Scottish Sanitary Survey Programme

Sanitary Survey Review
Loch Fyne Ardkinglas
AB 147
June 2014

Cefas

Food Standards Agency
food.gov.uk

Report Title	Loch Fyne Ardkinglas Review
Project Name	Scottish Sanitary Survey
Client/Customer	Food Standards Agency Scotland
Cefas Project Reference	C5792D
Document Number	C5792D_2013_3
Revision	V1.0
Date	09/06/2014

Revision History

Revision number	Date	Pages revised	Reason for revision
0.1	28/03/2014	All	Draft
1.0	05/06/2014	2,4,6,7,10,11,15, 21-29,30,33	Typographical corrections in accordance with comments received

	Name	Position	Date
Author	Michelle Price-Hayward	Senior Shellfish Hygiene Scientist	05/06/2014
Checked	Ron Lee	Principal Shellfish Hygiene Scientist	09/06/2014
Approved	Ron Lee	Principal Shellfish Hygiene Scientist	09/06/2014

Centre for Environment, Fisheries & Aquaculture Science, Weymouth Laboratory, Barrack Road, The Nothe, Weymouth DT4 8UB. Tel 01305 206 600
www.cefas.defra.gov.uk

Report Distribution

Name	Agency
Joyce Carr	Scottish Government
Hazel MacLeod	SEPA
David Denoon	SEPA
Fiona Garner	Scottish Water
Alex Adrian	Crown Estate
Fraser Anderson	Argyll & Bute Council
Andy MacLeod	Argyll & Bute Council
David Attwood	Harvester

Partner Organisation

The shoreline survey and its associated report were undertaken by SRSL, Oban.

Table of Contents

Review Specification & Introduction

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 recommends 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, this review is comprised of a brief desktop search of publicly available information together with a shoreline survey. No additional data requests are submitted to external bodies. The review is intended to identify significant changes in:

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

The output of the review is a report identifying any new information that has been obtained and/or whether major elements of the original sanitary survey can be regarded as essentially unchanged. That report includes 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, a description of the revised boundaries and a revised sampling plan with the boundaries and RMP(s) locations.

A sanitary survey was undertaken in 2007 for Loch Fyne: Ardkinglas. The survey was conducted to identify the location, extent and nature of the shellfishery and the potential sources of faecal contamination to the shellfishery, and to recommend boundaries and sampling plans for the production areas.

The output of the sanitary survey included a report and recommended sampling plans for the two species cultured within the production area. These sampling plans are identified on the following pages alongside the recommended changes following findings from this review.

The present report constitutes a review of publicly available information in order to assess changes that have occurred since the 2007 sanitary survey report (see the Review Specification section for further detail). It is not intended to present detailed information relating to pollution sources that were identified in the previous report. This review should be read in conjunction with the 2007 sanitary survey report.

Sampling Plan - Loch Fyne: Ardkinglas mussels

	2008 recommendations	2013 review	Changes
PRODUCTION AREA	Loch Fyne: Ardkinglas mussels		None
SITE NAMES	Ardkinglas mussels – north site		Amended to reflect fishery layout
SIN	AB 147		None
SPECIES	Common mussels		
TYPE OF FISHERY	Longline aquaculture		
NGR OF RMP	NN 1674 1015	NN 1673 1024	Amended to reflect movement of the mussel farm
EASTING	216740	216730	
NORTHING	710150	710240	
TOLERANCE (M)	10	40	Amended to allow shifting of mussel lines
DEPTH (M)	1	1	None
METHOD OF SAMPLING	Hand		None
FREQUENCY OF SAMPLING	Monthly		
LOCAL AUTHORITY	Argyll & Bute Council		
AUTHORISED SAMPLER(S)	Christine McLachlan, William MacQuarrie, Ewan McDougall, Donald Campbell	Fraser Anderson Karen Goodchild William McQuarrie Ewan McDougall Allison Hardie	Change in personnel
RECOMMENDED PRODUCTION AREA	Area bounded by lines drawn between NN 1500 1002 and NN 1500 0865 and between NN 1748 1057 and NN 1748 1135	Area bounded by lines drawn between NN 1500 1002 and NN 1500 0865 and between NN 1748 1057 and NN 1748 1135	None

Sampling Plan – Loch Fyne: Ardkinglas Pacific oysters

	2008 recommendations	2013 review	Changes
PRODUCTION AREA	Loch Fyne: Ardkinglas Pacific oysters		None
SITE NAMES	The Shore, The Point, Policy Gates	The Point	Amended to reflect RMP location
SIN	AB 147		None
SPECIES	Pacific oysters		
TYPE OF FISHERY	Trestle	Trestle and suspended cage	Change in culture method
NGR OF RMP	NN 1741 1054	NN 1741 1054	None
EASTING	217410	217410	
NORTHING	710540	710540	
TOLERANCE (M)	10	10	
DEPTH (M)	1	1	
METHOD OF SAMPLING	Hand		None
FREQUENCY OF SAMPLING	Monthly		
LOCAL AUTHORITY	Argyll & Bute Council		
AUTHORISED SAMPLER(S)	Christine McLachlan, William MacQuarrie, Ewan McDougall, Donald Campbell	Fraser Anderson Karen Goodchild William McQuarrie Ewan McDougall Allison Hardie	Change in personnel
RECOMMENDED PRODUCTION AREA	Area bounded by lines drawn between NN 1500 1002 and NN 1500 0865 and between NN 1748 1057 and NN 1748 1135	Area bounded by lines drawn between NN 1500 1002 and NN 1500 0865 and between NN 1748 1057 and NN 1748 1135	None

1. Area and Fishery

Loch Fyne is located on the west coast of Scotland, at the northern end of the Firth of Clyde. It is a long, fjordic sea loch hosting a number of shellfish and finfish aquaculture fisheries. The Ardkinglas production area, at the head of Loch Fyne, received a sanitary survey in 2007/2008. The general location of the Loch Fyne Ardkinglas production area is shown in Figure 1.1.

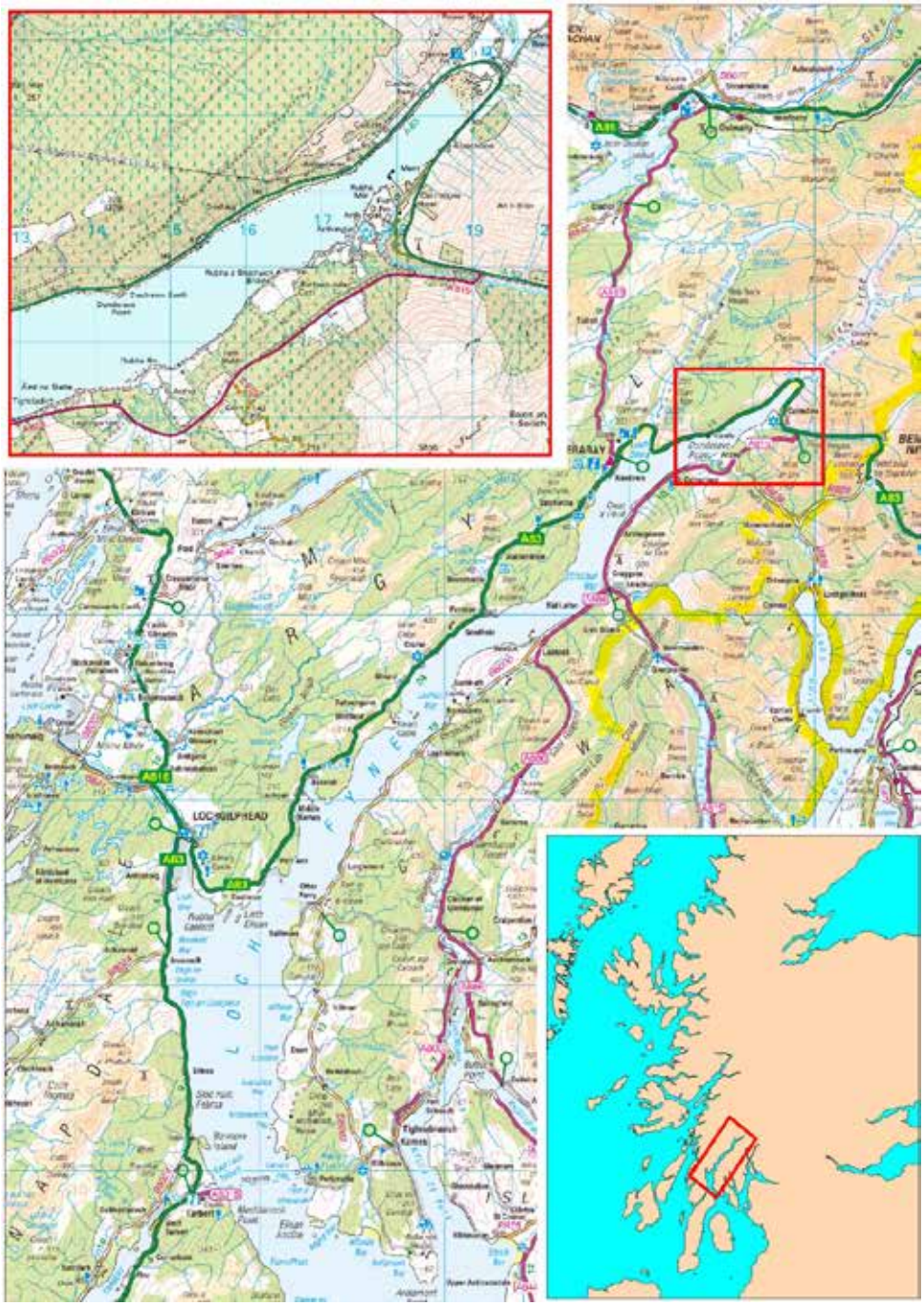

Figure 1.1 Location of Loch Fyne: Ardkinglas

The Loch Fyne: Ardkinglas production area is classified for the production of both Pacific oysters (*Crassostrea gigas*) and common mussels (*Mytilus* sp). Fishery identification details and representative monitoring points are given in Table 1.1.

Table 2.1 Loch Fyne: Ardkinglas classified fishery

Production area	SIN	Species	RMP (from FSAS RMP listing)	Recommended RMP from 2007 survey
Loch Fyne: Ardkinglas	AB-147-034-08	Common mussels	NN 1673 1024	NN 1674 1015
Loch Fyne: Ardkinglas Oysters	AB-147-034-13	Pacific oysters	NN 1741 1054	NN 1741 1054

The production area boundaries are described as “the area bounded by lines drawn between NN 1500 1002 and NN 1500 0865 and between NN 1748 1057 and NN 1748 1134” and have not changed since the 2008 sanitary survey report.

At the time of the October 2007 shoreline survey, Pacific oysters were grown in poches on trestles set on the intertidal shoreline extending southward approximately 1.4 km from Ardkinglas House to just south of the point near Bàthach-Bàn Cottage. The majority of trestles were located between Ardkinglas House and Rubha Beag, however two further areas of trestles were situated between Rubha Beag and the Saw Mill, and at Bàthach-Bàn. Common mussels were grown on pegged droppers suspended from long lines set in two large blocks, one south of Rubha Beag and the other south of Rudha a’Bhàthaich Bhàin.

At the time of shoreline survey in 2013, the areas of trestles on the intertidal shore had shrunk markedly, with the remaining production still located in the same three main areas as before. However, the blocks of trestles were both smaller and less numerous at Ardkinglas House and the Saw Mill whilst an additional area of trestles had been set to the south of the areas previously seen at Bathach-Ban and the three blocks seen there in during the 2007 shoreline survey were now replaced with one block situated lower on the shore. A single trestle was set at the RMP location for sampling purposes.

There has been a shift in the production method for oysters from the use of poches on trestles to oblong baskets hung either from trestles or in cassettes of 5 suspended from longlines on the inshore side of the mussel farms.

The mussel RMP recommended in 2008 has been amended as the block of longlines has moved further offshore. However, it is still situated in the southeast corner of the farm which is consistent with the relative location recommended in 2008. The Pacific oyster RMP has remained the same. The relative locations of the areas under culture, RMPs, seabed lease areas and production area boundaries are shown in Figure 1.2.

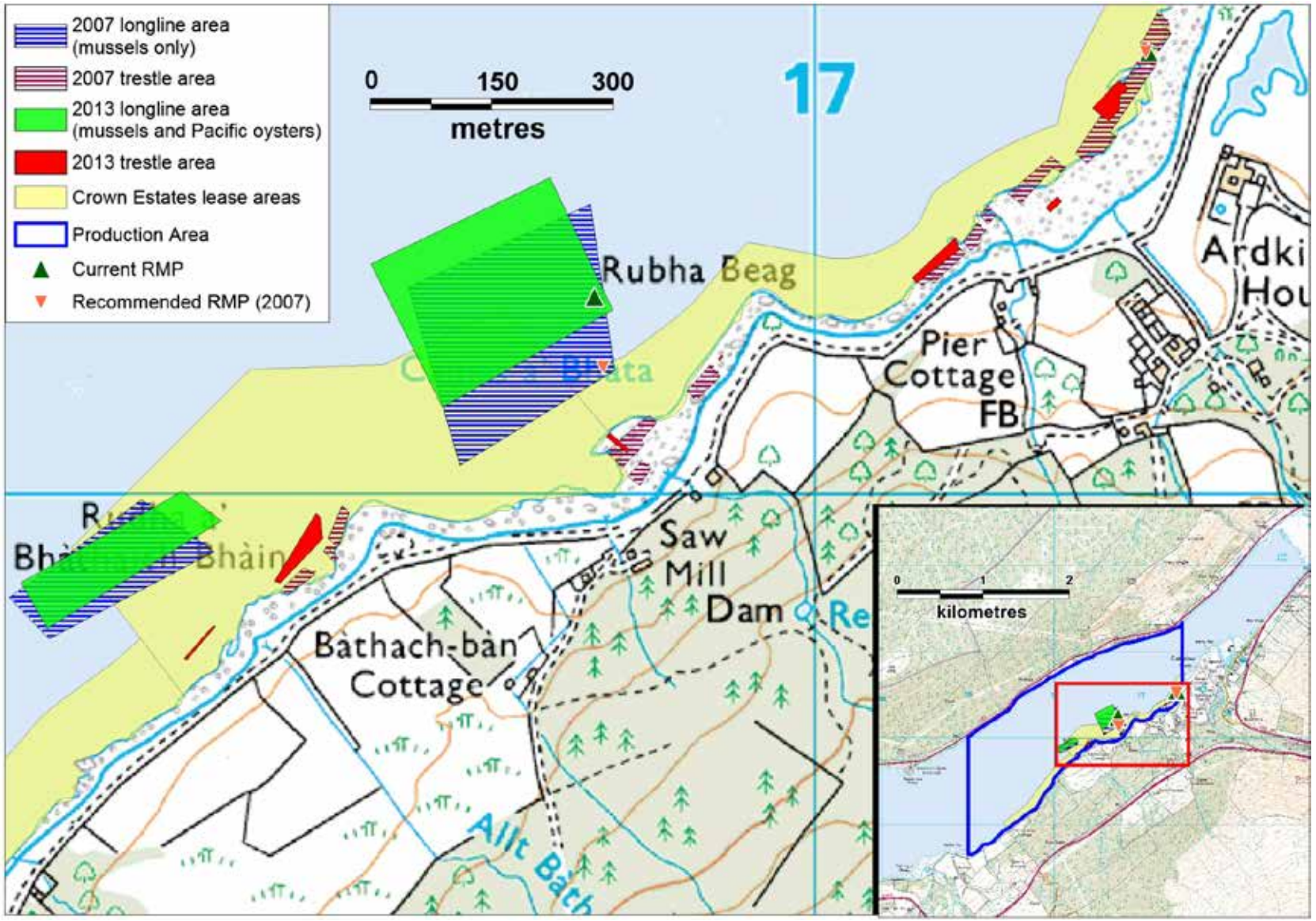

Figure 1.2 Current fishery production area, with current and historical farm boundaries at Loch Fyne: Ardkinglas

2. Population and Human Sewage Impacts

Population

Population data for both the 2001 and 2011 censuses was obtained from the General Register Office for Scotland. Totals for the those areas around upper Loch Fyne are shown in Table 2.1. Direct comparisons are precluded by the changes in some of the output areas and in the output area identifiers. However, the total area included from both datasets is essentially the same. A map showing the population density by output area, as well as the locations of main centres of population, is shown in Figure 2.1.

