by the mapping software. So, where normal scientific notation for 1000 is 1×10^3, in digital format it is written as 1E+3.

7. Meteorological data

Meteorological data was purchased from the Meteorological Office for wind and rainfall graphs in the 2007 Report, for the survey period 01/01/2003 - 31/12/2006. These graphs have been reproduced to allow for comparisons with the more recent dataset in this review. Rainfall data from Eallabus weather station (approximately 6km south of the production area) was used for the 2007 Report and was recorded (total daily rainfall in mm) for 1166 days out of the 1400 survey days. Wind data was taken from Tiree weather station (approximately 80km NNW of the production area) and was supplied complete in 3 hourly intervals.

Meteorological data for this review survey period (01/01/03 - 31/12/2011) was purchased from the Meteorological Office in October 2012. Rainfall data from Eallabus was incomplete (50% missing for several months). Rainfall data from Tiree weather station was therefore used instead: where rainfall data was recorded for 2068 out of the 2070 survey days. Tiree weather station was the closest station to the production area after Eallabus. Overall it is expected that rainfall at the production area and Tiree will be similar, despite day to day differences caused by localised weather patterns. Wind data was taken from Tiree weather station and was supplied complete in 3 hourly intervals.

7.1 Rainfall

Storm events and high rainfall levels are commonly associated with increased faecal contamination of coastal waters through surface water run-off from land and through sewer/waste water treatment plant overflows (Mallin et al, 2001: Lee and Morgan, 2003).

Direct comparisons between 2003-2006 and 2007-2012 datasets are not possible due to the different weather stations used: Eallabus and Tiree respectively. Simple comparisons however were made between sites and years and are reported below.

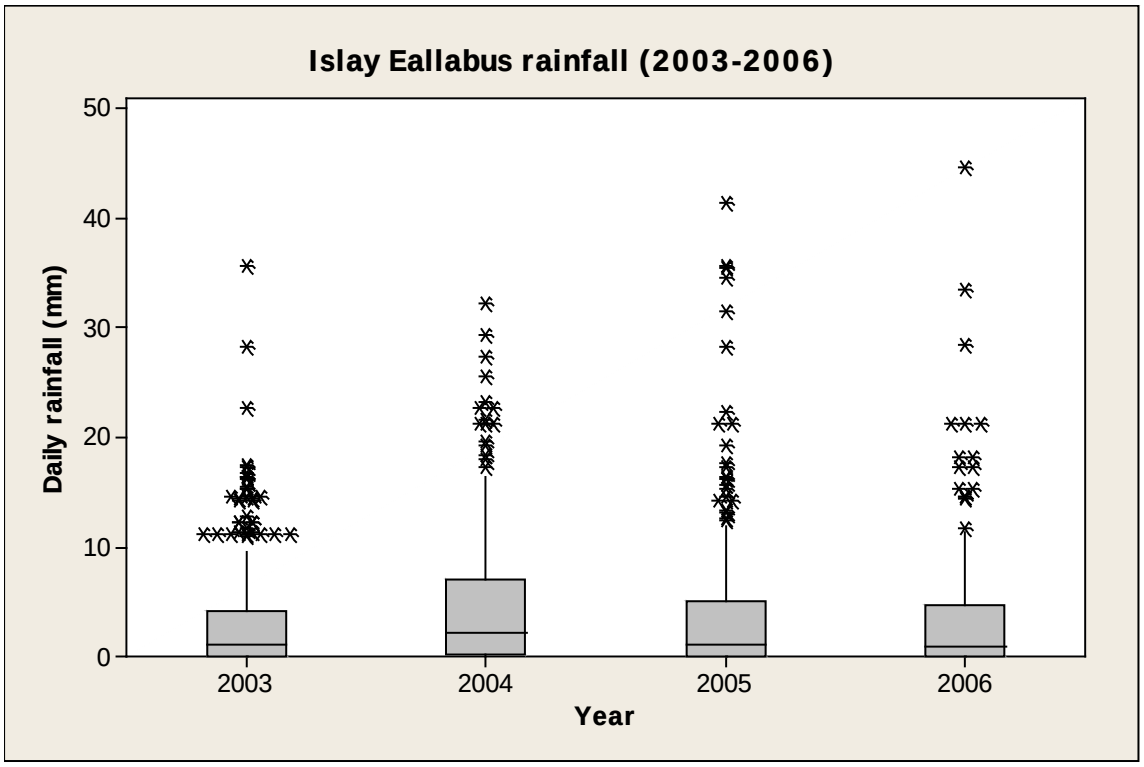

Figure 7.1 Boxplot of daily rainfall at Eallabus by year (2003-2006)

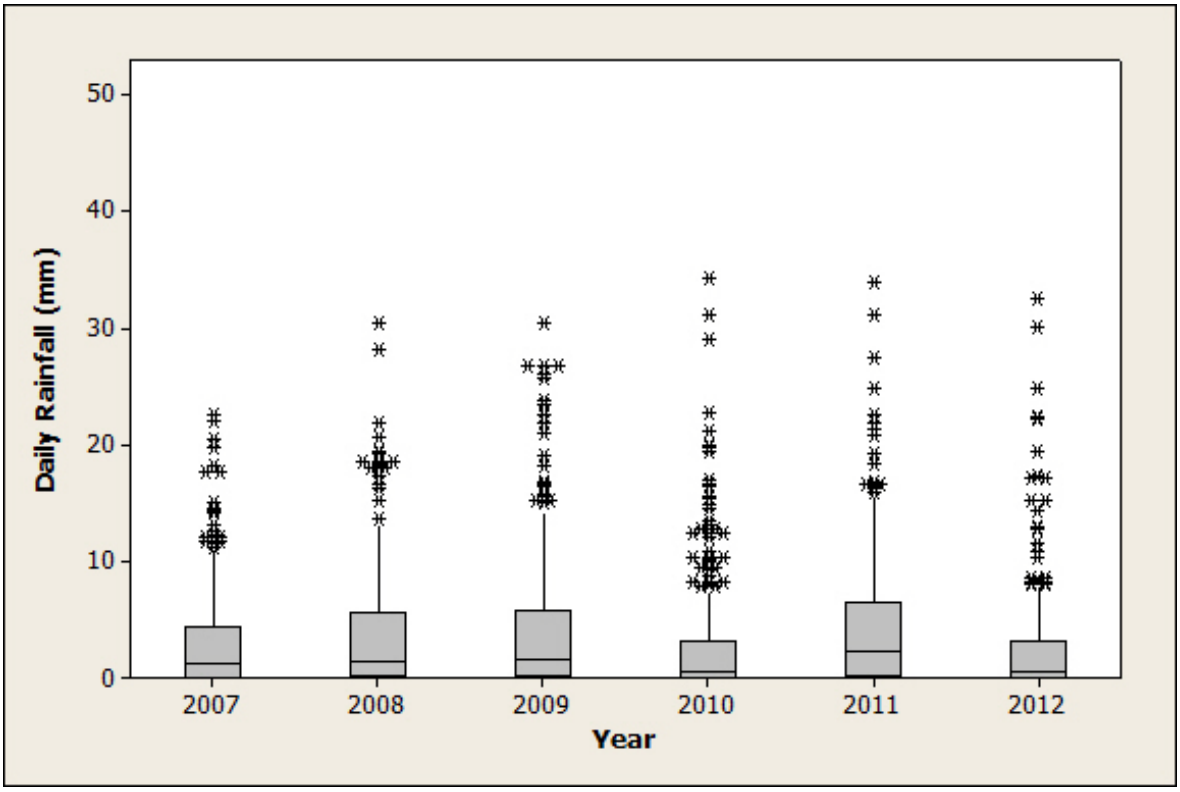

Figure 7.2 Boxplot of daily rainfall at Tiree by year (2007-2012)

Rainfall across all years (2003-2012) has a middle 50% box below 10 mm rainfall, with median rainfall between 0-5 mm. The majority of whiskers extend up to 35 mm rainfall for all years, though for 2005 and 2006 there are several results with elevated rainfall levels of 42 mm and 45 mm.

Monthly rainfall data for each survey period are shown in Figure 7.3 and Figure 7.4.

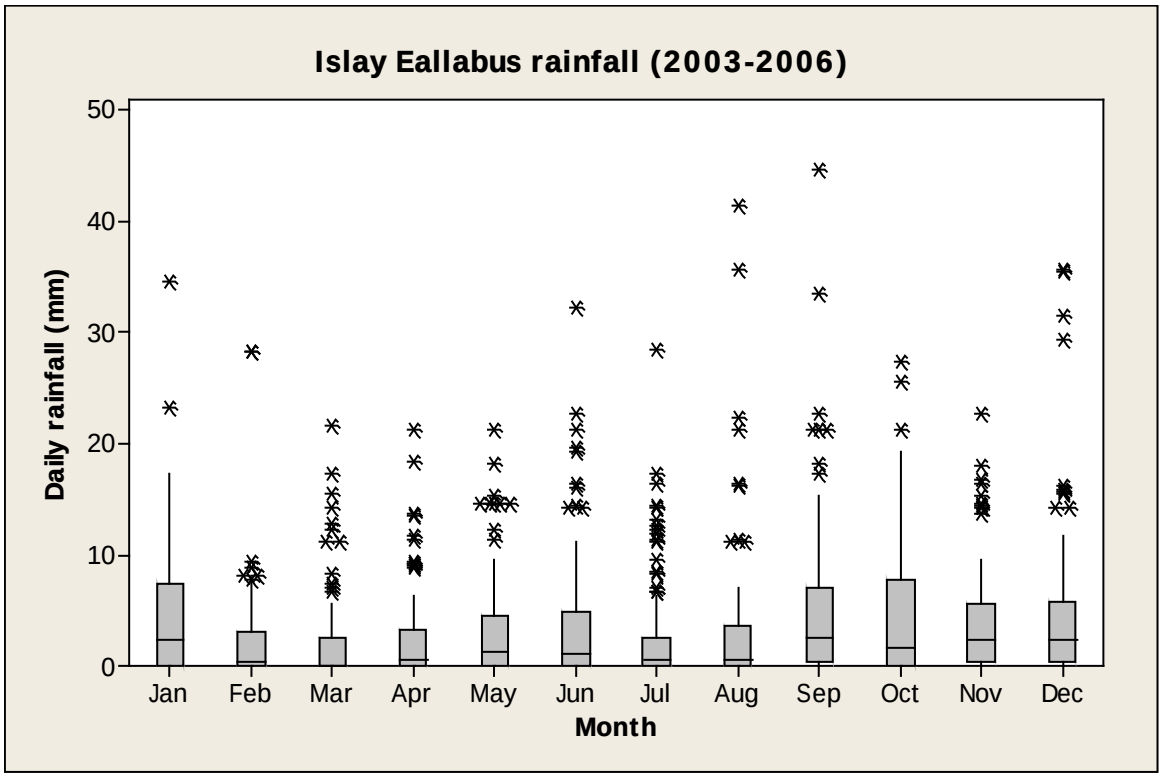

Figure 7.3 Boxplot of daily rainfall at Eallabus by months (2003-2006)

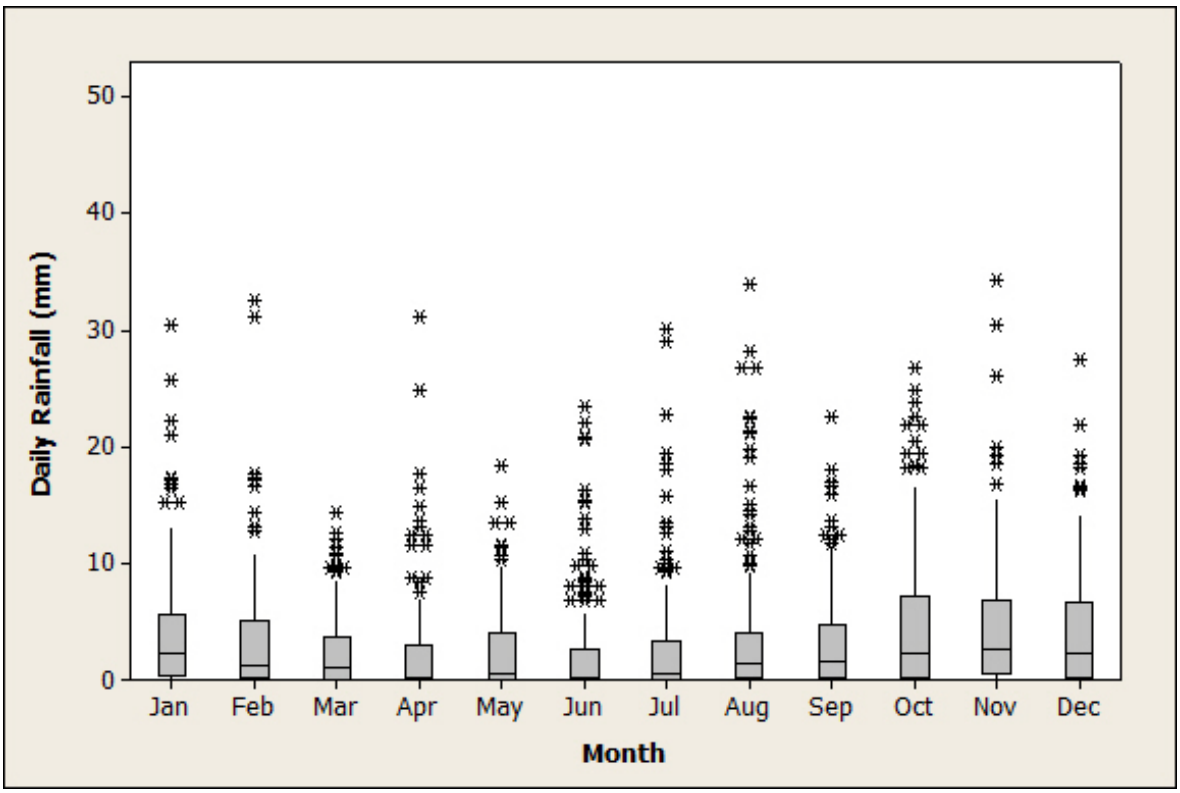

Figure 7.4 Boxplot of daily rainfall at Tiree by months (2007-2012)

The highest rainfall measurements for both survey periods occur between months September-January. As found with the yearly rainfall data, all months middle 50% boxes lie below 10mm rainfall, with the median rainfall level between 0-5 mm for both datasets, and across all months. Whiskers for both datasets are also similar, with the majority lying between 7-25 mm rainfall.

Wind

Wind speed and direction drive surface water and currents that play an integral part in particulate dispersal. Winds typically drive surface water at approximately 3% of the wind speed (Brown, 1991) so a gale force of 34 knots/17.2 m/s would drive a surface water current of approximately 1 knot/0.5 m/s.