Table 2.1 Population census data for areas around Loch Fyne: Ardkinglas, from 2001 and 2011

2001 Census		2011 Census	
Output Areas	**Population Counts**	**Output Areas**	**Population Counts**
60QD000029	103	S00069064	75
60QD000039	110	S00069088	126
60QD000069	184	S00069320	87
60QD000032	96	S00069342	78
60QD000033	153	S00069308	143
60QD000563	141	S00069332	86
60QD000073	136		
60QD000071	122	S00069341	116
60QD000072	105	S00069465	91
60QD000070	81	S00069053	83
		S00069625	114
		S00069626	86
		S00069628	106
Total	**1231**	*Total*	**1191**

A small decrease in population for the overall area was seen between 2001 and 2011. The remaining population has become more concentrated in the output areas around Inveraray, the principal centre of population for the area.

Although not specifically noted in the 2008 sanitary survey, the area draws significant numbers of visitors from outside the area. At the head of the loch are a council information point, visitor centre, restaurant, cafe, smokehouse and garden shop and there is a brewery with visitor centre a short distance north of the loch along the River Fyne. Ardkinglas House (http://www.ardkinglas.com/) is available for wedding hire and open year round for visitors to the gardens and private tours of the house. Public tours are offered weekly from April to October.

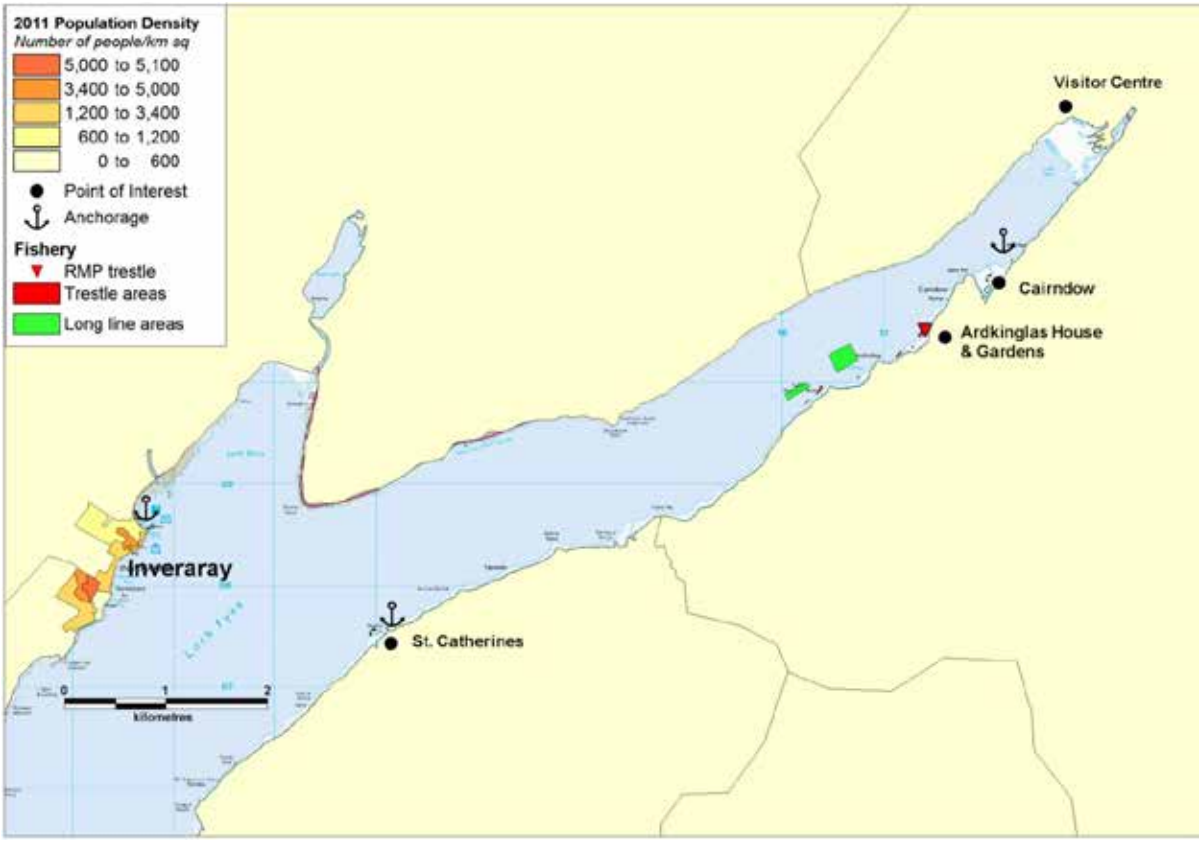

Figure 2.1 Population and visitor attractions around upper Loch Fyne

The smaller village of Cairndow lies immediately to the north of the fishery. There is a small hotel (19 rooms) and pub, and some of the homes in the area are likely to be only seasonally occupied. A fish processing plant is located to the south of the village. The plant employs approximately 40-50 people. The Loch Fyne Oysters Ltd depuration facility is located on the shore adjacent to the fishery. A community website associated with Cairndow identified that approximately 200 people live in Cairndow and that over 200 people work in and around Cairndow (http://www.hereweare-uk.com/news/index.html). Further to the southwest is the settlement of St. Catherines, which has a hotel and caravan park.

Information on planning applications for the area around upper Loch Fyne was sought via the Argyll & Bute Council Planning portal (http://publicaccess.argyll-bute.gov.uk/publicaccess/) on 20/3/2014. Only those consents involving changes in sewerage arrangements were considered in this review.

A significant number of planning applications were submitted to Argyll & Bute Council for developments around Inveraray and Cairndow. Most applications related to conversion of existing buildings to dwellings or construction of new dwellings in or near Inveraray, Cairndow and St. Catherines. Nine consents related to properties in and around Cairndow and the head of the loch. Three applications related to development at the loch head. These included applications

for creation of a visitor centre at the brewery and installation of improved septic facilities for the restaurant, both of which were observed during the shoreline survey. The brewery application included an estimate of 25 visitors per day. The third application related to mixed use development, including 16 homes and a child care centre, on land adjacent to Ardkinglas sawmill at Clachan. This had not yet been developed at the time of shoreline survey.

A further application pertained to the development of 15 homes and road access on land at Pheasant Field, approximately 200m to the southwest of Ardkinglas House. Undeveloped plots at this location are currently being marketed.

Planning applications relating to property developments at Cairndow and at Loch Fyne head suggest that there is potential growth in human population in these areas.

Sewage Discharges

The sanitary survey identified two community septic tanks: one serving the town of Inveraray and another serving the village of Cairndow. In addition, the Scottish Environment Protection Agency (SEPA) provided information on consented discharges from seven smaller, private septic tanks, half of which discharged to land and the other half of which discharged to Loch Fyne.

Information provided by Scottish Water suggested that only a small proportion of the properties in Cairndow were connected to mains sewerage, and a proposed scheme to provide an expanded service to the village received little interest and so was abandoned. During the 2007 shoreline survey, septic tanks and/or outfalls were observed near the restaurant and community centre at the head of the loch, adjacent to a fish processing plant near the north end of the oyster farm, and at the shellfish depuration centre at Ardkinglas. The discharges nearest the shellfish farm, and therefore considered of greatest impact to water quality there, were the discharges from the Cairndow septic tank, the fish processing plant and the depuration centre.

Locations for the Cairndow septic tank and outfall were confirmed during the 2013 shoreline survey. Discharges for both septic tank effluent and trade effluent were also seen again in 2013 and remained in use. A septic tank for Ardkinglas House was not found, however according to the estate owner, the outfall for the tank discharged some distance beyond the oyster trestles on the adjacent shore to the house. This pipe is buried and therefore was not visible at even very low spring tides. The septic tank outfall from the depuration centre was not seen during the 2013 survey.

Table 2.2 Sewage discharge-related observations around Loch Fyne: Ardkinglas - 2013 shoreline survey

No.	Date	NGR	Associated photograph (Appendix X)	Description
1	09/09/2013	NN 1765 1086	Fig 6	Two metal discharge pipes on shore in front of [Scottish Salmon Company]. Sample taken from flow below pipes, smell of sewage. Sewage fungus below and green algae growing around pipes. One pipe is heavily flowing, the other is just dripping.
2	09/09/2013	NN 1765 1087	Fig 7	Pipe encased in concrete running far out to sea from [Scottish Salmon Company] - effluent pipe according to staff member. Can hear water running in pipe.
3	09/09/2013	NN 1809 1097		Strong smell of sewage and toilet paper on shore. No pipes, outfalls or septic tanks observed.
4	09/09/2013	NN 1809 1099	Fig 9	Clay outfall pipe from Scottish Water septic tank discharges into river. Smell of sewage.
5	09/09/2013	NN 1818 1105	Fig 10	Metal pipe runs under the road onto shore. Houses behind [above shoreline] Pipe diameter 20 cm. No discharge [seen].
6	09/09/2013	NN 1823 1111		Clay pipe, approx. diameter 30 cm. No flow, no algal growth around it.
7	09/09/2013	NN 1827 1117	Fig 12	An orange pipe with approx. 30 cm diameter directed into river. No flow from pipe.
8	10/09/2013	NN 1890 1265	Fig 19	Septic tank at Loch Fyne Oyster Visitor Centre.
9	10/09/2013	NN 1889 1263	Fig 20	Watercourse running from side of Loch Fyne Restaurant indication of sewage fungus present, also smelly.

The septic tank at the head of the loch was observed and though the outfall was obscured by vegetation, the watercourse flowing adjacent to the tank appeared to be receiving septic effluent based on the odour and the small amount of sewage fungus seen there. The water sample taken from this outlet in 2013 showed markedly reduced levels of *E. coli* compared to the 2007 survey (<1000 cfu/100 ml in 2013 compared to >100000 cfu/100 ml in 2007).

The septic tank and outfall at Inveraray were not visited during the review shoreline survey as the sanitary survey identified that discharges from this area were considered unlikely to significantly impact water quality at the fishery.

The planned development of up to 15 houses at Pheasant Field is intended to include 2 septic systems that would discharge to the adjacent, unnamed watercourse. Additional septic input to this watercourse would be expected to have a significant impact on the nearby oyster trestles. The locations of community discharges and observed discharges from the 2013 shoreline survey, as well as planning applications, are shown in Figure 2.2.

Conclusions

There has been an improvement to the discharge from the restaurant at the head of the loch, which should result in a decrease in faecal indicator load coming from that source. There has been no substantive change to discharges from Cairndow and the fish processing plant to the north of the oyster farm. The outfall from the depuration plant was not seen, but is presumed to be extant.

The main human sewage impacts remain to the northern end of the shellfishery. Proposed development, particularly on the Ardkinglas estate, could increase this impact in future.

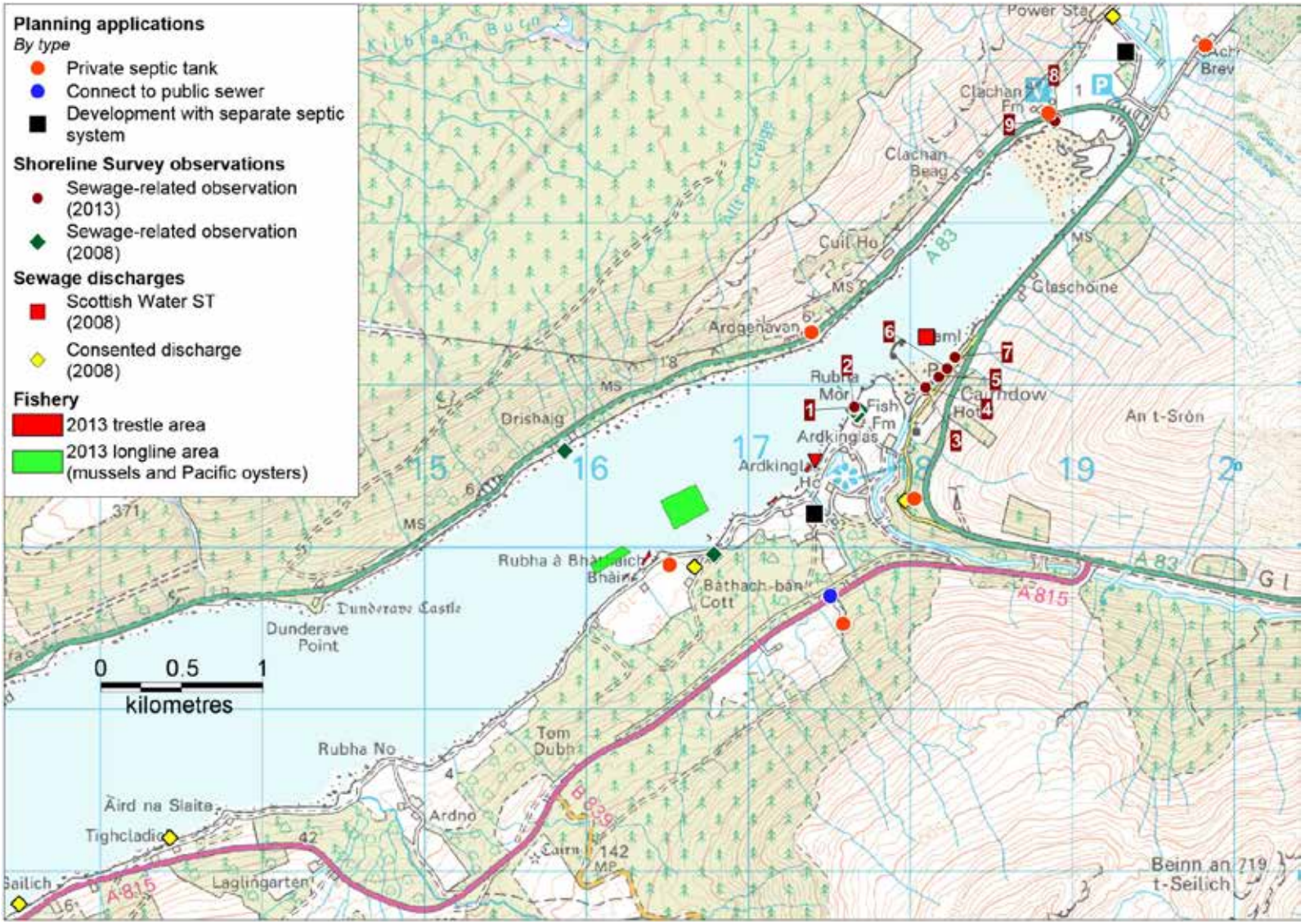

Figure 2.2 Sewage sources and sewage related observations in the vicinity of Loch Fyne: Ardkinglas