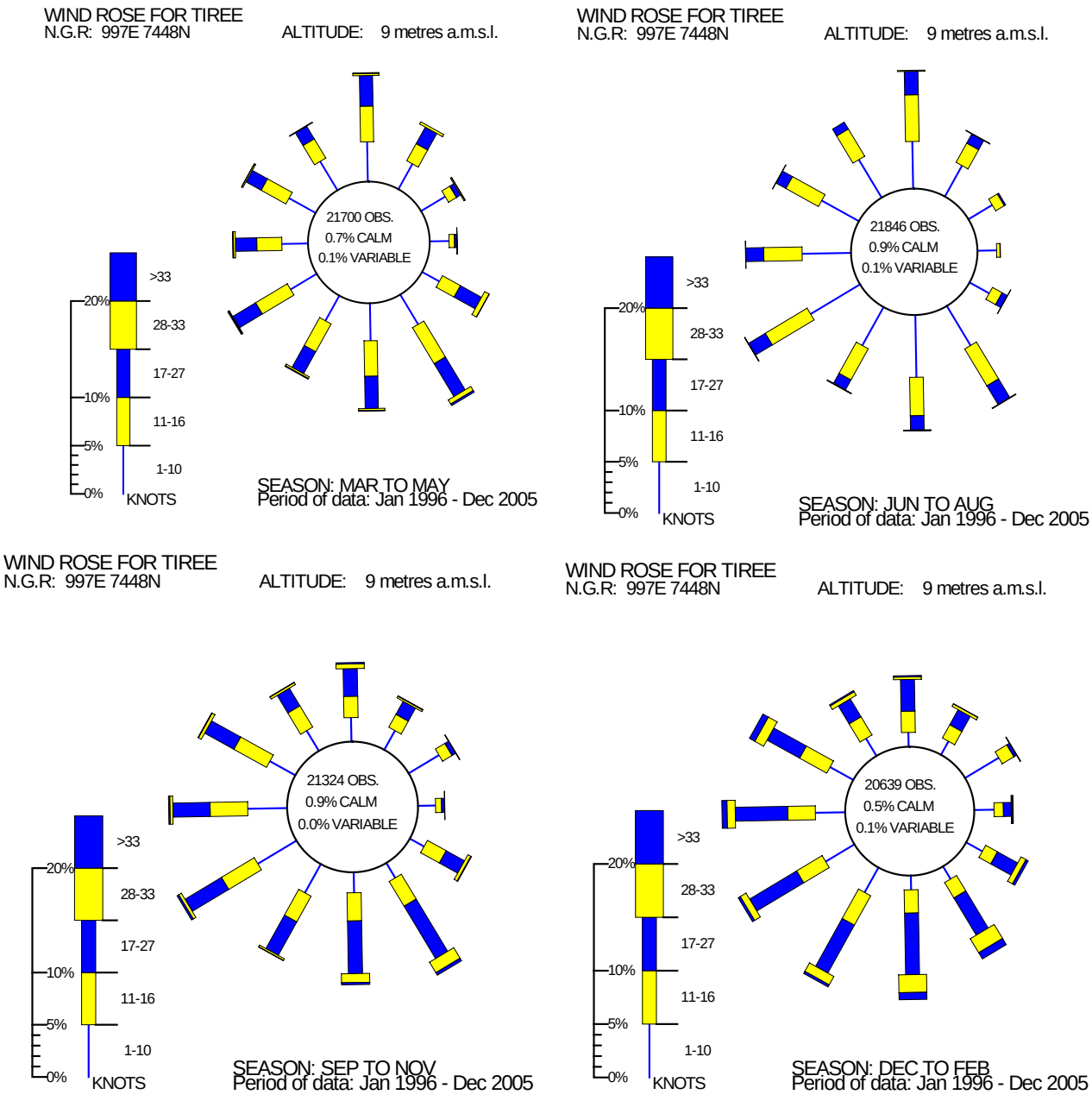

Figure 7.5 Seasonal wind roses for Tiree (1996-2006)

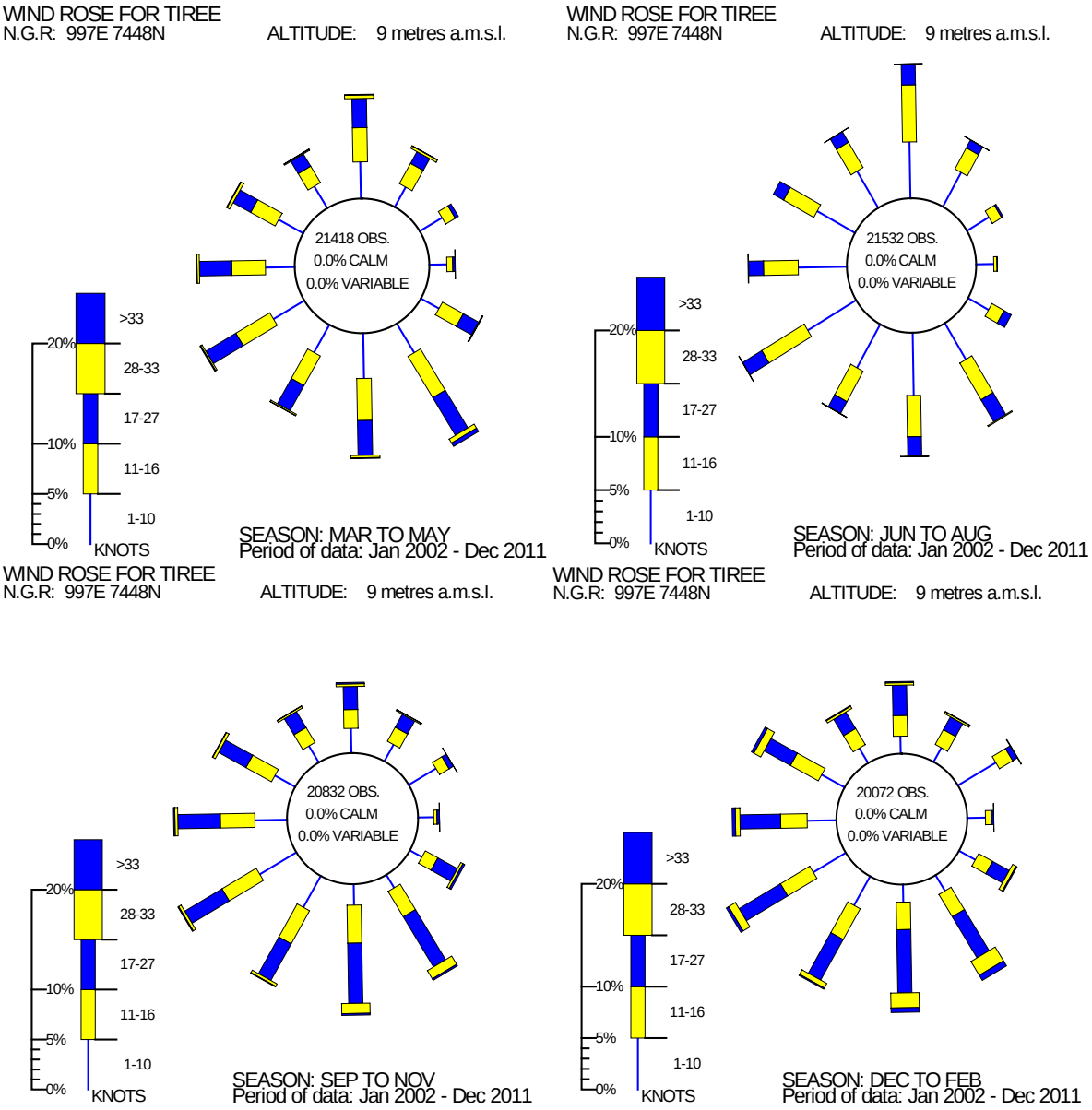

Figure 7.6 Seasonal wind roses for Tiree (2002-2011)

Prevailing winds throughout all four seasons and across the two survey periods appears to be south and west, with the highest winds recorded in autumn and winter. Slight variations are evident between survey periods and seasons.

Wind in the summer (June-August) between years 2007 and 2011 has shown to have slightly increased since the last survey period (1996-2006), with more wind exceeding 33 knots from the NNW. Similarly, during winter months (December-February) between years 2007 and 2011 wind speeds have increased since the last dataset (1996-2006) in the SE and SW directions up to 28-33 and >33 knots.

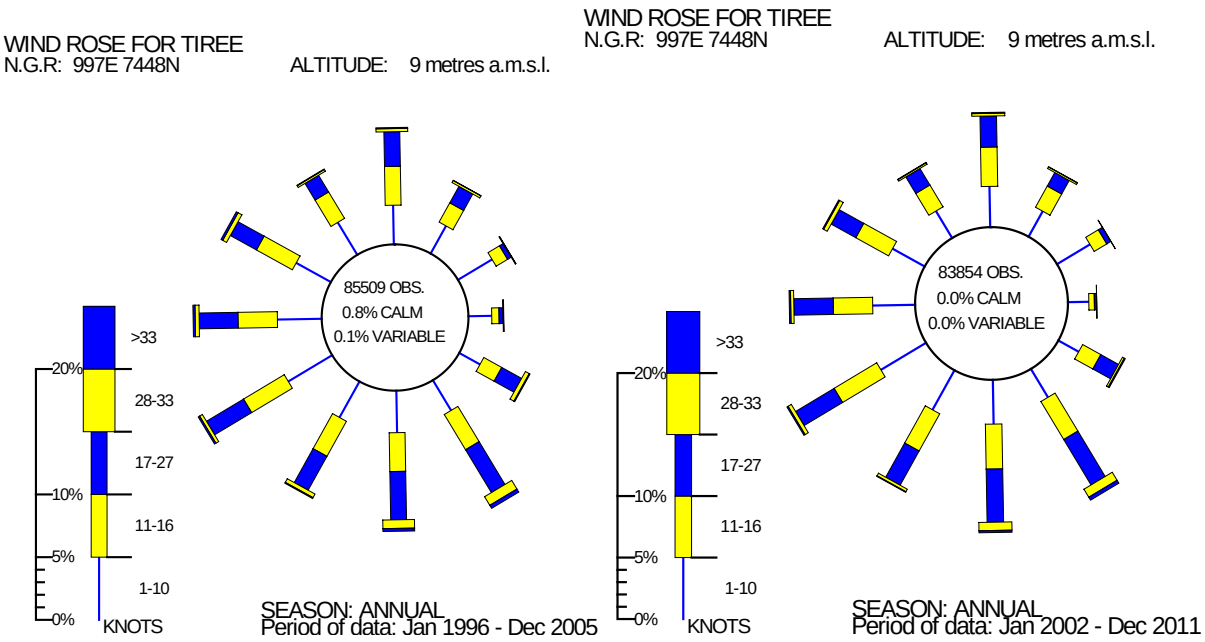

Figure 7.7 Annual wind roses for Tiree 1996-2005 and 2007-2011

The prevailing annual wind direction at Tiree between 1996-2006 and 2002-2011 is the same, with high winds coming from the south and west. Between survey periods, there appears to be a slight increase in the 2007-2011 dataset with recorded wind speeds of >33 knots in the SW. Overall, due to the topography of Loch Gruinart, it is believed that tidally driven circulation will be a more important factor to consider when looking into particulate dispersal, than wind driven circulation. However, strong winds and a high spring tide will increase the tide height, flushing out accumulated faecal matter from above the high water mark into the Loch.

8. Historical *E.* coli Data

8.1 Geographical patterns of results

Results for all samples assigned against Loch Gruinart, Craigens from the 01/01/2007 to 31/09/2012 were extracted from the FSAS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. Data was extracted from the database in October 2012. All *E. coli* results were reported as most probable number per 100 g of shellfish flesh and intravalvular fluid.

Three samples were recorded on the database as 'rejected' and were deleted. One sample was rejected due to being received at the laboratory outside of the 48hr window. All remaining samples had box temperatures of ≤8 ^{o}C. Three samples had an *E. coli* result of <20, so were assigned values of 10 *E. coli* MPN/100g. Three samples plotted on land and were deleted.

The location of the current nominal RMP, tolerance allowance and shellfish sampling locations for the sampling period 01/01/2007 – 31/12/2012 are plotted in Figure 8.1.

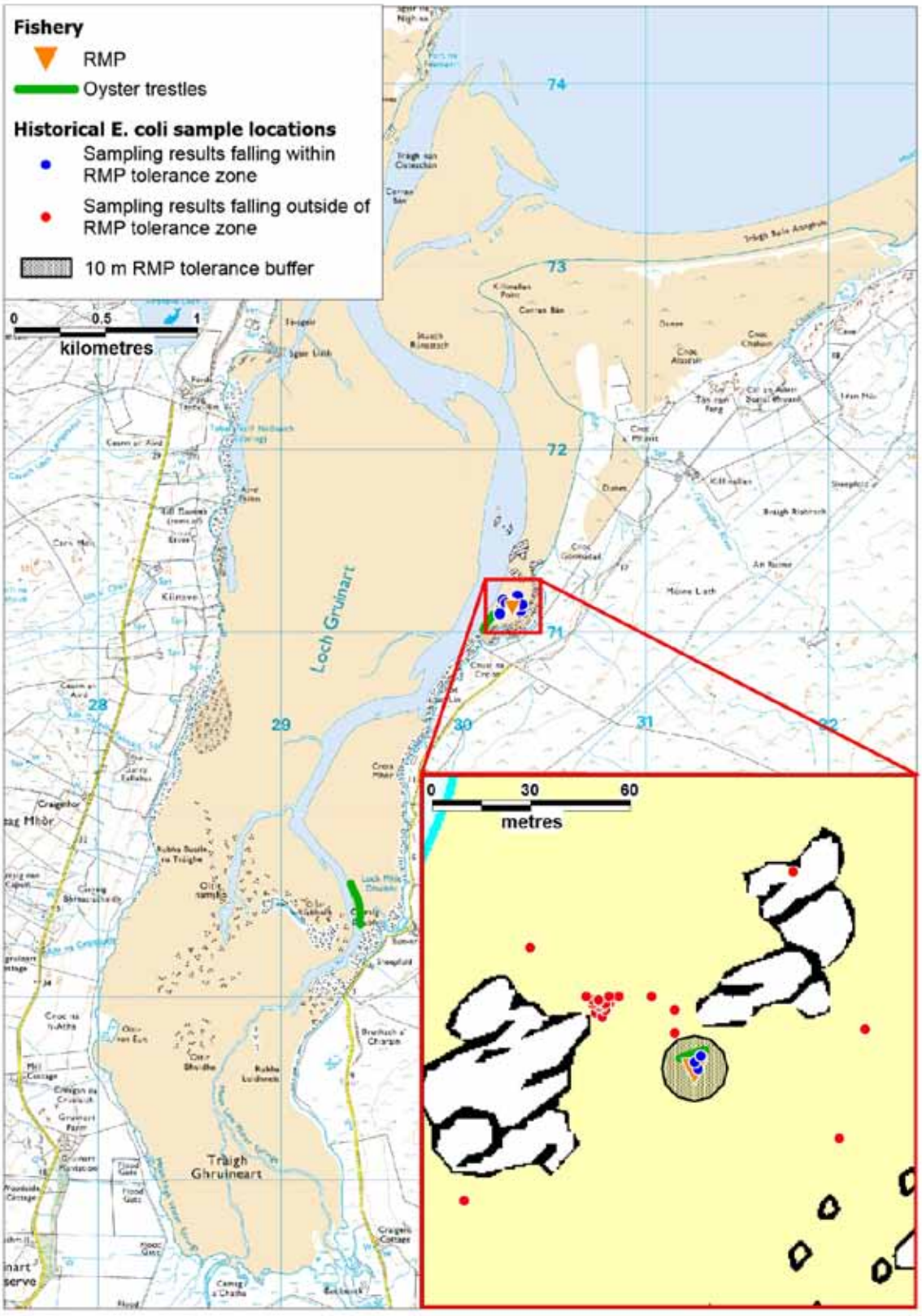

Figure 8.1 Sampling locations of Loch Gruinart and tolerance around the RMP

Three out of the total 51 sampling locations lay on the current nominal RMP and within the RMP tolerance boundary. The remaining sampling locations were predominantly to the NW of the RMP, within 6 metres of the location of the previous RMP (NR 303 712) with four other points outlying to the NE, SE and SW.

All points plot within 60 m of the current nominal RMP at NR 3027 7114, with the majority of points lying within a 30 m boundary.

8.2 Temporal patterns of results

Pacific oyster *E. coli* sample results from Loch Gruinart, between years 2001-2012 are shown in Figure 8.2.

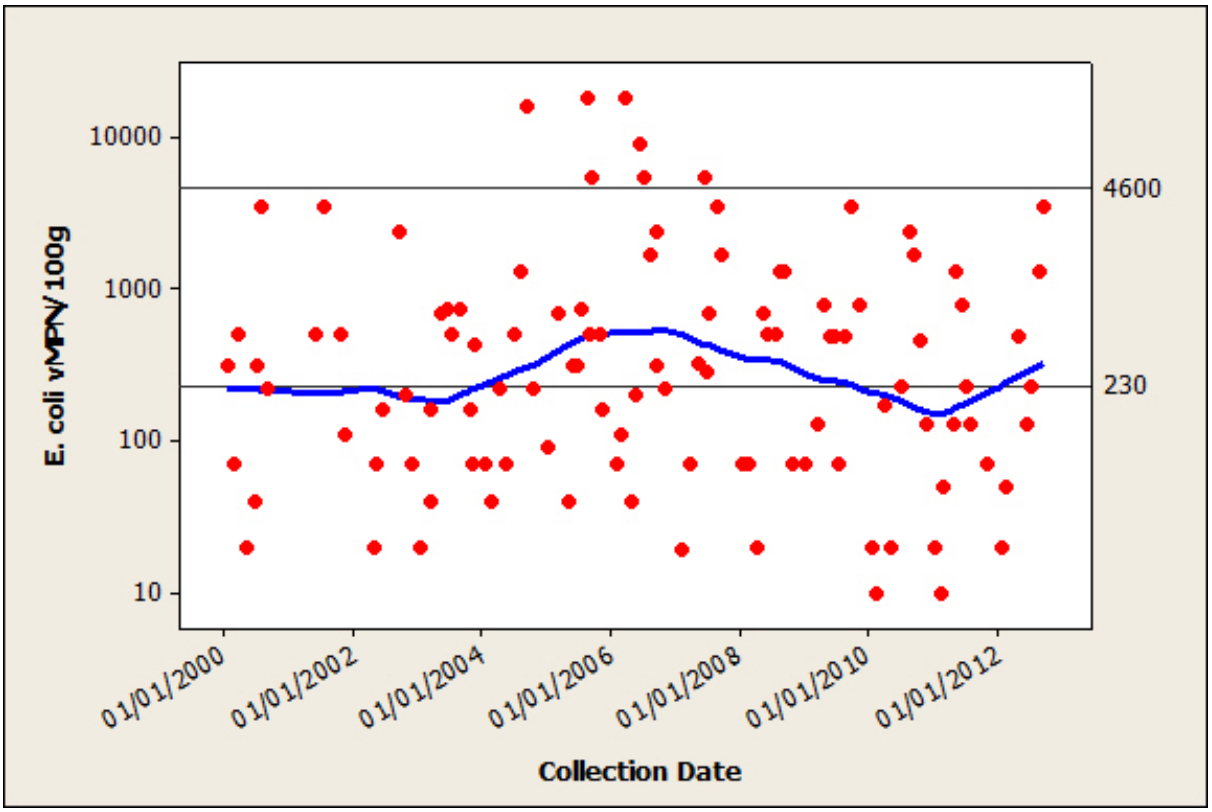

Figure 8.2 Scatterplot of shellfish *E. coli* result by date (2000-2012), with a lowess line

The number of samples taken across the years appears even and the majority of *E. coli* results are between 50-4600 *E. coli* MPN/100g. There are several results above 4600 *E. coli* MPN/100g between years 2005-2008, which causes a peak in the lowess line. Overall there is little change in average concentrations.