3. Agricultural Impacts

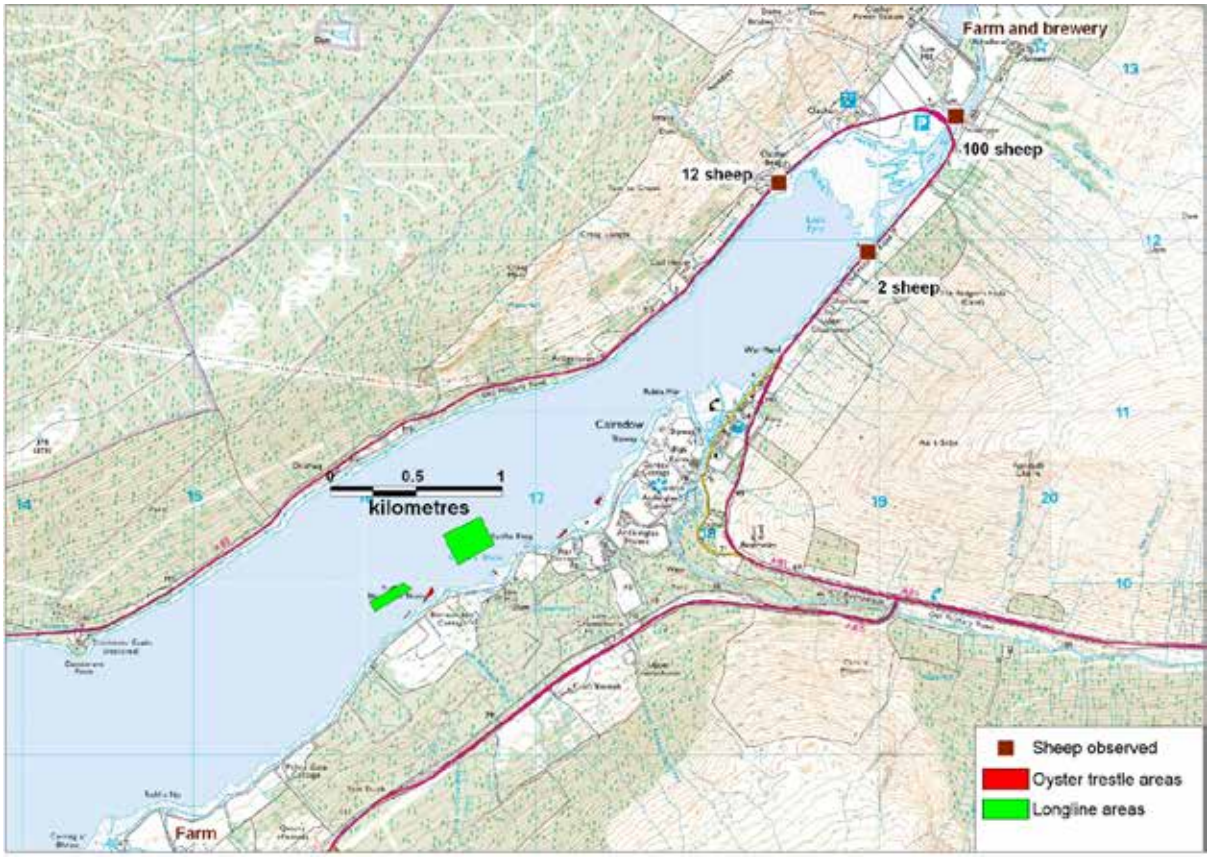

Figure 3.1 Farm animals and associated observations made during the 2013 shoreline survey

Much of the shoreline around the loch is wooded and therefore unsuitable for agricultural use other than forestry. Some of the area around the loch is managed forestry, however the majority is part of the Ardkinglas Estate.

Areas of improved grassland are found around the head of the loch and along the lower River Fyne. As during the 2007 shoreline survey, sheep were seen grazing land at the head of the loch, adjacent to the river and community centre. In addition, cattle are kept on the farm at Achadunan, where there is also a brewery.

Livestock were also seen during the 2007 shoreline survey at a farm southwest of the production area. This farm was not visited during the 2013 shoreline survey. Publicly available satellite images taken sometime between May 2011 and May 2012 (http://www.bing.com/maps/?mkt=en-gb, viewed 27/3/2014) showed the farm to be active, with approximately 200 sheep in fenced fields around the farm at the time of imaging. A further 200+ sheep were visible on fields to the north of the farm and brewery at the head of the loch. All animals appeared to be fenced and no evidence was found of livestock on the shoreline during the 2013 shoreline survey. Overall the number of livestock present is higher than estimated in the

2008 sanitary survey, with the greater number of animals present on fields adjacent to the lower River Fyne. The farm to the southwest of the production area lies 1.6 km from the southern extent of the mussel and oyster farms and is therefore closer to the shellfishery than the farmed area around the River Fyne, which is over 2 km away from the nearest part of the shellfish farm.

4. Wildlife

For this review, information on pollution sources from wildlife has been obtained from Seabird 2000 data (Mitchell, Newton, Ratcliffe, & Dunn, 2004), through shoreline surveys conducted in 2007 and 2013, and through a desk-based internet search. Shoreline survey observation information only relates to the time of the surveys undertaken in October 2007 and on the 4th & 5th September 2013. Wildlife observations are displayed in Figure 4.1. Birds were the only wildlife noted during the shoreline survey, with two large congregations seen: approximately 100 gulls and 40 geese were seen on the intertidal shoreline at the head of the loch and approximately 100 gulls were seen at the mouth of Kinglas Water, where goose droppings were also seen. Other observations related to individual or very small numbers of birds only.

No records were found in the Seabird 2000 data for breeding birds along the coastline of Loch Fyne. The intertidal area at the head of the loch may host wading birds and gulls.

Neither grey nor harbour seals were recorded in the northern end of Loch Fyne in August counts undertaken by the Seal Mammal Research Unit (SMRU, 2012). No seals were observed during either shoreline survey.

Deer are present in the woodland areas around the loch, though no estimates were available of the numbers. Deer, as well as other smaller land mammals, are likely to contribute to faecal indicator loadings carried in watercourses throughout the area.

Overall, no information was found to suggest a significant change in wildlife impacts at Loch Fyne: Ardkinglas.

5. Watercourses

A total of 32 watercourses had been measured and sampled during the 2007 shoreline survey, and of these two watercourses discharging nearest the trestles, an unnamed watercourse and Kinglas Water, were identified as being the most significant in terms of impact to the shellfishery. Loadings at these two watercourses were 3.1×10^{11} and 2.1×10^{11}, respectively. Rain was recorded on

the morning of the second survey day, however the previous and subsequent days were dry.

The 2013 shoreline survey was undertaken under dry weather on the survey days, though heavy rain had fallen prior to the survey and during the evening of the first survey day.

A full list of recorded flow measurements and sample results from the 2013 shoreline survey can be found in the shoreline survey report in Appendix 2.

Table 5.1 shows watercourse loadings estimated on the basis of the 2013 shoreline survey measurements and *E. coli* concentrations.

Table 5.1 Watercourse loadings at Loch Fyne: Ardkinglas, 2013 survey

No.	Description	NGR	2013 *E. coli* (cfu/ 100 ml)	2007 Loading (*E. coli* per day)	2013 Loading (*E. coli* per day)
1	Allt na Criche	NN 18429 12317	<10	not recorded	$<1.7 \times 10^{8}$
2	Unnamed watercourse	NN 18892 12634	<1000	$1.8 \times 10^{12*}$	$<2.14 \times 10^{10}$
3	River Fyne	NN 19477 12711	90	5.4×10^{10}	3.8×10^{12}
4	Unnamed watercourse	NN 18939 11937	20	not recorded	1.62×10^{8}
5	Kinglas Water – East branch	NN 18094 10990	50000	**	3.01×10^{12}
6	Kinglas Water – West branch	NN 17962 10917	40	2.1×10^{11}	5.36×10^{10}
7	Unnamed watercourse	NN 17343 10354	780	3.1×10^{11}	1.15×10^{10}
8	Alltan Fichead Sgillinne	NN 17244 10309	20	3.3×10^{10}	1.11×10^{9}
9	Allt Camas a Bhata	NN 16816 10040	<10	1.8×10^{10}	$<6.74 \times 10^{8}$
10	Piped watercourse-unnamed	NN 16743 09953	<10	not calculated	$<2.5 \times 10^{3}$
11	Allt Bathaich Bhain	NN 16336 09816	50	5.8×10^{10}	2.97×10^{8}
12	Allt na Cruaidhlinn	NN 16031 09544	30	3.7×10^{10}	8.16×10^{8}

* Depth estimated as the river was flowing to strongly to measure safely
** Kinglas Water was sampled as a single watercourse in 2007

In order to enable comparison of changes in freshwater contamination levels over time, loadings from the 2008 report are listed in next to those from 2013. For watercourses other than the River Fyne and Kinglas Water, the calculated loadings were lower at the time of 2013 shoreline survey than had been recorded in 2007. Loadings to the River Fyne were two orders of magnitude higher.

The situation at Kinglas Water is complicated by the fact that at the 2013 shoreline survey, the two branches of the water were sampled separately due to the state of tide and the observed Cairndow septic tank outfall. The sample for Kinglas Water East branch was taken immediately below the outfall and, based on the *E. coli*

result of 50000 cfu/100 ml, represents the partially diluted effluent from the septic tank and therefore over represent the overall loading in that part of the watercourse. The west branch of Kinglas Water had a lower loading than that recorded in 2007.

Heavy rainfall was recorded during and prior to the 2013 shoreline survey dates, and therefore the higher flow and loading observed in the River Fyne may be due to the wet conditions. The reason for the lower loadings in the smaller watercourses is unclear, but the River Fyne drains a much larger catchment to the north of the loch whilst the other watercourses drain much smaller catchments and therefore are likely to respond more quickly to changes in rainfall.

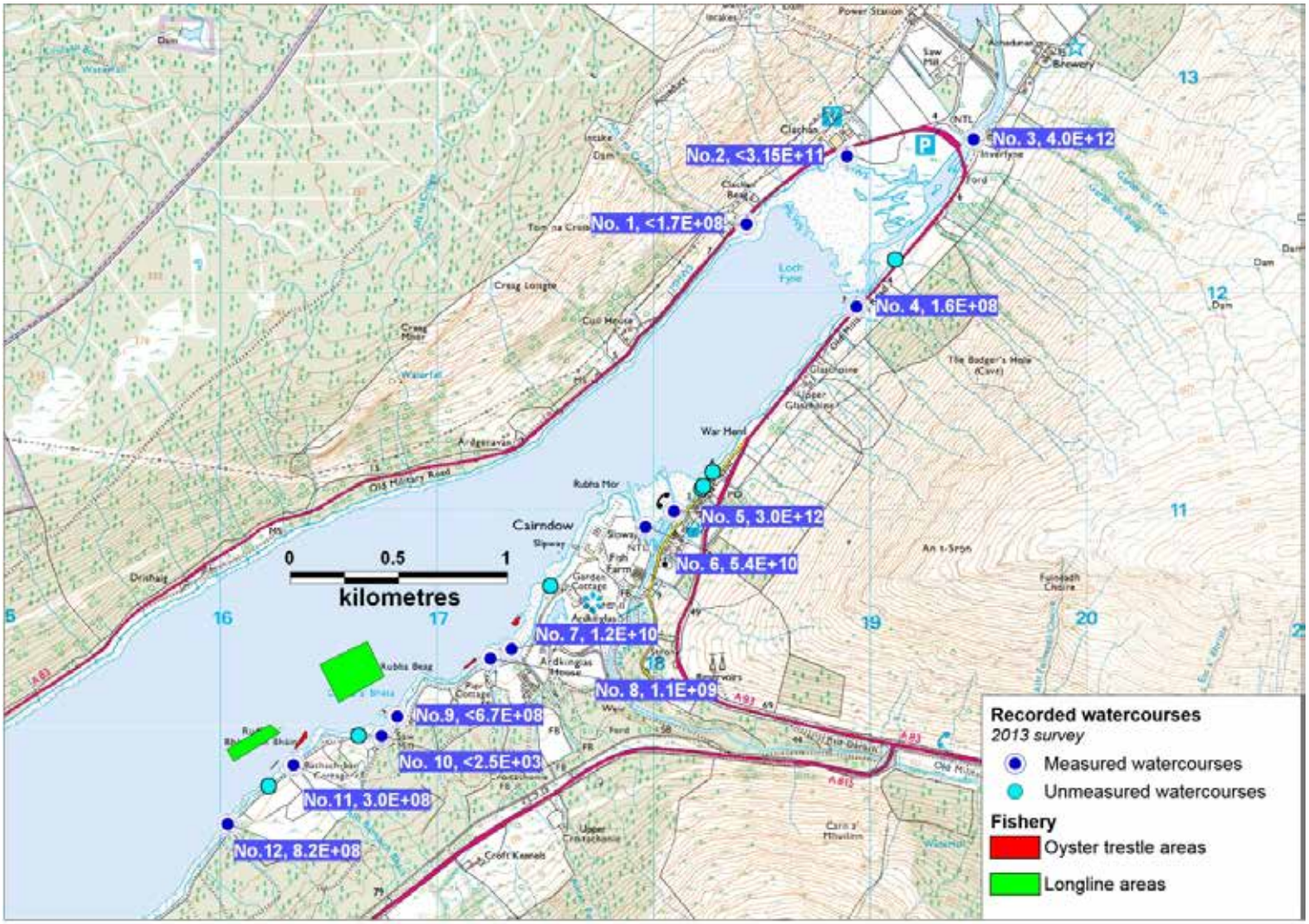

Figure 5.1 Watercourse loadings estimated from measurements made during the 2013 shoreline survey

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 $1x10^3$, in digital format it is written as 1E+03.

6. Meteorological data

Meteorological data from Inveraray Castle had been purchased from the United Kingdom Meteorological Office (Met Office) for the survey period 01/01/2003 - 31/12/2007 for the analyses undertaken for the 2008 Loch Fyne: Ardkinglas Sanitary Survey Report. However, the data from this station for the period 2008-2013 was incomplete and therefore not useful for comparative purposes for this review.

New rainfall data was purchased in March 2013 for the Benmore, Younger Botanical Garden (Benmore) weather station for the period 2003 to 2013. Rainfall was recorded in total daily rainfall (mm) for 3939 out of 4018 days. In the data for 2012, rainfall was not recorded for 57 days, of which 27 were in September.

This weather station lies approximately 25 km southwest of the Loch Fyne Ardkinglas production area.

Wind data was purchased from the Met Office for the Glasglow Bishopton weather station for the 2002-2011 period. This station lies approximately 45 km south of the Ardkinglas production area.

Rainfall

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

Figures 6.1 and 6.2 summarise the pattern of rainfall recorded at Benmore. The box and whisker plots summarise the distribution of individual daily rainfall values (observations) by year (Figure 6.1) or by month (Figure 6.2). The grey box represents the middle 50% of observations, with the median shown as a black line within the box. The whiskers extend to the largest or smallest observations up to 1.5 times the box height above or below the box. Individual observations falling outside the box and whiskers are represented by the symbol *.

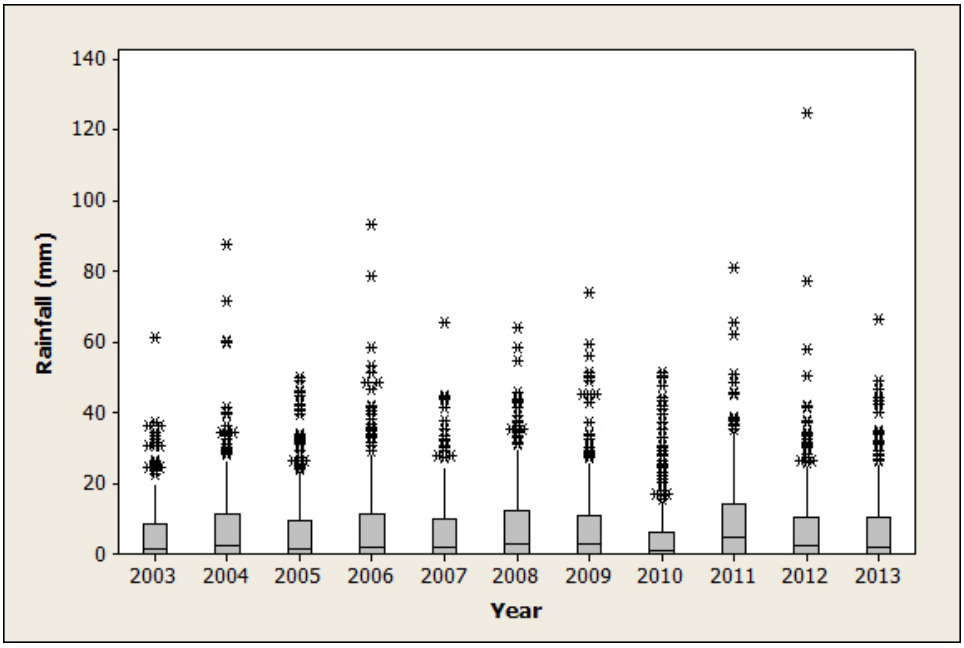

Figure 6.1 Boxplot of daily rainfall at Benmore, Younger Botanical Garden by year (2008-2012)

The majority of observations were below 10mm per day. Extreme rainfall events of greater than 40 mm per day occurred in all years. The largest single rainfall event exceeded 120 mm and occurred in 2012. The driest year was 2010 (1952 mm) and the wettest year was 2011 (3340 mm). Overall, there was slightly higher rainfall over the 5 years from 2008-2012 (13462 mm) than during the earlier period of 2003-2007 (12537), representing an increase of approximately 7%. This is despite the missing data from 57 days in 2012, and had the data been complete a greater difference would have been seen.