The historical classification status for the oyster fishery at Loch Gruinart varies between A and B, and is listed per month and year in Table 8.1.

Table 8.1 Classification status for Loch Gruinart Pacific oysters

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001	A	A	A	A	A	A	B	B	B	B	B	B
2002	A	A	A	A	A	A	B	B	B	B	B	B
2003	A	A	A	A	A	A	A	A	A	A	A	A
2004	A	A	A	A	A	A	A	A	A	A	A	A
2005	A	A	A	A	B	B	B	B	B	B	B	A
2006	A	A	A	A	B	B	B	B	B	B	B	A
2007	A	A	A	B	B	B	B	B	B	B	B	B
2008	B	B	B	B	B	B	B	B	B	B	B	B
2009	B	B	B	A	B	B	B	B	B	A	A	A
2010	A	A	A	B	B	B	B	B	B	B	B	B
2011	A	A	A	B	B	B	B	B	B	B	B	B
2012	A	A	A	B	B	B	B	B	B	B	B	B
2013	A	A	A									

During years 2003-2004 the oyster fishery at Loch Gruinart was classified as A all year round. This has since changed to a seasonal AB, with class B predominantly between April-December since 2007. In 2008 the fishery was class B all year.

Descriptive statistics for the *E. coli* results across sampling years 2000-2012 are listed in Table 8.2.

Table 8.2 Summary of statistics of *E. coli* results 2000-2012

Sampling Summary				
Production area	Islay: Loch Gruinart			
Site	Loch Gruinart			
Species	Pacific oysters			
SIN	AB 094 011 13			
Location	Loch Gruinart			
Years	2000-2006		2007-2012	
Total no. of samples	58		51	
	No. 2000	8	No. 2007	8
	No. 2001	4	No. 2008	9
	No. 2002	6	No. 2009	9
	No. 2003	10	No. 2010	9
	No. 2004	8	No. 2011	9
	No. 2005	11	No. 2012	7
	No. 2006	11	No. 2013	-
Results Summary				
Minimum	20		<20	
Maximum	>18000		5400	
Median	310		230	
Geometric mean	333		231	
90 Percentile	5400		1700	
95 Percentile	16100		3500	
No. exceeding 230/100g	30 (52%)		25 (49%)	
No. exceeding 1000/100g	12 (21%)		11 (22%)	
No. exceeding 4600/100g	6 (10%)		1 (2%)	
No. exceeding 18000/100g	2 (3%)		0	

Sampling results are shown to have varied between survey sampling years. The number of results >230 *E. coli* MPN/100 g has decreased (2.7%) between the first dataset (2000-2006) and the review dataset (2007-2012). A small increase (0.9%) in results >1000 *E. coli* MPN/100 g was present in the review dataset, whilst fewer (9.4%) results >4600 *E. coli* MPN/100 g and no results exceeded 18000 *E. coli* MPN/100 g. This correlated with a maximum for of >18000 *E. coli* MPN/100 g for the sampling years 2000-2006 and 5400 *E. coli* MPN/100 g for the sampling years 2007-2012. This also caused the 95 percentile to be greater for the sampling years 2000-2006 than 2007-2012. Overall *E. coli* results from the review dataset are generally lower than those from the first survey (2000-2006).

To test the significance in differences of sampling results between the two datasets, statistical analyses on the statistical software package Minitab were carried out.

Two sample t-test

A two sample t-test $\log_{10}$-transformed was carried out to determine whether there was a significant difference between *E. coli* results and the two survey periods (2000-2006 and 2007-2012).

No significant difference was found between log-transformed *E. coli* results from the two survey periods (Two sample t-test, t = 1.08, d.f. = 106, p = 0.284).

Chi-squared test

A Chi squared test was conducted to test for a significant difference in the observed and expected results of *E. coli* results above 230 *E. coli* MPN/100 g and 4600 *E. coli* MPN/100 g from both survey periods (2000-2006 and 2007-2012).

Table 8.3 Chi-squared test results

		***E. coli* MPN/100g**		**Total**
		≤230	>230	
2000-2006	Observed	28	30	58
2007-2012	Observed	23	28	51
	Total	51	58	109

No statistically significant difference was found between sampling results ≤ 230 *E. coli* MPN/100g and >230 *E. coli* MPN/100g between sampling periods (Chi-square test, X^2 = 0.110, DF = 1, P = 0.740).

Table 8.4 Chi-squared test results

		***E. coli* MPN/100g**		**Total**
		≤230	>230	
2000-2006	Observed	52	6	58
2007-2012	Observed	50	1	51
	Total	102	7	109

A statistically significant difference was found between sampling results ≤4600 *E. coli* MPN/100g and >4600 *E. coli* MPN/100g between sampling periods (Chi-square test, X^2 = 3.174, DF = 1, P = 0.075). More results >4600 *E. coli* MPN/100g were observed than expected in the 2000-2006 dataset, compared to fewer results >4600 *E. coli* MPN/100g were observed than expected in the 2007-2012 dataset.

9. Movement of contaminants

Hydrography at Loch Gruinart remains largely unchanged since the 2007 Report. Recent satellite imagery (© Google Earth 2012) shows how the sand bars at the entrance of the Loch have moved since 2008 in Figure 9.1 where the image on the left is from 2008 and on the right 2010. Shifts in sand bars are a normal and regular phenomenon. It is unclear whether the shifts will have significantly changed the tidal flushing within Loch Gruinart. It should also be noted that the time of year may also be significant in shaping the extent of the sand bars, with images taken at 23/09/2008 and 23/07/2011 respectively. Tidal state may also play a role in the sand bars that are evident in these images.

Figure 9.1 Google Earth Images of Loch Gruinart Craigens. Image courtesy of Image © 2012 Getmapping plc, DigitalGlobe, GeoEye. Data SIO, NOAA, U.S. Navy, NGA, GEBCO.

10. Overall Assessment

This assessment considers the information obtained since the 2007 Report and the potential changes in extent and location of faecal contamination.

Human sewage Impacts

Human sewage impacts remain largely unchanged since the 2007 Report and are categorised as being small, with no public sewage discharges and only 7 consented private septic tanks discharging into Loch Gruinart. Of these seven discharges, six soakaway to areas with good soil drainage characteristics, which will operate efficiently under normal conditions. The only septic tank that discharges into freshwater (Abhainn a Mhuillinn) is on the western side of Loch Gruinart and is not considered a contamination risk to the fishery. An additional presumed septic tank was observed at NR 29526 67650. The septic tank at Loch Gruinart RSPB Reserve was also not noted in the 2007 Report. Treatment involves reedbed filtration, which after heavy rainfall may cause an increase in faecal matter entering Loch Gruinart before sufficient filtration takes place.

Two additional small freshwater discharges were again identified during the present shoreline survey, one on the eastern shore and the other on the western shore. These were previously noted in the 2007 Report.

No significant changes to dwellings were found around Loch Gruinart. A steady increase in visitors to the Loch Gruinart RSPB visitor centre was reported, with this year's count 14,000, a rise from 12,000 in 2008. This increase is not thought to have a significant impact on faecal discharge from the reserve as the RSPB visitor centre sewage system has a capacity of 20,000pa. However this increase does suggest that tourism is increasing around Loch Gruinart and this may impact sewage discharging from other dwellings nearby that are predominantly used as holiday lets.

Agricultural impacts

Large numbers of livestock continue to be reared on fields surrounding the production area and evidence of livestock along the shoreline and around watercourses was prevalent during the latest shoreline survey. Livestock are therefore expected to continue to significantly contribute to contamination of the fishery, with contamination entering predominantly entering from the west and south coasts.

Two changes in agriculture were observed during the shoreline survey; turnips were being grown on the east side of the loch and a reclaimed wetlands area lay south. The wetlands area is used for overwintering birds and undergoes a flooding regime managed by the RSPB. This will prevent sheep grazing on this part of the Loch, which was previously thought to be a significant contamination source. However, the impact of overwintering geese remains uncertain.