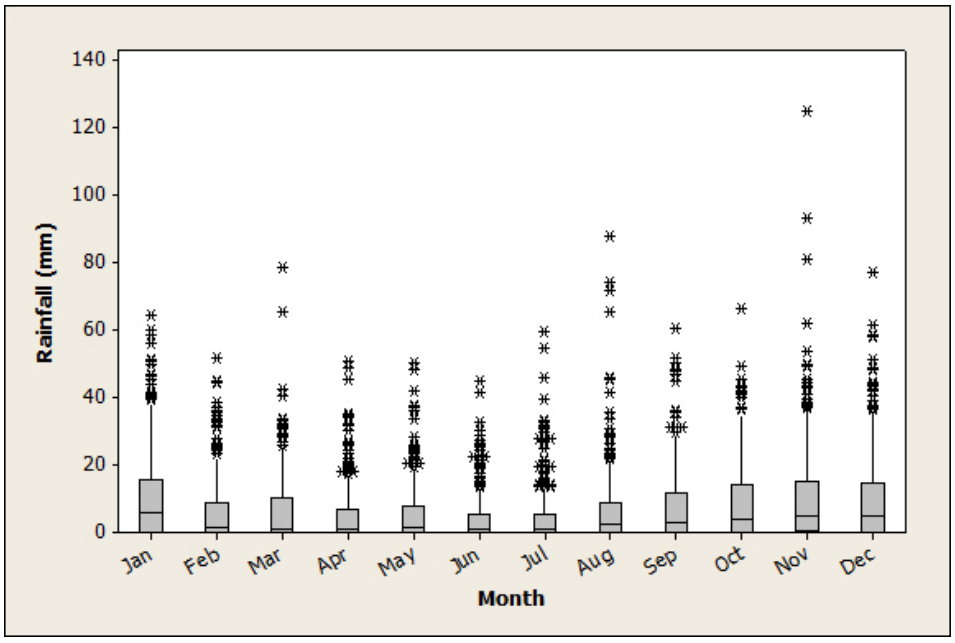

Figure 6.2 Boxplot of daily rainfall at Benmore, Younger Botanical Garden by month (2008-2012)

Overall, daily rainfall values were highest from October to January, and lowest from April to July. Extreme rainfall events exceeding 40 mm per day occurred in all months in the dataset, and therefore runoff associated with high rainfall can occur at any time of year.

Overall patterns in rainfall did not change significantly between the periods, despite the change in rainfall stations.

Wind

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

Figure 6.3 shows seasonal wind roses for Glasgow Bishopton for the period 2002-2011 while Figure 6.4 shows the annual wind rose for the same period. Due to the distance between the wind station and the production area, there are likely to be differences in the wind experienced between them due to differences in the surrounding topography and the locations of weather systems.

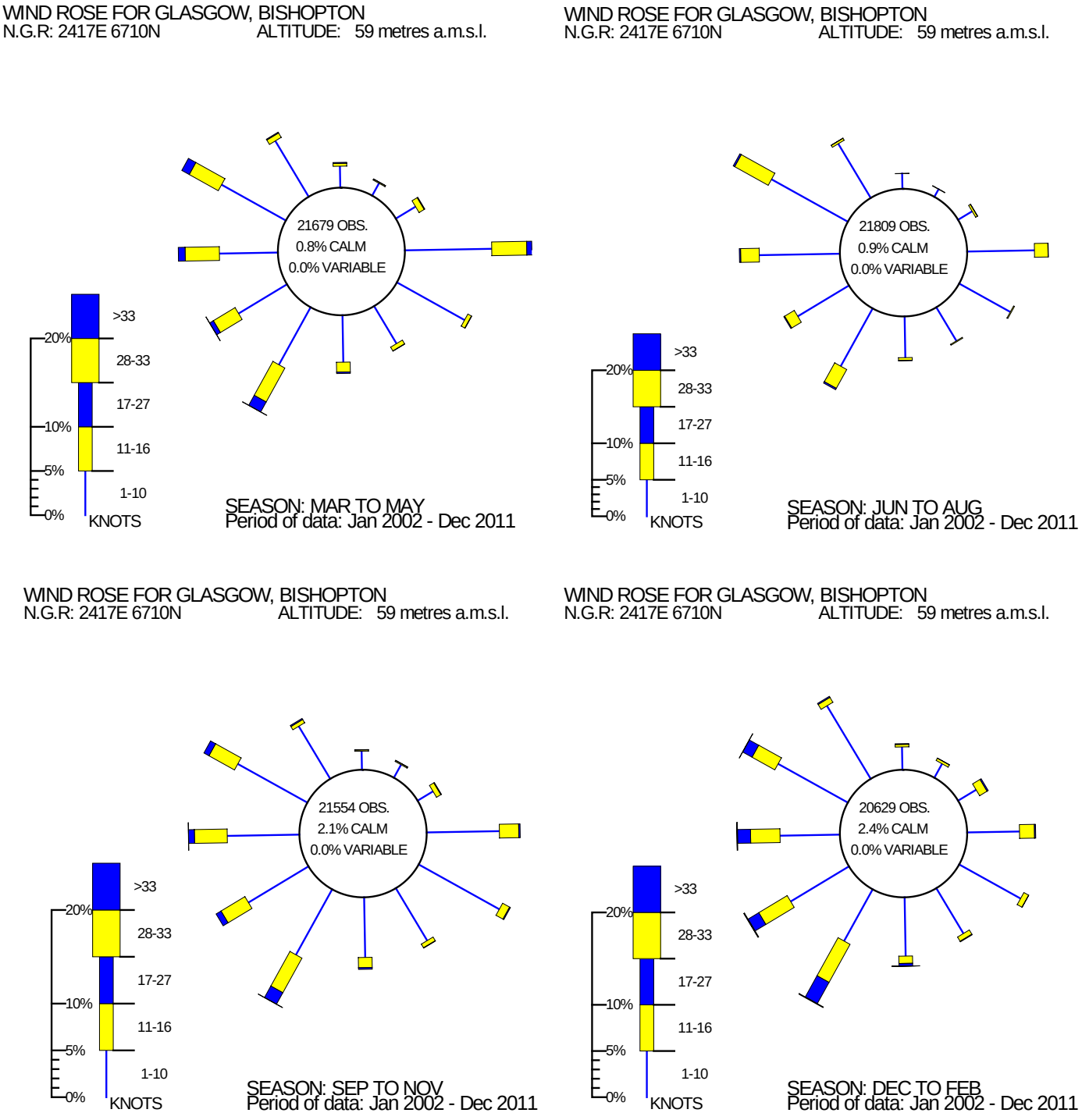

Figure 6.3 Seasonal wind roses for Glasgow Bishopton (2002-2011)

Prevailing winds are from the westerly half of the compass throughout most of the year. However, winds blow from the east a significant proportion of the time, particularly from March to May. Wind strength is weakest from all directions from June to August.

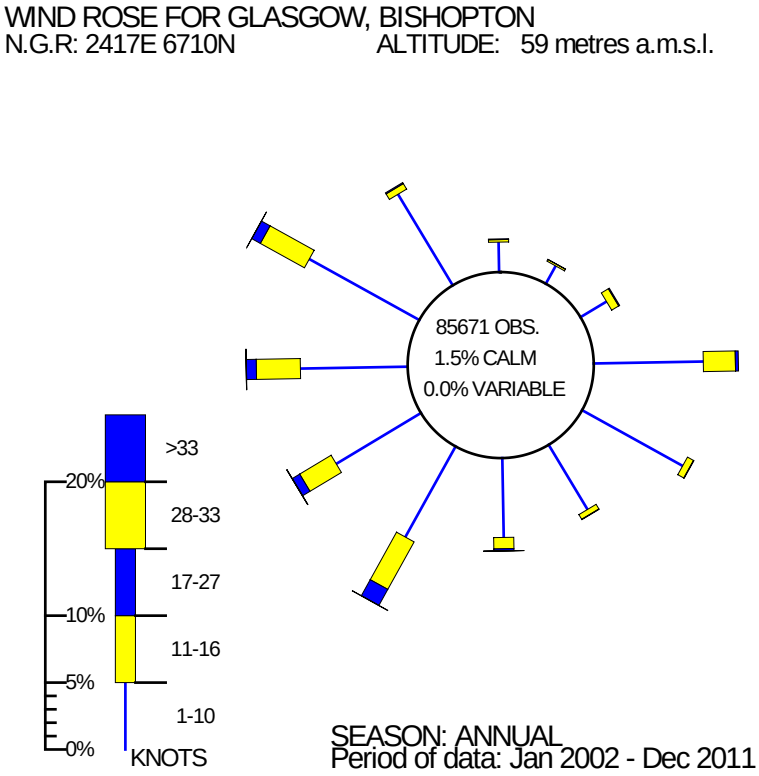

Figure 6.4 Annual wind rose at Glasgow Bishopton (2002-2011)

As was noted in the sanitary survey report , local topography is likely to lead to some significant differences between wind recorded at Glasgow Bishopton and the production area. As the local topography at Bishopton has an east-west aspect, strong winds are seen from the east and west, with much weaker winds from the north and south. The upper part of Loch Fyne, where the Ardkinglas shellfishery is located, is oriented along a northeast-southwest axis with steep hills along both sides of the loch. Therefore, winds at the fishery are likely to blow more strongly along the same axis as the loch, or from the southwest and northeast. The prevailing winds at Bishopton are southwesterly and at Loch Fyne, winds from this direction are likely to drive contaminants toward the head of loch.

7. Historical *E.* coli Data

Results assigned against Loch Fyne: Ardkinglas production area from 01/01/2008 to 31/12/2013 were extracted from the FSAS database on 17/02/2014 and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. Historical *E. coli* data used in the 2008 report had already been extracted and validated. For the purposes of this report, results for samples pre-dating 2002 were omitted from the analysis.

All *E. coli* results were reported as most probable number per 100 g of shellfish flesh and intravalvular fluid.

The results have been analyses and presented separately by species.

Pacific oysters

A total of 69 *E. coli* results from Pacific oysters were reported in the database. Of these, six results were reported as <20 and were reassigned a value of 10 *E. coli MPN*/100 g for the purposes of statistical evaluation and graphical representation. One result was reported as >18000 and was reassigned a value of 36000 for the purposes of statistical evaluation and graphical representation.

One sample was reported as rejected on the FSAS database and so was omitted from the analysis.

Most of the samples (55/69) were received at the laboratory within 24 hours of collection. The remaining 14 samples were received at the laboratory within 48 hours of collection.

All samples plotted within the production area boundaries. Sample locations are shown in Figure 7.1.

Summary of microbiological results

The summary of sampling results between sampling periods 2002-2007 and 2008-2013 is given below in Table 7.1. A comparison of results appears to show a slight deterioration in results since the sanitary survey.

Table 7.1 Sampling summary results for Pacific oysters at Loch Fyne Ardkinglas, 2002- 2013.

Sampling Summary				
Production area	Loch Fyne Ardkinglas			
Site	All			
Species	Pacific oysters			
SIN	AB 147 035, AB 147 035			
Location	Various			
Years	2002-2007		2008-2013	
Total no. of samples	124		69	
	No. 2002	21	No. 2008	12
	No. 2003	24	No. 2009	12
	No. 2004	25	No. 2010	11
	No. 2005	22	No. 2011	11
	No. 2006	23	No. 2012	11
	No. 2007	9	No. 2013	12
Results Summary				
Minimum	<20		<20	
Maximum	>18000		16000	
Median	80		140	
Geometric mean	100		160	
90 Percentile	1700		1380	
95 Percentile	2400		6480	
No. exceeding 230/100g	37 (30%)		24 (35%)	
No. exceeding 1000/100g	19 (15%)		11 (16%)	
No. exceeding 4600/100g	5 (4%)		4 (6%)	
No. exceeding 18000/100g	1 (1%)		0	

Small increases were seen in the proportion of results exceeding 230, 1000 and 4800 *E. coli* MPN/100 g since the 2007 sanitary survey. No results exceeding 18000 *E. coli* MPN/100 g occurred in the later period.

Table 7.2 Classification status for Loch Fyne: Ardkinglas Pacific oysters

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	A	A	A	A	A	A	A	B	B	B	A	A
2004	A	A	A	A	A	A	A	B	B	B	A	A
2005	A	A	A	A	A	B	B	B	B	B	A	A
2006	A	A	A	A	A	B	B	B	B	B	A	A
2007	A	A	A	A	A	B	B	B	B	B	B	A
2008	A	A	A	A	A	B	B	B	B	B	B	A
2009	A	A	A	A	A	B	B	B	B	B	B	B
2010	A	A	A	A	A	B	B	B	B	B	B	A
2011	A	A	A	A	A	A	B	C	C	B	B	B
2012	A	A	A	A	A	A	B	C	B	B	B	B
2013	A	A	A	A	A	A	B	B	B	B	B	B
2014	A	A	A									

Geographical patterns of results

Pacific oyster *E. coli* monitoring sampling locations from 2008 to 2013 are shown in Figure 7.1. The size of each point shown is proportional to the *E. coli* result reported for the sample.