Wildlife Impacts

While seals, otters and deer are known to be present around the fishery, their contamination impact remains uncertain. In addition, increasing numbers of geese overwintering at Loch Gruinart over the past two years will have increased their impact on the fishery, though the extent of this impact remains unclear.

Through discussions held with the harvester, a decrease in seal sightings was also reported, though when they have been seen, they have been in greater numbers

than previously observed. It is not expected that this will change will have a spatial implication on the impact of seals to the fishery.

Seasonal Variation

The classifications at Loch Gruinart Craigens has been a seasonal A/B for most years, with the A period usually covering January to March, and class B at other times, although this has varied over the years. This may coincide with higher visitor numbers at the RSPB Reserve, seasonal changes in livestock population and behaviour, and changes in rainfall.

Watercourses

Impacts from watercourses remain unchanged since the 2007 Report, with Abhainn Bun an Uillt and the Killinallan River both significantly impacting the fishery on ebb and flow tides with high *E. coli* loadings/day. Unnamed watercourses on the southern end of Loch Gruinart are also likely to contribute to contamination crossing the fishery at the ebb tide. Extent of this contamination will depend upon tide times, and level at which the oyster trestles become exposed.

Meteorology and movement of contaminants

The nearest weather station with the most complete dataset for this review was Tiree. Rainfall patterns in both datasets showed a marked increase in average rainfall beginning in September - January. An increase in rainfall following a period of drier weather would tend to flush bacteria from the surrounding land into the loch and will therefore coincide with high *E. coli* results.

The tidal nature at Loch Gruinart means movement of contaminants is predominantly tidally influenced, being driven into the loch on the incoming flood tide and drawn toward the ‘central’ channel, before heading out of the loch on the ebb tide. Given the location of the oyster bed, contaminants from streams and grazing animals on the adjacent shore would be washed across the trestles on each tide and as a result concentrated in the oysters.

Analysis of Results

The number of shellfish classification samples collected each year has varied markedly. In the last five years, between 7 and 9 samples were submitted per year, and for the sampling period 2000-2006 there were between 4 and 11 samples submitted per year. Historical *E. coli* data also shows that the geometric average of sample results for the period 2000-2006 is higher than those taken between 2007and 2012. The 95 percentile is also considerably greater from samples taken between 2000 and 2006 (16100 *E. coli* MPN/100 g) compared to between 2007 and 2012 (3500 *E. coli* MPN/100 g). It is unlikely that this change in results is due to the change in the location of the RMP.

Shellfish sampling conducted during the shoreline survey showed the highest *E. coli* (790 *E. coli* MPN/100 g) sample was taken at the southern end of the SGWs (NR 29438 69399), and directly south of Abhainn Bun an Uillt. The other three samples were taken from a more northern location, south of the Killinallan River. These samples varied from 130-490 *E. coli* MPN/100 g, with the most southerly sample having the lowest reading. It is therefore likely that positioning the oyster trestles mid-way between the Killinallan River and Abhainn Bun an Uillt will prevent these watercourses significantly contaminating the oysters, though despite pollution from these watercourses diluting, they are still likely to contaminate the oysters to some level.

Freshwater samples varied in results between <100 – 2700 *E. coli* cfu/100 ml. There was no clear trend in high and low *E. coli* results, thought two of the highest results were found on the western shoreline of the Loch. A large proportion of the freshwater discharges are found on the southern and eastern shorelines, closely associated with the SGW and likely to contaminate the fishery during ebb and flow tides.

Movement of contaminants

Movement of contaminants in Loch Gruinart is likely to be largely the same, despite some changes in sand bars at the mouth of Loch Gruinart. It appears even across the fishery on the incoming and outgoing tides, which spreads the impact across the extent of the fishery, leading to significant levels of contamination throughout with little to distinguish one area of the farm as less impacted than another.

Conclusions

The conclusion from the 2007 Report indicated that the following were the main potential sources of faecal contamination to the fishery at Loch Gruinart:

- Seals foraging amongst the trestles.
- Livestock frequenting areas below the tideline (in particular the salt flats at the south of the loch).
- Runoff from the pastures adjacent to the growing area (although no significant rain had been experienced at the site for at least a week prior to the survey).

From the recent shoreline survey no new and significant contamination risks were identified. However, some existing contamination risks are likely to have intensified. As reports have shown, overwintering geese numbers at Loch Gruinart have increased significantly since the 2007 report. Although this risk cannot be quantified, it is likely to have increased contamination from geese and will enter from all sides of Loch Gruinart. In particular, faecal loading from Loch Gruinart at the head of Loch Gruinart may preferentially increase and lead to increased contamination crossing oyster trestles used to grow juvenile oysters, at the southern end of the production area,

11. Recommendations

Production area

Production area boundaries should remain as the area enclosed by lines drawn between NR 2955 6935 to NR 2900 6935 to NR 2899 7000 to NR 3000 7147 to NR 3050 7147 extending to MHWS.

RMP

The RMP should remain the same as that classified by FSAS at NR 3027 7114.

Tolerance

10m

Depth

Not applicable

Frequency

Due to historical monitoring results showing seasonal fluctuations, it is recommended that monthly sampling is maintained for this production area.

12. References

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FSAS classification 2012-2013
http://www.food.gov.uk/multimedia/pdfs/shellclassscot2012.pdf

13. List of Figures and Tables

Appendices

1. Shoreline Survey Report

Appendix 1

Shoreline Survey Report

Production area:	Islay
Site name:	Loch Gruinart Craigens
SIN:	AB 094 011 13
Species:	Pacific oyster *(Crassostrea gigas)*
Harvester:	Mr Craig Archibald
Local Authority:	Argyll & Bute
Status:	Survey review
Date Surveyed:	16-17 October 2012
Surveyed by:	Michelle Price-Hayward; Eilidh Cole; Lars Brunner; Gail Twigg
Existing RMP:	NR 3024 7116
Area Surveyed:	North and south of the oyster farm on the eastern side of the loch. At the head of the loch, in the vicinity of Craigens Farm. On the western side of the loch, immediately opposite the oyster farm and at the northern end of the shoreline walk.

Weather

16th October 2012: Dry for 24 hours before and for most of the day; very fine drizzle around 15.00pm for approximately five minutes; very calm winds; cloud cover 70-80%; temperature 5.8°C.

17th October 2012: Heavy rain overnight; day started dry, rain started approximately 09.30am, occasionally heavy, stopped at approximately 13.30pm; cloud cover 100% at start of survey 80% towards the end; winds Northerly F10; temperature 7.8°C.

Fishery

The fishery is situated on the eastern shore of Loch Gruinart. The Pacific oyster *(Crassostrea gigas),* are grown in triangular baskets in cross-section, which are stacked on trestles. Three stacked rows, approximately seven per row ≈ (equates to) 21 per trestle. The whole trestle can be easily transported from shore to shed and baskets removed for easy collection.

Sewage Sources

There are four small settlements around the loch, Graighmor on the west, Aoradh and Craigens to the south, and Killnallan to the north-east. Most of the population is concentrated around the southern end of the loch. There are two farms on Loch Gruinart. SEPA identified 7 consented private septic tank discharges (2007), all but one of which discharged to land. Two additional small discharges to freshwater were observed during the shoreline survey.

Seasonal Population

Although there are no official campsites and caravan parks in the immediate area around the loch, on the first survey day (16/10/2012), a caravan with an

accompanying 4x4 vehicle was parked near the shore. The RSPB reserve and visitor centre is open at all times and offers guided walks in the summer months.

Boats/Shipping

There are no piers or anchorages in the area. However on the day of the survey (16/10/2012) a rib/inflatable boat was noted on the shore near the caravan described above.

Farming and Livestock

Sheep are grazed over much of the area. Many are fenced in but some roam freely. Approximately 450 sheep were counted (not including some free roaming) during the shoreline survey. Cattle were also present but in smaller numbers, at a count of approximately 30 (not including cattle in barn). The terrain was fairly rough and could have obscured additional animals. One cattle grid was present at the start of the walk at Craigens farm. Mr Archibald stated that at the time of the last survey there were approximately 1200 sheep and 1100 lambs and that this number may be down at present, but that geese numbers had and were increasing every year. There is an RSPB reserve in the area which farms cattle (250) and sheep (200). The RSPB are managing and extending an area of spring-sown arable crops to benefit winter farmland birds and provide some feed for livestock.

Land Use

Out with the RSPB reserve the land use in the area is almost exclusively agriculture.

Land Cover

The area around the loch is a mix of wetland, grassland, moorland and arable habitat. Improved pasture land is also evident, much of it grazed by sheep. The only crops noted on the day of survey were turnips growing in one field. There is a marshy area at the southern end of the loch where large numbers of geese roost overnight. The RSPB manages the reserve using a controlled grazing regime and maintaining winter flooding in the southern area of the loch to allow areas for geese. Cattle are taken indoors at this time or moved to other pastures.

Watercourses

A number of watercourses of various sizes and direct runoff from land were observed discharging into the loch, on both the east and west side, several of which were sampled. Areas of land seepage were evident.

Wildlife/Birds

The RSPB reserve hosts very large numbers of barnacle and Greenland white-fronted geese in autumn/winter. These were very much in evidence from areas of droppings and also flocks moving around grazing areas. Smaller numbers of wading birds were also noted on the shore. There is a seal haul out at or near the oyster trestles although no seals were noted at the time of survey.

Appendix 1

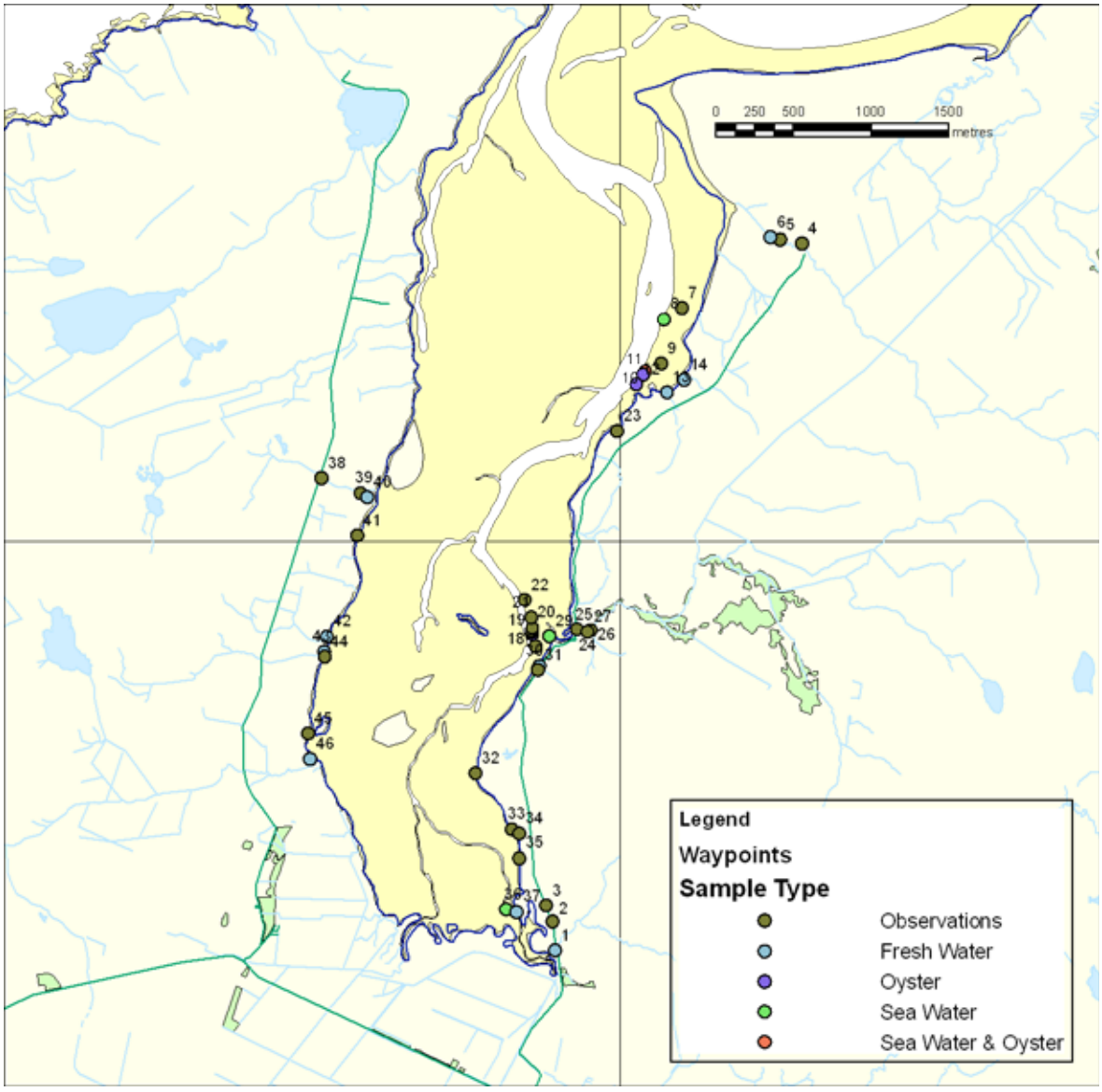

Figure 1 Map of shoreline observations, water and shellfish samples.

Appendix 1

Table 1 Shoreline Observations.

No.	Date	Time	NGR	Easting	Northing	Associated photograph	Associated sample	Observations/Description
a	16/10/12	09:30:36	NR29586 66360	129586	666360			Head of Loch, farms fields, 250 approx. sheep. Sheep gates between path and fields. Fields partitioned. Sound of geese.
b	16/10/12	09:42:12	NR29584 66460	129584	666460			More sheep to right of path approx. 100 sheep. Cattle in barn. Smell of silage and slurry.
1	16/10/12	09:56:36	NR 29583 67360	129583	667360		ISW1	Stream coming from hill, running under road then heading out to loch. Width185cm; depth 20cm; flow 0.12m/s; s.d. 0.006. Approx. 25 sheep in field next to road. Sheep droppings are present beside river.
2	16/10/12	10:06:14	NR 29569 67547	129569	667547			Many geese can be seen on mudflats. Approx.12 sheep grazing on open ground.
3	16/10/12	10.10.58	NR 29526 67650	129526	667650	Figure 2		Septic tank not shown on original survey plan. Well symbols were marked on map. Sheep roaming freely on both sides of path leading North.
4	16/10/12	10.50.17	NR 31175 71920	131175	671920	Figure 3		House is unoccupied but the farm is in use. There are sheep in field further back from farm. Water course running beside farm.
5	16/10/12	10.54.28	NR 31034 71945	131034	671945	Figure 4		Run-off from land drain. Water-logged area in field.
6	16/10/12	10.58.49	NR 30974 71962	130974	671962		ISW2	Stream coming from hill, running under wooden bridge then heading out to loch. Width 120cm; depth 35cm; flow 0.335m/s; s.d. 0.037; salinity 0.
7	16/10/12	11.37.49	NR 30402 71503	130402	671503			Watercourse flowing over mudflats to loch.
8	16/10/12	11.45.22	NR 30284 71431	130284	671431		ISW3	Seawater sample.

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No.	Date	Time	NGR	Easting	Northing	Associated photograph	Associated sample	Observations/Description
9	16/10/12	12.02.31	NR 30269 71145	130269	671145			Pictures of Regulatory Monitoring Point (RMP).
10	16/10/12	12.12.26	NR 30164 71095	130164	671095	Figure 5	ISSF1/ISW4	Oyster sample and seawater sample. Pacific oysters grown in stacked triangular cross-section baskets on trestles.
11	16/10/12	12.25.52	NR 30149 71074	130149	671074		ISSF2	Oyster sample.
12	16/10/12	12.27.47	NR 30107 71011	130107	671011		ISSF3	Oyster sample.
13	16/10/12	12.44.09	NR 30307 70957	130307	670957		ISW5	Stream coming from hill then heading out to loch. Width 55cm; depth 10cm; flow 0.124m/s; s.d. 0.011
14	16/10/12	13:01:53	NR 30416 71040	130416	671040		ISW6	Width 8 cm; depth 3cm; flow 0.465m/s*. Cow droppings around this site. Area almost exclusively agriculture.
15	16/10/12	15.03.01	NR 29456 69326	129456	669326	Figure 6		Survey resumed. View from the top of the shore showing track marks and extent of oyster trestles.
16	16/10/12	15.05.15	NR 29438 69399	129438	669399		ISSF4	Oyster sample. Tide starting to come in.
17	16/10/12	15:12:14	NR 29433 69415	129433	669415			Corner of oyster trestles.
18	16/10/12	15:12:42	NR 29431 69424	129431	669424			Corner of oyster trestles.
19	16/10/12	15:13:13	NR 29437 69440	129437	669440			Corner of oyster trestles.
20	16/10/12	15:13:29	NR 29436 69445	129436	669445			Corner of oyster trestles.
21	16/10/12	15:15:43	NR 29429	129429	669512			Corner of oyster trestles.