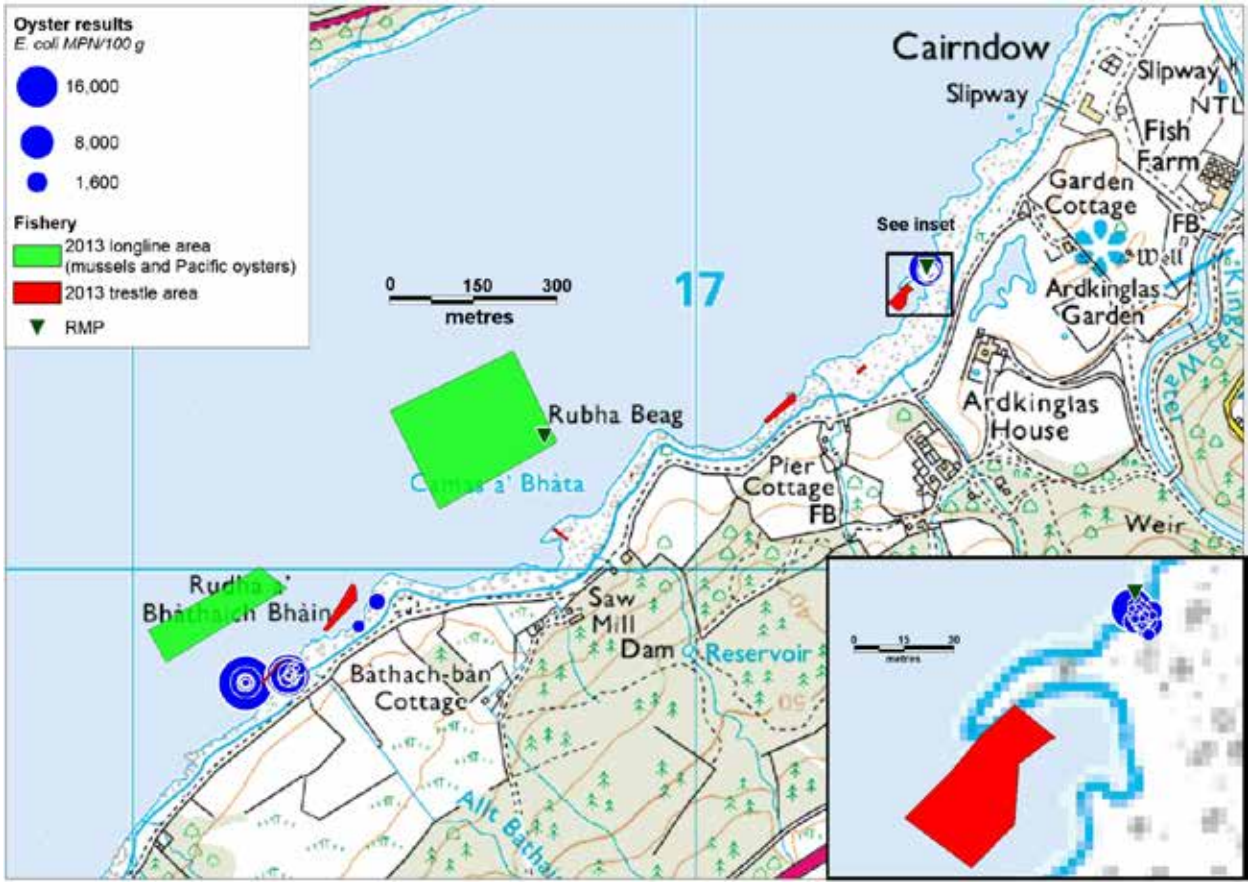

Figure 7.1 Pacific oyster sample results and locations at Loch Fyne: Ardkinglas

Results were attributed to two sites: The Point, and Policy Gates. Policy Gates samples all plotted toward the south end of the fishery around Bathac-Ban cottage. The Point samples all plotted at the north end of the fishery near Ardkinglas House, where a sampling trestle is in place at the RMP. The highest recorded results came from the southern end of the sampling area, however high results were seen at both sampled locations. Samples were taken from Policy Gates until February 2010, and from March 2010 onwards all sampling has been undertaken at The Point. Although the highest recorded sample results came from the Policy Gates area, it is not clear whether this was due to location or timing. A two sample t-test undertaken on the $\log_{10}$ transformed *E. coli* results for the two locations revealed no statistically significant difference between them (t=-0.33, DF=38, p=0.743).

Temporal patterns of results

The trends of *E. coli* results have been analysed for the years between the previous sampling period (2002-2007) and the current sampling period (2008-2013).

To test for significant differences between results from samples taken over the two periods, the following statistical analyses were carried out:

- A two sample t-test (using $\log_{10}$ transformed *E. coli* data) to determine whether there was a statistically significant difference between *E. coli* results between the two sampling periods.
- A Chi squared test was used to test for significant difference in observed and expected *E. coli* results above the level of 230 *E. coli* MPN/ 100 g from both sampling periods.
- A Fisher's Exact Test was used to test for significant difference in the observed and expected *E. coli* results above 1000 *E. coli* MPN/ 100 g from both sampling periods. This was due to two cells having expected counts at less than five, preventing the Chi-squared approach being a valid statistical analytical method.

Temporal trends are displayed below in Figure 7.2, followed by results from the statistical analyses.

Temporal trends are displayed in the scatterplot in Figure 7.2. A Lowess trend line has been added to highlight any overall or cyclical trends in the data. (Lowess parameters: degree of smoothing = 0.3, number of steps = 6).

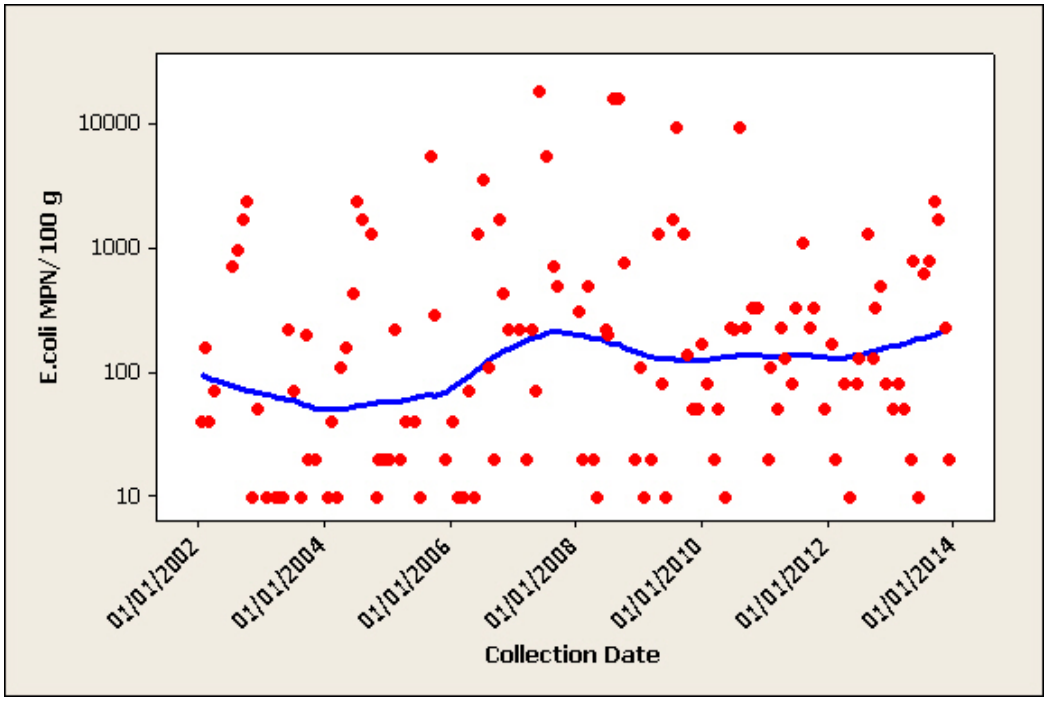

Figure 7.2 Scatterplot of Loch Fyne: Ardkinglas Pacific oyster *E. coli* results by date (2002-2013)

Overall, the graph shows a very slight increasing trend in results. The rise is most apparent between 2004 and 2008. No cycles are apparent in the data. A few very high results occurred between 2006 and 2010, and fewer results at or below the limit of detection have been seen since 2006. No statistically significant difference was seen between log transformed *E. coli* results from the two survey periods (Two sample t-test, t=-1.24, DF=120, p=0.218).

Table 7.3 Results above and below 230 and 1000 *E. coli MPN*/100 g for Pacific oyster *E. coli* results at Loch Fyne Ardkinglas

		***E. coli* MPN/100g**			***E. coli* MPN/100g**		
		≤230	>230	**Total**	≤1000	>1000	**Total**
2002-2007	Observed	43	19	62	51	11	62
2008-2013	Observed	45	24	69	58	11	69
	Total	88	43	131	109	22	131

No statistically significant difference was found between sampling results ≤230 *E. coli* MPN/100 g and >230 *E. coli* MPN/100 g between sampling periods (Chi-square test, X^2 = 0.254, DF=1, p=0.615).

No statistically significant difference was found between sampling results ≤1000 *E. coli* MPN/100 g and >1000 *E. coli* MPN/100 g between sampling periods (Chi-square test, X^2 = 0.076, DF=1, p=0.783).

Common mussels

A total of 9 *E. coli* results reported as <20 were reassigned a value of 10 *E. coli MPN*/100 g for the purposes of statistical evaluation and graphical representation.

Two samples were reported as rejected on the FSAS database and so were omitted from the analysis.

Most of the samples (59/71) were received at the laboratory within 24 hours of collection. The remaining 12 samples were received at the laboratory within 48 hours of collection.

All samples plotted within the production area boundaries. Sample locations are shown in Figure 7.4.

Table 7.4 Sampling summary results for Loch Fyne Ardkinglas common mussels between 2002 and 2013

Sampling Summary				
Production area	Loch Fyne Ardkinglas			
Site	NA			
Species	Common mussels			
SIN	AB-147-035-08			
Location	Various			
Years	2002-2007		2008-2013	
Total no. of samples	64		71	
	No. 2002	11	No. 2008	11
	No. 2003	12	No. 2009	12
	No. 2004	12	No. 2010	11
	No. 2005	9	No. 2011	12
	No. 2006	11	No. 2012	13
	No. 2007	9	No. 2013	12
Results Summary				
Minimum	<20		<20	
Maximum	>18000		16000	
Median	45		80	
Geometric mean	64		85	
90 Percentile	500		490	
95 Percentile	750		1045	
No. exceeding 230/100g	15 (23%)		14 (20%)	
No. exceeding 1000/100g	3 (5%)		4 (6%)	
No. exceeding 4600/100g	2 (3%)		2 (3%)	
No. exceeding 18000/100g	1 (2%)		0	

Table 7.5 Classification status for Loch Fyne Ardkinglas mussels

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2003	A	A	A	A	A	A	A	B	B	B	A	A
2004	A	A	A	A	A	A	B	B	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	A	A	B	B	B	B	B	B	B
2008	A	A	A	A	A	A	B	B	B	B	B	B
2009	A	A	A	A	A	A	B	B	B	B	B	B
2010	A	A	A	A	A	A	B	B	B	B	B	A
2011	A	A	A	A	A	A	A	A	B	B	A	A
2012	A	A	A	A	A	A	A	A	A	A	A	A
2013	A	A	A	A	A	A	B	B	B	A	A	A
2014	A	A	A									

The area has tended to be Class B during the summer and autumn months, although the actual months that were class B have varied from year to year. The area was given a year-round A classification in 2012.

Geographical patterns of results

Common mussel *E. coli* monitoring sampling locations from 2008 to 2013 are shown in Figure 7.3. The size of each point shown is proportional to the *E. coli* result reported for the sample.

All mussel samples were reported against The Point. Most of these were taken from the long-line farm near Rubha Beag, however one sample came from the oyster sampling trestle near Ardkinglas House. The sampling location within the long-line farm has shifted over time. From 2007-2009, samples were taken from a an area nearer the middle of the current farm, at roughly NN 1661 1020. From 2010 to early 2012, the sampled location moved approximately 140 m to the southeast, to an area around NN 1674 1015. Results for this location/time period were lower than previously. The sampling point was moved to the current RMP at NN 1673 1024 in early 2012 and all samples since then on have been taken from within 20 m of the RMP. The highest results occurred at the locations further off shore, however there was no statistically significant difference between results at the two offshore sample clusters (Two sample t-test, t=0.22, DF=43, p=0.829).

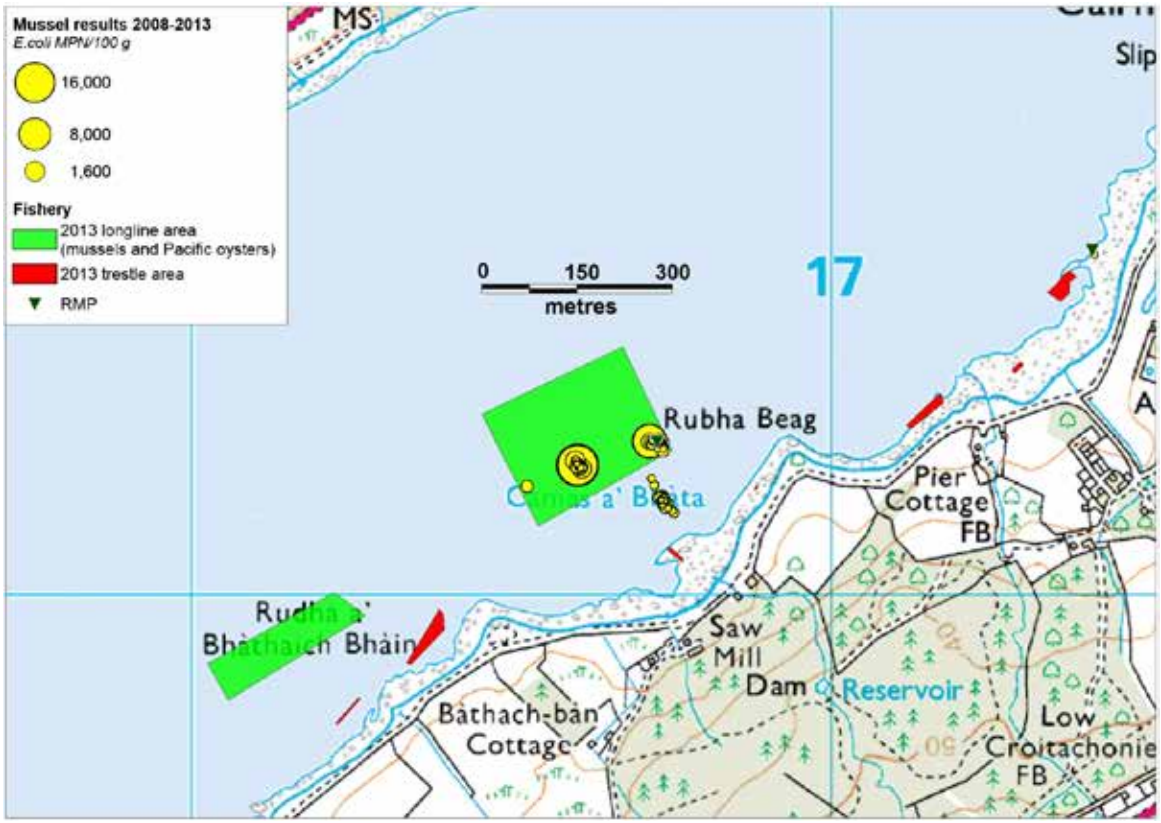

Figure 7.3 Mussel sample results and locations

Temporal patterns of results

The trends of *E. coli* results have been analysed for the years between the previous sampling period (2002-2007) and the current sampling period (2008-2013).

To test for significant differences between results from common mussel samples taken at Loch Fyne Ardkinglas over the two periods, the following statistical analyses were carried out:

- A two sample t-test (using $\log_{10}$ transformed *E. coli* data) to determine whether there was a statistically significant difference between *E. coli* results between the two sampling periods.
- A Chi squared test was used to test for significant difference in observed and expected *E. coli* results above the level of 230 *E. coli* MPN/ 100 g from both sampling periods.
- A Fisher's Exact Test was used to test for significant difference in the observed and expected *E. coli* results above 1000 *E. coli* MPN/ 100 g from both sampling periods. This was due to two cells having expected counts at less than five, preventing the Chi-squared approach being a valid statistical analytical method.

Temporal trends are displayed below in Figure 7.4, followed by results from the statistical analyses.