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No.	Date	Time	NGR	Easting	Northing	Associated photograph	Associated sample	Observations/Description
			69512					
22	16/10/12	15:18:14	NR 29385 69622	129385	669622			Corner of oyster trestles.
23	16/10/12	15:43:57	NR 29982 70708	129982	670708			Track going down to shore from road. 1 caravan, 1 4 X 4 car parked near shore. 1 launch on shore.
24	17/10/12	08:55:09	NR 29726 69433	129726	669433			Reading taken at car and start of second day of survey.
25	17/10/12	08:59:14	NR 29814 69429	129814	669429		ISW7	Stream coming from hill then heading out to loch. Width 2m; depth 30cm; flow 0.256m/s; s.d. 0.015. Cow dung in field next to water course. Evidence of cows being next to river by poached ground.
26	17/10/12	09:15:43	NR 29793 69419	129793	669419			Heading south, between oyster shed and sheepfold there is a turnip field.
27	17/10/12	09:28:12	NR 29547 69390	129547	669390		ISW8	Seawater sample.
28	17/10/12	09:37:23	NR 29480 69198	129480	669198	Figure 7 Figure 8	ISW9	Stream runs along the side of sheep fold and into a metal pipe which sticks out of the bottom of field. Large, rusty metal pipe leading from sheep fold down towards outfall from pipe, at time of survey no water coming from this pipe. Water flows under road and splits into two larger metal pipes. Upper pipe dia. 30cm; flow 0.076m/s*. Lower pipes: left pipe dia. 45cm; flow 0.022m/s*; right pipe dia. 45cm; flow 0.011m/s*.
29	17/10/12	09:47:13	NR 29473 69170	129473	669170			Sheep fold with approx. 20 sheep in adjacent field.
30	17/10/12	10:03:48	NR 29072 68503	129072	668503			Land run-off, shallow, green algae present.

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No.	Date	Time	NGR	Easting	Northing	Associated photograph	Associated sample	Observations/Description
31	17/10/12	10:15:10	NR 29305 68142	129305	668142	Figure 9		Goose droppings fairly dense and spread over a wide area.
32	17/10/12	10:22:23	NR 29354 68117	129354	668117			Natural drainage ditch along with some man-made drainage ditches.
33	17/10/12	10:26:55	NR 29353 67955	129353	667955			Sheep droppings in the intertidal drift. No geese present but approx. 15 wading birds on shore. Area of improved grassland.
34	17/10/12	10:49:16	NR 29267 67626	129267	667626	Figure 10	ISW10	River. Width 4m; depth 55cm; flow 0.254m/s; s.d. 0.021; salinity 27‰. Grassland around river water-logged.
35	17/10/12	11:05:04	NR 29333 67610	129333	667610		ISW11	Water sample taken for fresh water test.
36	17/10/12	12:39:10	NR 28077 70405	128077	670405			West side of the loch survey. 14 cows at start of survey at the farm (Garra Eallabus).
37	17/10/12	12:46:45	NR 28329 70308	128329	670308			Evidence of sheep drinking water from here, droppings present and poaching of ground. Approx. 20 sheep in field.
38	17/10/12	12:49:01	NR 28371 70281	128371	670281	Figure 11	ISW12	Stream flowing downhill through field heading out to loch. Width 53cm; depth 9.5 cm; flow 0.503 m/s; s.d. 0.012. Large piece of rusty corrugated iron in stream. Further downstream large plastic container. 16 cows in adjacent field.
39	17/10/12	13:03:58	NR 28308 70033	128308	670033			Fields around the shoreline are fenced but evidence of both cows and sheep being on the shore with the presence of droppings.
410	17/10/12	13:20:23	NR 28110 69386	128110	669386		ISW13	Small stream flows through rough grassland to loch. Water flow slow. Width 60cm; depth 19cm; flow 0.017m/s; s.d. 0.005.
41	17/10/12	13:38:50	NR 28095	128095	669289		ISW14	Small stream flows through rough grassland to loch. Width 70cm; depth 8.5 cm; flow 0.155m/s; s.d. 0.007. This stream is

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No.	Date	Time	NGR	Easting	Northing	Associated photograph	Associated sample	Observations/Description
			69289					a split from previous waymark 42. At this point the sea is approx. 1km away.
42	17/10/12	13:40:17	NR 28099 69256	128099	669256			Dead sheep in stream.
43	17/10/12	13:51:54	NR 27988 68759	127988	668759			Approx. 300 geese on mudflats.
44	17/10/12	13:59:31	NR 28002 68597	128002	668597	Figure 12	ISW15	Small stream flows through rough grassland to loch. Width 20cm; depth 25cm; flow 0.326 m/s; s.d. 0.012.

Photographs referenced in the table are attached as Figures 2 – 12.

*Indicates flow rate measured using volume of water collected over a specific time.

Appendix 1

Sampling

Water and shellfish samples were collected at sites marked on the map in Figure 1. Samples were transferred to either Biotherm 10 or Biotherm 25 boxes with ice packs and shipped to Glasgow Scientific Services (GSS) for *E. coli* analysis. All samples were shipped on the day collected except ISSF 4 which was shipped the following day. All samples were received and analysed by GSS on the day following collection, except for ISSF 4 which was analysed two days following collection. Sample temperatures on arrival at GSS ranged between 1.5 ºC and 8.0 ºC. The results are presented in Tables 2 and 3.

Seawater samples were tested for salinity by GSS and results reported in mg Chloride per litre. These results have been converted to parts per thousand (ppt) using the following formula:

Salinity (ppt) = 0.0018066 X Cl^- (mg/L)

As the oyster fishery was at an intertidal zone, shellfish samples were taken at low tide and no boat was required. No salinity profiles were taken.

Table 2 Water Sample Results

No.	Date	Sample	Grid Ref	Type	*E. coli* (cfu/100ml)	Salinity (ppt)
1	16/10/2012	ISW1	NR 29583 67360	Fresh	100	-
2	16/10/2012	ISW2	NR 30974 71962	Fresh	100	-
3	16/10/2012	ISW3	NR 30284 71431	Sea	3	35.41
4	16/10/2012	ISW4	NR 30164 71095	Sea	10	34.33
5	16/10/2012	ISW5	NR 30307 70957	Fresh	<100	-
6	16/10/2012	ISW6	NR 30416 71040	Fresh	<100	-
7	17/10/2012	ISW7	NR 29814 69429	Fresh	100	-
8	17/10/2012	ISW8	NR 29547 69390	Sea	66	35.95
9	17/10/2012	ISW9	NR 29480 69198	Fresh	100	-
10	17/10/2012	ISW10	NR 29267 67626	Sea	2100	26.38
11	17/10/2012	ISW11	NR 29333 67610	Fresh	2000	-
12	17/10/2012	ISW12	NR 28371 70281	Fresh	900	-
13	17/10/2012	ISW13	NR 28110 69386	Fresh	1900	-
14	17/10/2012	ISW14	NR 28095 69289	Fresh	2000	-
15	17/10/2012	ISW15	NR 28002 68597	Fresh	2700	-

Table 3 Shellfish Sample Results.

No.	Date	Sample	Grid Ref	Type	*E. coli* (MPN/100g)
1	16/10/2012	ISSF1	NR 30164 71095	Pacific Oysters	460

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2	16/10/2012	ISSF2	NR 30149 71074	Pacific Oysters	490
3	16/10/2012	ISSF3	NR 30107 71011	Pacific Oysters	130
4	16/10/2012	ISSF4	NR 29438 69399	Pacific Oysters	790

Where watercourses were too small or impractical to measure using the flow meter then flow rate was measured using a bucket where a measured volume of water was collected over a specific time. This was then calculated using the equation:

$V = 354 \times Q/D^2$ where,

Velocity (V) = Vel. m/s

Flow (Q) = m^3/h (1L/s = $3.6m^2/h$)

Diameter (D) = Internal diameter of pipe in mm

Photographs

Figure 2 Septic tank not shown on original survey plan.

Appendix 1

Figure 3 Stream running past farm.

Figure 4 Run-off from land pipe.

Appendix 1

Figure 5 Pacific oysters growing in stacked triangular baskets on trestles. Water and oyster sample ISSF1/ISW4.

Figure 6 View from top of shore showing track marks and extent of oyster trestles.

Appendix 1

Figure 7 Stream running through metal pipe.

Figure 8 Same stream as above channelled into two metal pipes. Water sample ISW9.

Appendix 1

Figure 9 Goose droppings.

Figure 10 River and water-logged rough grassland. Water sample ISW10.

Appendix 1

Figure 11 Stream with rusty corrugated metal sheeting. Water sample ISW12.

Figure 12 Small stream flowing through rough grassland to loch. Water sample ISW15. Geese can be seen in distance on mudflats.