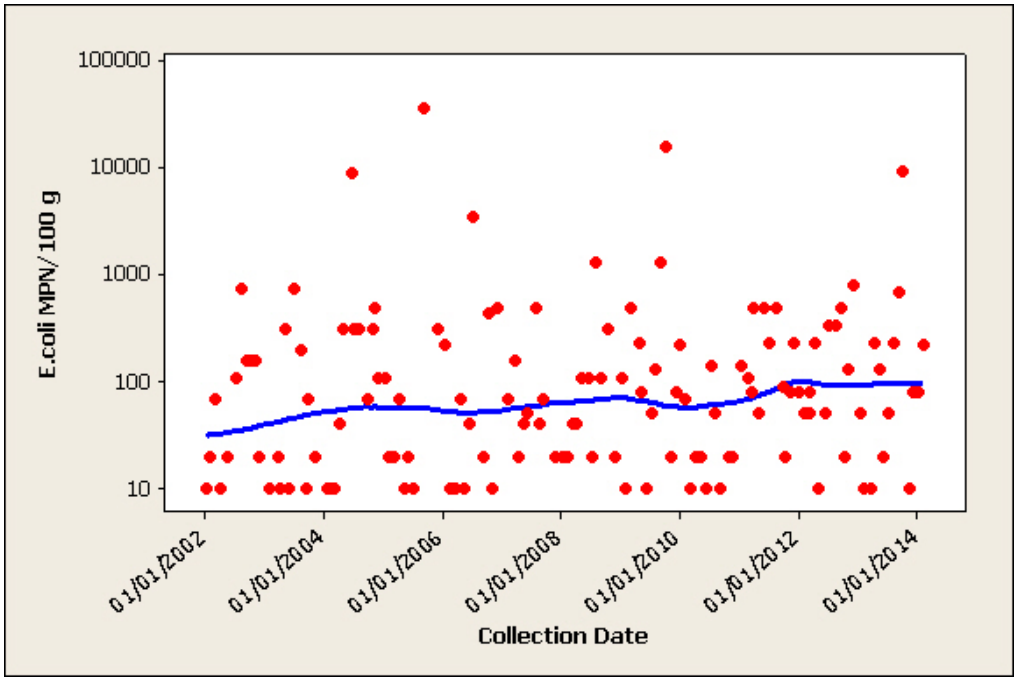

Figure 7.4 Scatterplot of Loch Fyne: Ardkinglas common mussel *E. coli* results by date, 2002-2013

Overall, the graph shows a slight increasing trend in results. No cycles are apparent in the data. Very high results occurred intermittently across the time period, with the most recent occurring in 2013. No statistically significant difference was seen between log transformed *E. coli* results from the two survey periods (Two sample t-test, t=-1.05, DF=125, p=0.297).

Table 7.6 Chi-squared test and Fisher's Exact test results above and below 230 and 1000 *E. coli MPN*/100 g for common mussel results at Loch Fyne: Ardkinglas

		***E. coli* MPN/100g**			***E. coli* MPN/100g**		
		≤230	>230	**Total**	≤1000	>1000	**Total**
2002-2007	Observed	49	15	64	61	3	64
2008-2013	Observed	57	14	71	67	4	71
	Total	106	29	135	128	7	135

No statistically significant difference was found between sampling results ≤230 *E. coli* MPN/100 g and >230 *E. coli* MPN/100 g between sampling periods (Chi-square test, X^2 = 0.276, DF=1, p=0.599).

No statistically significant difference was found between sampling results ≤1000 *E. coli* MPN/100 g and >1000 *E. coli* MPN/100 g between sampling periods (Chi-square test, X^2 = 0.061, DF=1, p=0.804). Fisher's exact test was performed due to the low number of results >1000 *E. coli*/100 g. This confirmed that there was no statistically significant difference between the sampling periods (p=1.0)

8. Movement of contaminants

The main conclusions of the 2008 sanitary survey report with respect to movement of contaminants were as follows:

- Weak tidal currents in the upper loch would lead to small net transport distances attributable to this mechanism alone. Wind is expected to drive the majority of water movement, with greater transport aided by spring tidal currents.

- Predicted transport distances due to tidal effects were less than 500 m at Inveraray and significantly less at Cairndow, so that particles would still be in the vicinity of the release point after 48 hours.

- Significant stratification was noted at the head of the loch, where there is a large input of freshwater, mainly from the River Fyne and Kinglas Water, but also from a large number of smaller watercourses. This is likely to result in density-driven flows with lower salinity water tending to move southwestward at the surface.

- Southerly and westerly winds would tend to drive surface currents and contaminants up toward the loch head whilst northerly winds would drive them down the loch.

An internet search undertaken for this review showed that there have been no recent assessments of the hydrography or bathymetry at upper Loch Fyne that could be used to assess changes in the movement of contaminants.

9. Overall Assessment

This assessment considers the information obtained since the 2008 sanitary survey report and the potential changes in extent and location of faecal contamination.

Fishery

Both common mussels and Pacific oysters continue to be produced in this area. Mussel production at the northernmost of the two long-line sites has shifted slightly offshore from where it was previously and therefore the RMP has also shifted westward with the mussel farm. The southernmost long-line farm has remained in largely the same location, but covered a smaller area than observed in 2007.

The overall trestle area used for Pacific oyster production was found to be smaller than that recorded during the 2007 shoreline survey and it has also shifted southward. The area of active oyster culture now lies southwest of the RMP. The

harvester has been trialling the use of suspended baskets on the areas of long-lines. This is expected to result in lower contamination levels in the oysters due to the greater dilution of contaminants in the deeper water at the long lines.

Human sewage Impacts

The situation regarding sewage discharges impacting on the fishery has changed somewhat from that presented in the 2008 sanitary survey report. The installation of improved treatment to the discharge from the restaurant at the head of the loch has resulted in a significant reduction to the contribution of faecal indicator bacteria from that source.

Sewage discharges from properties in the village of Cairndow have not changed significantly since 2008, when it was found that most properties continued to be on private septic tanks.

The septic tank discharge from Ardkinglas House, which was not discovered during the 2007 shoreline survey, is now known to discharge via a buried pipe to a point beyond the oyster trestles west of the house. Planning applications have been submitted for the development of 15 additional houses on estate land to the southeast of the house, with septic waste planned to discharge to the adjacent watercourses (an unnamed watercourse and Alltan Fichead Sgillinne). This would significantly increase the sewage impact to the fishery, particularly at the intertidal trestles near the outlets of these watercourses.

The outfall from the fish processing plant was observed to still be in use, though the septic tank outfall from the depuration plant for the shellfish farm was not seen (though intake and outlet pipes for the depuration tanks were seen) and it is not known whether this now discharges elsewhere.

Planning permission has been granted for a larger, mixed development at the head of the loch, though this project has not as yet gone forward. Further planning permission was granted for development of individual homes with septic tanks in Cairndow, St. Catherines, and Inveraray.

Overall, there has been no substantive change to discharges most likely to have the greatest impact on the fishery, which are the septic discharges from the fish processing plant, the depuration plant and Ardkinglas House. The location of the outfall from Ardkinglas House is now known to be offshore of the block of oyster trestles immediately south of the oyster RMP. The principal human sewage sources remain to the north of the long line farms.

There is the potential for a significant increase in the impact of sewage on the northern end of the fishery as development progresses at Pheasant Field, near Ardkinglas House. The impact of septic discharges from this area will depend on the final number of homes and the level of sewage treatment applied, however any

effluent would be most likely to affect the oyster trestles between Rubha Beag and Ardkinglas House, as well as the northern end of the northernmost long line farm.

Agricultural impacts

The only terrestrial farms near the fishery remain that at Ardno (1.6 km southwest of the nearest trestles) and those at the head of the loch around the lower River Fyne, over 2 km to the north of the oyster RMP. Estimates of animals present on these, based on 2013 observations and 2011-12 satellite imagery, suggest that the numbers of livestock present at both areas are higher than identified in the during the 2007 shoreline survey. Although the farm at Ardno is closer to the shellfishery, a larger number of animals are likely to be present at the head of the loch. Diffuse contamination from livestock at the head of the loch will be carried mainly in the River Fyne but also in the smaller watercourse discharging near Clachan. These will be carried southward in the freshwater flow from the river. Diffuse contamination arising around Ardno is likely to also be carried in the local watercourses and would be carried toward the fishery on a flood tide, though prevailing southwesterly winds are predicted to drive contaminants offshore from the shellfishery.

Wildlife Impacts

No significant change is noted to potential impacts from wildlife.

Seasonal Variation

No significant change is noted to seasonal variation in sources as there has been no significant change in agricultural use, rainfall or human population.

Watercourses

Watercourse loadings estimated from measurements made during the 2013 shoreline survey were mainly lower than those seen during the 2007 shoreline survey with the main exception of the River Fyne, which carried an estimated loading two orders of magnitude higher in 2013. The shoreline survey in 2013 was conducted in September, when there would have been higher numbers of livestock present (and higher numbers were noted at the head of the loch than in 2007). There had also been heavy rainfall during and previous to the survey, and this may have flushed through the smaller watercourses more quickly than the River, which drains a much larger catchment with higher agricultural use.

Movement of contaminants

No significant additional information was found on the potential movement of contaminants in the area.

Analysis of Results

Historical *E. coli* results

Comparison of *E. coli* monitoring results from periods 2002-2007 and 2008-2013 showed no statistically significant differences in results between the two periods for either mussels or Pacific oysters. The trend in results over time appears to show a very slight increase in results across the complete period for both species.

No statistically significant differences were found in the proportion of results exceeding 200 *E. coli* MPN/100 g and 1000 *E. coli* MPN/100 g for either species. No statistically significant differences were found between results at the different sampling locations used for each species over the period.

These results suggest that there have been no significant changes to contamination levels since the 2008 survey. Results greater than 4600 *E. coli* MPN/100 g occurred in Pacific oysters between 2008 and 2010, which were reflected in downgraded classifications in 2011 and 2012. Results of this magnitude have not recurred since 2010.

Shoreline survey samples

Results from Pacific oyster samples taken during the 2013 shoreline survey were higher at the northern and southern extents of the fishery. The results from the northern end were higher than that at the southern end, and all results exceeded 1000 *E. coli* MPN/100 g. Results from common mussel samples were slighter higher at the southern end of the mussel farms than at the northern end, and both samples results were below 1000 *E. coli* MPN/100 g.

The highest seawater sample result was 7300 *E. coli* cfu/100 ml, taken approximately 100 m offshore from the Cairndow outfall. All but two of the seawater results were higher than 10 cfu/100 ml. The seawater sample result from the southern end of the mussel farms was higher than that at the northern end, which is consistent with the results seen in flesh. This suggests that at the time of shoreline survey the southern end of the mussel farm was more impacted by faecal contamination than the northern end. Agricultural sources from the farm at Ardno lie to the south of the mussel farms, and could potentially be the cause of the higher results there.

Freshwater samples confirmed significant septic input from outfalls at Cairndow and the fish processing plant. Most of the watercourse results were below 100 *E. coli* cfu/100 ml, however the sample taken from the unnamed watercourse that discharges 140 m southwest of Ardkinglas House returned a result of 780 cfu/100 ml, suggesting moderate faecal contamination.

Conclusions

Overall, relatively little change was found to the main sources of faecal contamination to the fishery, and *E. coli* monitoring results over the period had not changes significantly.

The most significant changes have been to the fishery itself, with both trestle and long-line areas smaller overall than observed in the 2007 shoreline survey. The northernmost mussel farm has shifted offshore slightly, and the northern end of the oyster farm has shifted southward.

There has been significant improvement to the treatment of sewage effluent from the restaurant at the head of the loch, which should result in lower contribution to background faecal indicator concentrations from this source.

10. Recommendations

Pacific oysters

Production area

It is not feasible to exclude all identified potential sources of faecal contamination from the production area boundaries. Therefore, no changes are recommended to the current production area boundaries, which already exclude discharges from Cairndown and the fish processing plant.

RMP

As there have been no significant changes in results or in the discharges present in the area, no change to the RMP is recommended. However, should development progress at Pheasant Field, the RMP location should be reassessed.

Tolerance

It is recommended that the sampling tolerance be retained at 10 m as the samples are hand picked from a dedicated sampling trestle.

Depth

Sampling depth is not applicable.

Frequency

It is recommended that monthly monitoring be retained.

Common mussels

Production area

It is not feasible to exclude all identified potential sources of faecal contamination from the production area boundaries. Therefore, no changes are recommended to the current production area boundaries, which already exclude discharges from Cairndown and the fish processing plant.

RMP

As the mussel farm has moved offshore, and the sources of contamination have not changed significantly, the recommended RMP in the sampling plan should be amended to that currently in use, at NN 1673 1024.

Tolerance

It is recommended that the sampling tolerance be amended to 40 m to accommodate any movement of the mussel lines.

Depth

Sampling depth should be retained at 1 m.

Frequency

It is recommended that monthly monitoring be retained.

11. 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.

Cefas and FSAS (2008). Loch Fyne Ardkinglas Sanitary Survey Report.

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

Mitchell, I. P., Newton, S. F., Ratcliffe, N., & Dunn, T. E. (2004). *Seabird populations of Britain and Ireland: results of the Seabird 2000 census (1998-2002).* London: T & A D Poyser.

Special Committee on Seals, 2012. Scientific Adivde on Matters Related to the Management of Seal Populations: 2012. Accessed on 18/06/2013 at 10.15am [Online] Available at: http://www.smru.st-andrews.ac.uk/pageset.aspx?psr=411

12. List of Figures and Tables

Appendices

1. List of planning applications
2. Shoreline Survey Report

Appendix 1. List of planning Applications

Planning applications expected to affect the human population and overall faecal loading to upper Loch Fyne are listed in Table 1.

Table 1 Planning applications for the upper Loch Fyne area

Date	Reference number	Description
09/07/2008	08/01243/DET	Erection of dwellinghouse and formation of vehicular access.
14/01/2009	09/00029/VARCON	Removal of Condition 6 of Planning Permission 04/00296/COU relating to ancillary residential use.
12/03/2009	09/00385/OUT	Erection of mixed development comprising 16 dwellinghouses, 7 commercial units, childcare centre, installation of sewage treatment systems and access improvements
03/04/2009	09/00463/DET	Erection of 15 dwellinghouses, formation of vehicular access road and installation of sewage system, associated engineering works and formation of borrow pit
03/08/2009	09/01187/NMA	Erection of dwellinghouse, formation of vehicular access and installation of septic tank (non-material amendment relative to planning permission 06/00971/DET incorporating change to design of rear porch, additional window on SE elevation and change to eave design on front, SW elevation) (retrospective).
02/06/2010	10/00960/PP	Change of use of shop (Class 1) to form 2 studio apartments and formation of 2 retail units with associated external alterations
11/06/2010	10/01009/PP	Change of use of workshop to form public house including alterations and extension.
14/09/2010	10/01566/PP	Demolition of village hall and erection of dwellinghouse and detached garage/office and improvements to vehicular driveways
10/11/2010	10/01909/PP	Demolition of existing outbuilding and erection of annexe building (incorporating home office, garden outbuilding and ancillary accommodation) and installation of septic tank and soakaway.
07/01/2011	11/00014/PP	Erection of extension and alterations to visitor centre and installation of septic tank
19/04/2011	11/00639/PP	Erection of dwellinghouse (amended design to application ref. 10/00902/PP)
25/05/2011	11/00870/PP	Installation of sewage treatment plant
16/06/2011	11/01007/PP	Erection of 2 holiday letting dwellinghouses and associated car parking.
05/07/2011	11/01146/PP	Erection of detached dwellinghouse and detached garage
02/07/2011	11/01167/PP	Alterations and change of use of steading barns to 2 dwellinghouses and installation of septic tank
26/07/2011	11/01372/PP	Alterations and change of use of workshop store to form residential letting house.
09/07/2012	12/01503/PP	Change of use of warehouse to dwellinghouse involving alterations and exensions and formation of vehicular access (Amended Plan 15.10.2012)
02/10/2012	12/02159/PP	Alterations and extensions to dwellinghouse; erection of garage/boathouse; alterations to means of access including formation of separate pedestrian access; alteration of access to beach and formation of lay-by and

		installation of replacement sewage treatment plant.
29/11/2012	12/02637/PP	Demolition of log cabin and erection of dwellinghouse and installation of septic tank and soakaway
30/11/2012	12/02705/PP	Erection of 22 self catering units, 1 self catering apartment building, 1 staff accomodation unit, operations building, installation of 4 treatment plants and enabling works
03/12/2012	12/02722/PPP	Site for the erection of dwellinghouse and formation of vehicular access (renewal of planning permission reference 09/01538/PPP)
18/12/2012	12/02788/PPP	Site for the erection of one dwellinghouse, installation of septic tank and formation of vehicular access (Plot 2).
18/12/2012	12/02789/PPP	Site for the erection of one dwellinghouse, installation of septic tank and formation of vehicular access (Plot 1).
24/01/2013	13/00147/PP	Alterations and partial change of use of agricultural shed to accommodate brewing equipment, including re-cladding and associated external works, installation of grain silo and installation of treatment plant
17/08/2013	13/01816/PP	Alterations and change of use of commercial premises (originally Comrades Hall) to dwellinghouse, involving ancillary development
09/09/2013	13/02031/PP	Alterations to subdivide single dwellinghouse to form 2 dwellinghouses and installation of septic tank
28/11/2013	13/02761/PP	Demolition of former post office, erection of dwellinghouse and installation of sewage treatment plant

Appendix 2

Report Title	Loch Fyne Ardkinglas Shoreline Survey Report
Project Name	Shellfish Sanitary Surveys
Client/Customer	Cefas
SRSL Project Reference	00561_B0067

Document Number	B0067_Shoreline 0022

Revision History

Revision	Changes	Date
A	Issue for internal review	27/09/2013
01	First formal issue to CEFAS	27/09/2013
02	Second issue to Cefas incorporating comments at Rev 01	22/10/2013

	Name & Position	Date
Author	Debra Brennan, Eilidh Cole	20/09/2013
Checked	Andrea Veszelovszki	27/09/2013
Approved	Andrea Veszelovszki	22/10/2013

SRSL, Scottish Marine Institute, Oban, Argyll, PA37 1QA, tel 01631 559 470, www.samsrsl.co.uk

Shoreline Survey Report

Production area:	Loch Fyne: Ardkinglas Loch Fyne: Ardkinglas Oysters
Site name:	Policy Gates The Point The Shore
SIN:	AB-147-034-08 AB-147-035-08 AB-147-036-08 AB-147-034-13 AB-147-035-13 AB-147-036-13
Species:	Common Mussels (*Mytilus edulis*) Pacific Oysters (*Crassostrea gigas*)
Harvester:	Mr David Attwood
Local Authority:	Argyll and Bute
Status:	Existing area
Date Surveyed:	22/07/2013, 23/07/2013
Surveyed by:	Eilidh Cole, Debra Brennan
Existing RMP:	NN 1673 1024 NN 1741 1054

Area Surveyed

The shoreline was surveyed for approximately 6 km in total, from NN1603 0955 at the south east point of the sampling area heading northeast towards and around the head of the loch then northwest to NN 1842 1233.

Weather

Rainfall was recorded for the previous week (from 03/09/2013) leading up to the survey. During the survey, the weather was dry and mostly sunny.

Monday 09/09/2013 - Cloud cover was at approximately 80% at the start of the survey and steadily decreased throughout the day down to about 20%. Temperature was 17°C with the wind speed of 1.6km/h. Sea state 0 calm, no ripples.

Tuesday 10/09/2013 - Cloud cover was approximately 40%, steadily decreasing throughout the morning. Temperature 17°C, wind speed 1.7km/h. Sea state 0, calm, no ripples.

Stakeholder Engagement during the survey

Both the harvester (site manager) Mr David Atwood and Sampling Officer, Mr William McQuarrie were very helpful and cooperative during pre-survey arrangements. Mr Fraser Anderson, the Shellfish Regulatory Services Officer, met with the survey team briefly on Tuesday morning. The harvester's representative who took the survey team to the mussel farm on the Monday afternoon was also very co-operative and helpful both with sampling and with providing additional information on the fishery. Mr Attwood was unavailable to meet with the survey team on site.

Fishery

Loch Fyne, Ardkinglas is a Common Mussel (*Mytilus edulis*) and Pacific Oyster (*Crassostrea gigas*) fishery. The mussels are grown at two sites in close proximity to each other. The first most easterly site is comprised of ten lines with mussels grown on approximately 10m suspended culture lines; two of these lines have recently changed to the cultivation of oysters as a new system employing suspended boxes is being trialled. The second site further west is comprised of four lines. The mussels are harvested in the winter months only, from September to April.

There are six oyster trestles in the area from NN 1632 0981 to NN 1740 1054. There was also a 3m x1m cage next to one of the trestles with oyster bags attached. The oysters are also harvested only in the winter months between September and April.

Sewage Sources

The survey area at Ardkinglas is sparsely populated. There is a small village at Cairndow with approximately twenty private dwellings and four pipes were observed during the survey on the shoreline coming from four of these dwellings. There is also a pub/hotel which had a Scottish Water septic tank with a pipe leading onto the shore. Ardkinglas itself is a private estate with large houses and estate outbuildings with two of the houses on the loch side. Ardkinglas House is the largest building complex in this area. No sewage pipes were observed on the shoreline and no evidence of any type of sewage system was observed either. Loch Fyne Oysters has a processing plant to the east of Ardkinglas House and there was a sewage pipe discharging into Loch Fyne here. Panfish [Scottish Salmon Company] processing plant is west of Ardkinglas House and had a sewage pipe on the shoreline. At the head of the loch, Loch Fyne Visitor Centre has a restaurant and garden centre with a septic tank on the loch-side of the road. Just below the location of the tank an outflow was visible at the high tide mark and sewage fungus was growing here where the flow crossed the sediment. There were three private dwellings at Clachan Beag but no pipes were observed at this location.

Seasonal Population

Cairndow has a pub/hotel as mentioned above. There were no campsites or B&B's observed in the survey area.

Boats/Shipping

Apart from the small boat the team used to take the shellfish samples from no other vessels or moorings were observed on the loch during the survey.

Farming and Livestock

There were no observations of any sheep or other livestock on the actual shoreline at any point during the survey, nor was there any evidence that sheep had been on the shoreline i.e. no droppings or wool seen. Close to Ardkinglas House there were fourteen sheep grazing in a field along the road to the oyster farm. Just north of the River Fyne at the head of the loch, there were over one hundred sheep grazing in a field.

Land Use

There was very little grazing land around the shoreline area except at the head of the loch by River Fyne. There were scattered dwellings totalling approximately thirty houses mostly concentrated in the village of Cairndow. There were two commercial industries on the loch side, Loch Fyne Oyster processing plant and Panfish [Scottish Salmon Company] processing plant. Ardkinglas House is located on a private Estate surrounded by forestry.

Land Cover

To the north of the survey area the hillsides were completely covered in forestry, approximately 70% of which was coniferous and 30% deciduous trees. To the south, the steep hillside had a small plantation of coniferous trees but was mostly rough grass.

Watercourses

The largest watercourse observed is the River Fyne which runs into the head of the loch and its width was estimated to be 52.8m. (Value was estimated using GPS as river was too wide and deep to measure with tape). Kinglas water enters the loch by the village of Cairndow and its width was determined to be 14.4 m. The west tributary of the river is approximately 7.5m in width. (All these widths were estimated using the same GPS method as before).

Alt Na Criche enters the loch to the west of the Loch Fyne visitor centre and is 1.8m in width.

Wildlife/Birds

There were forty Pink Footed Geese, (*Anser brachyrhynchus)* in a field at the head of the loch. There were over one hundred gulls, a mixture of Common Gulls (*Larus canus*), Lesser Black Backed Gulls (*Larus fuscus)* and Herring Gulls (*Larus argentatus*) on the loch. A Common Teal (*Anas crecca*) and a Grey Heron (*Ardea cinerea*) were also observed during the survey. No other wildlife was observed in the area during the survey.

Shoreline Survey Maps

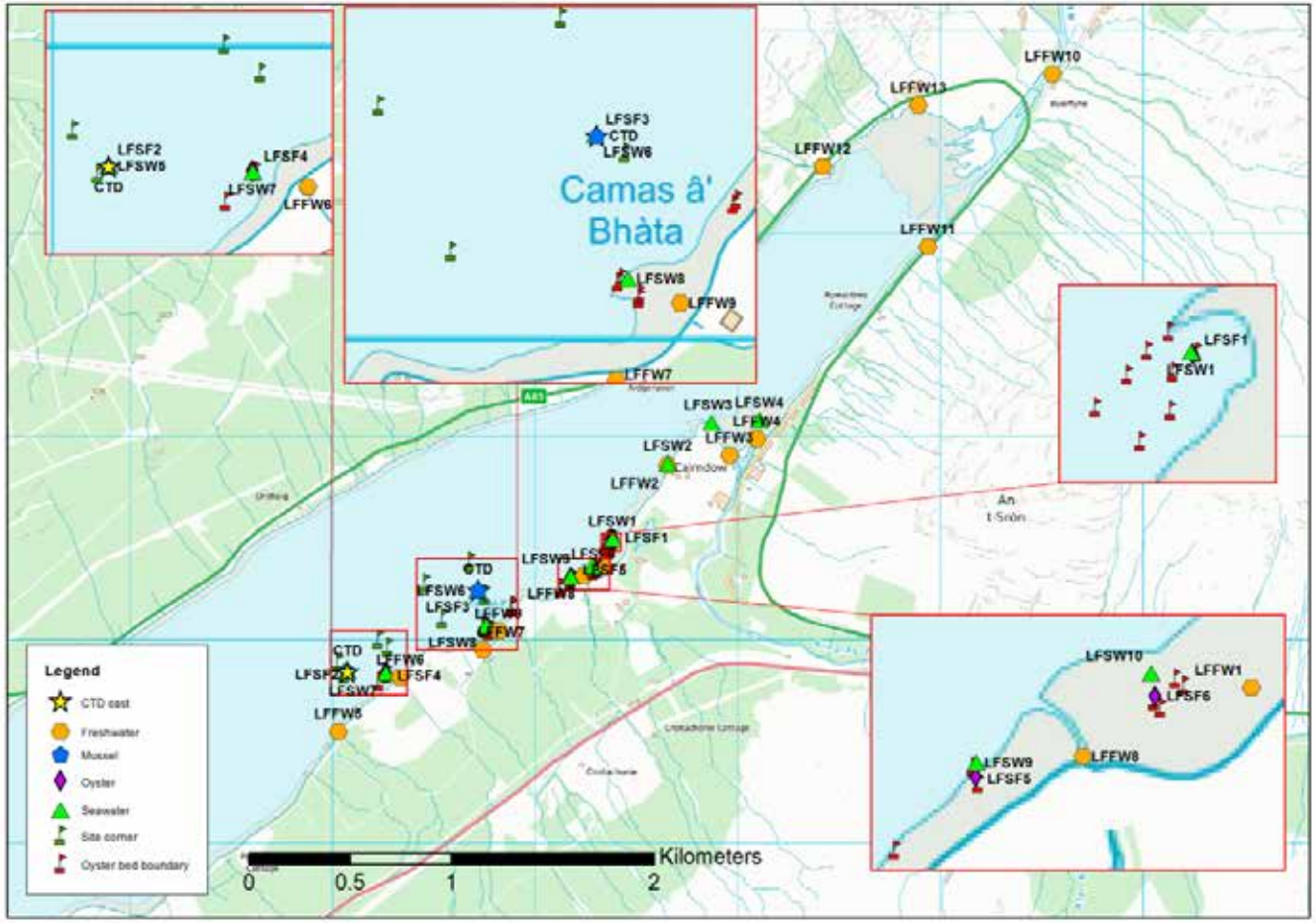

Figure 1. Ardkinglas Samples Waypoints

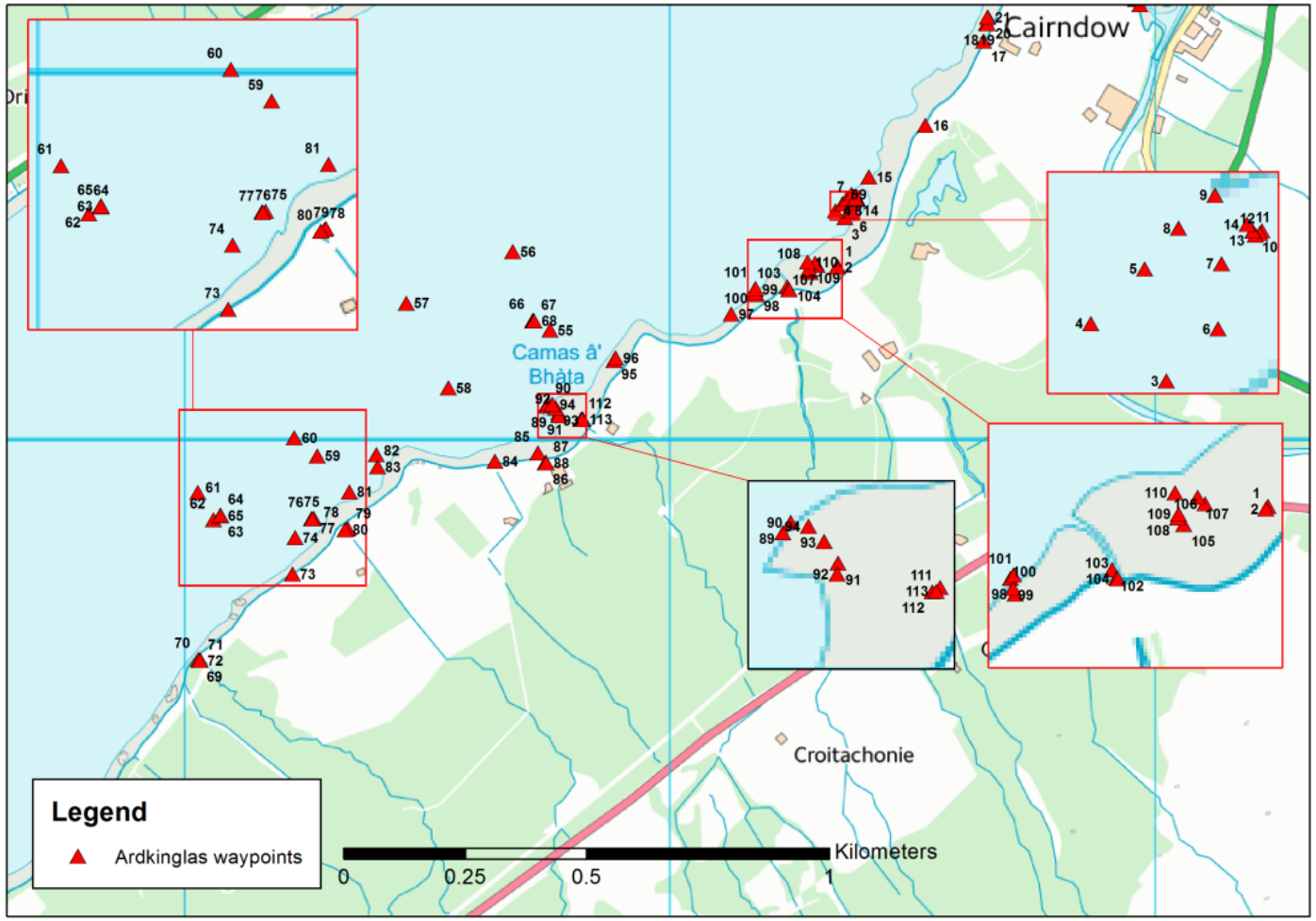

Figure 2. Ardkinglas Lower Loch Waypoints

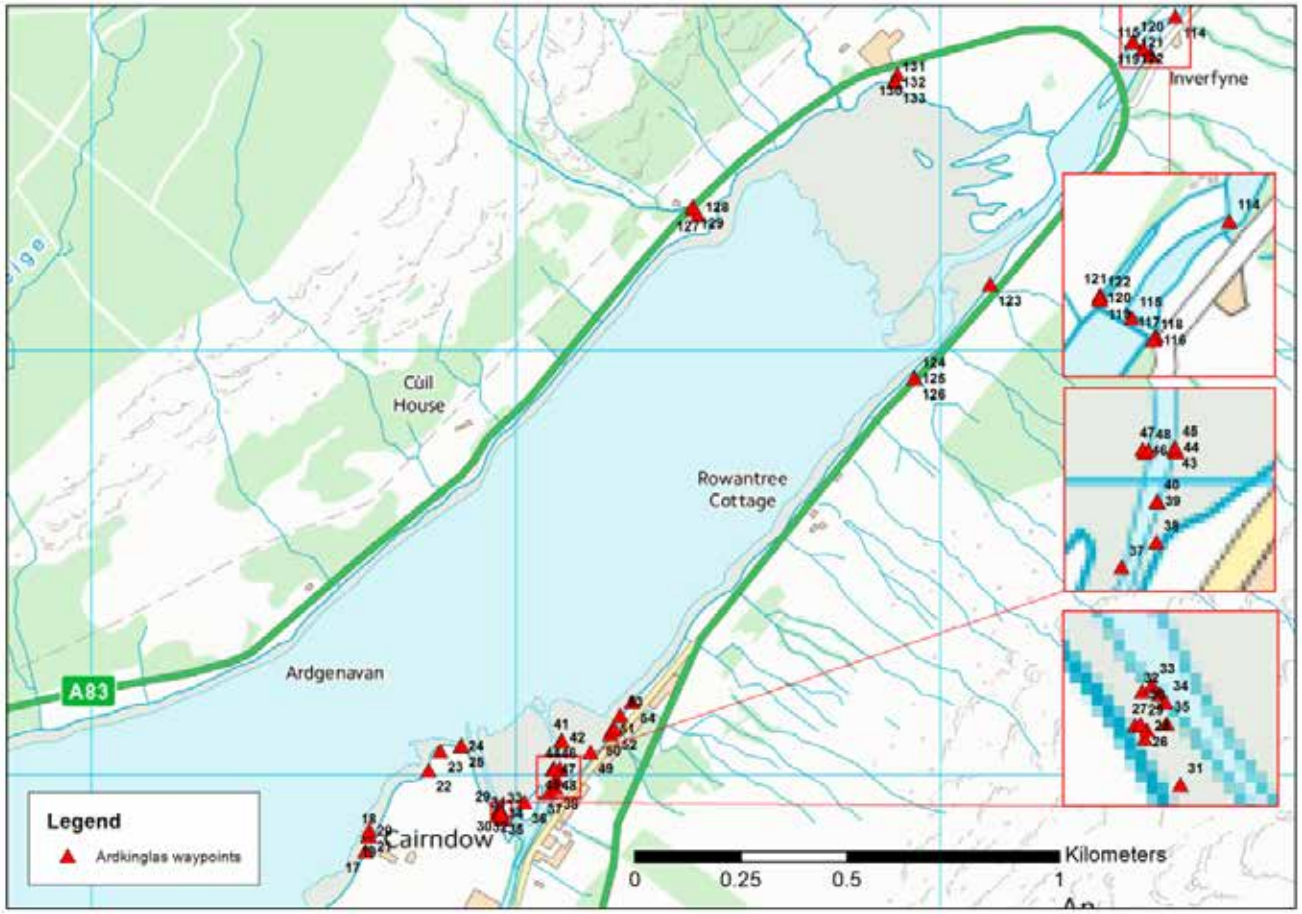

Figure 3. Ardkinglas Upper Loch Waypoints

Table 1 Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	09/09/2013	9:12	NN 17344 10356	217345	710357		LFFW1	Planned freshwater sample. Sample associated with observations at waypoint 2.
2	09/09/2013	9:13	NN 17343 10354	217344	710355	Fig 4		River running onto shore at Ardkinglas House. Measurements: Width: 2.32 m; Depth: 16 cm; Flow: 0.046 m/s; SD: 0.012. Trees behind river; oyster trestles next to river. One heron on shore, one seagull flying over the water.
3	09/09/2013	9:29	NN 17360 10456	217361	710457	Fig 5		Corners of oyster bed.
4	09/09/2013	9:30	NN 17341 10471	217341	710472			Corners of oyster bed.
5	09/09/2013	9:31	NN 17355 10486	217355	710486			Corners of oyster bed.
6	09/09/2013	9:32	NN 17374 10470	217374	710470			Corners of oyster bed.
7	09/09/2013	9:35	NN 17375 10487	217375	710488			Corners of oyster bed.
8	09/09/2013	9:36	NN 17364 10496	217364	710497			Corners of oyster bed.
9	09/09/2013	9:36	NN 17373 10505	217374	710506			Corners of oyster bed.
10	09/09/2013	9:37	NN 17385 10496	217386	710496			Corners of oyster bed.
11	09/09/2013	9:37	NN 17385 10495	217385	710495			Four cormorants on water, one seagull overhead.
12	09/09/2013	9:38	NN 17384 10495	217384	710495		LFSF1	Planned oyster sample.
13	09/09/2013	9:47	NN 17383 10496	217384	710496		LFSW1	Planned seawater sample.
14	09/09/2013	9:47	NN 17382 10497	217382	710498			Ardkinglas House just back from the shore. No pipes or discharges observed at low tide.
15	09/09/2013	9:52	NN 17409 10541	217410	710541			One stand-alone trestles with six bags of oysters.
16	09/09/2013	9:56	NN 17526 10647	217526	710648			Freshwater spring bubbling up from under rocks on shore. No sample taken as considered low risk for contamination (nothing in surroundings and no algal growth). One seagull observed.
17	09/09/2013	10:06	NN 17645 10821	217646	710822			Panfish - The Scottish Salmon Company building with two lorries parked outside. Seven crows in tree behind, one heron flying over water.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
18	09/09/2013	10:08	NN 17652 10858	217652	710858		LFFW2	Planned freshwater sample, contaminated. Sample associated with observations at waypoint 19.
19	09/09/2013	10:09	NN 17654 10857	217654	710858	Fig 6		Two metal discharge pipes on shore in front of Panfish. Sample taken from flow below pipes, smell of sewage. Measurements - Pipe diameters: 12 cm (both); Depth: 2 cml; Estimated flow: 15ml/s. Raw sewage fungus below and green algae growing around pipes. One pipe is heavily flowing, the other is just dripping.
20	09/09/2013	10:19	NN 17654 10870	217655	710871		LFSW2	Planned seawater sample.
21	09/09/2013	10:20	NN 17654 10870	217654	710871	Fig 7		Pipe encased in concrete running far out to sea from Panfish - effluent pipe according to staff member. Can hear water running in pipe. No obvious signs of contamination. One seagull flying overhead.
22	09/09/2013	10:33	NN 17794 11012	217794	711012			Six oyster catchers on rocky shore.
23	09/09/2013	10:36	NN 17822 11057	217822	711058			Approximately 100 seagulls on shore. Also a cormorant and a heron observed.
24	09/09/2013	10:40	NN 17870 11069	217870	711070		LFSW3	Planned seawater sample.
25	09/09/2013	10:40	NN 17870 11070	217871	711070			Seawater sample above was taken near where the flock of gulls were on the shore. Houses on shore nearby (approx. 17).
26	09/09/2013	10:55	NN 17959 10907	217960	710907		LFFW3	Planned freshwater sample. Sample associated with observations at waypoint 32.
27	09/09/2013	10:55	NN 17957 10910	217957	710910			Wide river flowing onto shore, houses behind. One Teal (duck).
28	09/09/2013	10:57	NN 17960 10909	217960	710909			Waypoints taken on southwest side of the river for width estimation.
29	09/09/2013	10:59	NN 17958 10910	217959	710911			Waypoints taken on southwest side of the river for width estimation.
30	09/09/2013	11:00	NN 17959 10918	217959	710918			Waypoints taken on southwest side of the river for width estimation.
31	09/09/2013	11:03	NN 17967 10897	217968	710897	Fig 8		Watercourse diversion of tributary through a large plastic pipe (diameter approx. 1 m) discharging into river, no access to it. Large volume of water discharging through pipe.
32	09/09/2013	11:09	NN 17962 10917	217963	710918			River measurements at sample location (sample taken at waypoint 26). Depth: 55 cm; Flow: 0.371 m/s; SD: 0.037
33	09/09/2013	11:10	NN 17961 10919	217961	710920			Waypoints taken on northeast side of the river for width estimation.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
34	09/09/2013	11:12	NN 17964 10915	217964	710916			Waypoints taken on northeast side of the river for width estimation.
35	09/09/2013	11:14	NN 17964 10910	217965	710911			Waypoints taken on northeast side of the river for width estimation.
36	09/09/2013	11:22	NN 18020 10936	218021	710937			Goose droppings on grassy shore.
37	09/09/2013	11:26	NN 18077 10958	218078	710959			Second branch of large river sampled at waypoint 26.
38	09/09/2013	11:28	NN 18094 10970	218094	710971			Strong smell of sewage and toilet paper on shore. No pipes, outfalls or septic tanks observed.
39	09/09/2013	11:29	NN 18094 10990	218095	710990		LFFW4	Planned freshwater sample. Sample associated with waypoint 40.
40	09/09/2013	11:30	NN 18094 10990	218095	710991	Fig 9		Clay outfall pipe from Scottish Water septic tank discharges into river (river width associated with waypoints 43-48). Smell of sewage. Pub and hotel behind and approx. 17 houses. Pipe diameter: 12 cm; Width of flow in pipe: 12 cm; Depth 1: 31 cm; Flow 1: 0.014 m/s; SD 1: 0.005. Depth 2: 40 cm; Flow 1: 0.014 m/s; SD 1: 0.001.
41	09/09/2013	11:43	NN 18106 11082	218107	711082		LFSW4	Planned seawater sample.
42	09/09/2013	11:44	NN 18109 11080	218109	711081			Two seagulls on water.
43	09/09/2013	11:57	NN 18103 11015	218103	711015			Waypoints taken on east side of the river for width estimation.
44	09/09/2013	11:59	NN 18103 11014	218104	711014			Waypoints taken on east side of the river for width estimation.
45	09/09/2013	11:59	NN 18103 11016	218103	711016			Waypoints taken on east side of the river for width estimation.
46	09/09/2013	12:02	NN 18088 11013	218089	711014			Waypoints taken on west side of the river for width estimation.
47	09/09/2013	12:03	NN 18087 11015	218088	711016			Waypoints taken on west side of the river for width estimation.
48	09/09/2013	12:04	NN 18090 11014	218090	711015			Waypoints taken on west side of the river for width estimation.
49	09/09/2013	12:08	NN 18175 11054	218176	711054	Fig 10		Metal pipe runs under the road onto shore. Houses behind. Pipe diameter 20 cm. No discharge.
50	09/09/2013	12:12	NN 18222 11096	218223	711097			River running from hillside onto shore under the road with houses behind. Width estimated to be 1-2 m.
51	09/09/2013	12:13	NN 18226 11105	218226	711106			Clay pipe, approx. diameter 30 cm. No flow, no algal growth around it.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
52	09/09/2013	12:14	NN 18231 11110	218232	711110	Fig 11		Small flow trickling through rocks with source unknown and impossible to identify. Flow is smelly and murky. No sample taken as deemed low risk with no obvious source in surroundings.
53	09/09/2013	12:17	NN 18245 11141	218246	711141			Old metal pipe running from a structure that looks disused. No flow, diameter is approx. 50 cm.
54	09/09/2013	12:19	NN 18274 11173	218275	711174	Fig 12		Small river running from hillside onto shore. Houses next to river. Width of river is approx. 1 m. An orange pipe with approx. 30 cm diameter directed into river. No flow from pipe. No sample taken as deemed to be of low risk due to lack of obvious contamination, the small size of the river and that the larger river was sampled which is in close proximity to this smaller watercourse.
55	09/09/2013	13:52	NN 16753 10225	216753	710225	Fig 13		Waypoint marking the corners of the first set of 10 mussel lines. South east corner.
56	09/09/2013	13:55	NN 16676 10387	216676	710387			Waypoint marking the corners of the first set of 10 mussel lines. North east corner.
57	09/09/2013	13:57	NN 16456 10281	216456	710281			Waypoint marking the corners of the first set of 10 mussel lines. North west corner.
58	09/09/2013	14:00	NN 16543 10106	216544	710106			Waypoint marking the corners of the first set of 10 mussel lines. South west corner.
59	09/09/2013	14:02	NN 16272 09965	216273	709966			Waypoint marking the corners of the second set of 4 mussel lines. South east corner.
60	09/09/2013	14:03	NN 16225 10003	216225	710003			Waypoint marking the corners of the second set of 4 mussel lines. North east corner.
61	09/09/2013	14:05	NN 16026 09890	216027	709891			Waypoint marking the corners of the second set of 4 mussel lines. North west corner.
62	09/09/2013	14:06	NN 16059 09834	216059	709834			Waypoint marking the corners of the second set of 4 mussel lines. South west corner.
63	09/09/2013	14:08	NN 16073 09843	216074	709844		LFSW5	Planned seawater sample.
64	09/09/2013	14:09	NN 16073 09842	216074	709843		LFSF2	Planned shellfish sample from the top 1.5 m of line.
65	09/09/2013	14:10	NN 16073 09843	216074	709843		CTD	CTD cast 1.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
66	09/09/2013	14:24	NN 16717 10245	216717	710245		LFSW6	Planned seawater sample. Confirmed RMP.
67	09/09/2013	14:26	NN 16719 10244	216719	710245		CTD	CTD cast 2.
68	09/09/2013	14:26	NN 16719 10244	216719	710244		LFSF3	Planned shellfish sample. End of survey day 1.
69	10/09/2013	9:06	NN 16029 09544	216030	709544			Start of survey day 2.
70	10/09/2013	9:07	NN 16027 09546	216028	709547		LFFW5	Planned freshwater sample. Sample associated with measurements and observations at waypoint 71 and 72.
71	10/09/2013	9:11	NN 16031 09544	216032	709544			Watercourse observations - Width: 59 cm; Depth: 17 cm; Flow: 0.314 m/s; SD: 0.013
72	10/09/2013	9:12	NN 16031 09544	216032	709544			Watercourse running from hillside onto shore.
73	10/09/2013	9:26	NN 16222 09722	216222	709722			Watercourse running onto shore. Too shallow to sample but algal growth visible on rocks.
74	10/09/2013	9:30	NN 16227 09797	216227	709798			Oyster trestles most of them out of use. West end.
75	10/09/2013	9:34	NN 16265 09837	216266	709837	Fig 14		East end of oyster trestles. Two trestles with new bag system.
76	10/09/2013	9:35	NN 16261 09836	216262	709837		LFSF4	Planned oyster sample.
77	10/09/2013	9:43	NN 16262 09835	216263	709836		LFSW7	Planned seawater sample.
78	10/09/2013	9:53	NN 16334 09815	216335	709816		LFFW6	Planned freshwater sample. Sample associated with measurements and observations at waypoint 79 and 80.
79	10/09/2013	9:55	NN 16336 09816	216336	709817			Watercourse measurements - Width: 1.1 m; Depth: 24 cm; Flow: 0.026 m/s; SD: 0.007
80	10/09/2013	9:55	NN 16330 09813	216331	709814			Watercourse from hill running into loch.
81	10/09/2013	10:01	NN 16339 09891	216339	709892			West end of oyster trestles. Six out of fifteen are in use.
82	10/09/2013	10:05	NN 16394 09968	216395	709969			East end of oyster trestles.
83	10/09/2013	10:07	NN 16397 09943	216397	709944			Mid-point of oyster trestles closest to shore.
84	10/09/2013	10:13	NN 16638 09955	216639	709955			Watercourse from hill running onto shore. Width: 60 cm, too shallow to sample.
85	10/09/2013	10:19	NN 16728 09972	216728	709972	Fig 15		Inlet and outlet pipes from Loch Fyne Oysters.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
86	10/09/2013	10:24	NN 16742 09951	216743	709951		LFFW7	Planned freshwater sample. Sample associated with measurements and observations at waypoint 87 and 88.
87	10/09/2013	10:25	NN 16743 09953	216744	709953	Fig 16		Watercourse measurements - Width of flow: 40cm; Pipe diameter: 72 cm; Flow: 1.531 m/s; SD: 0.02
88	10/09/2013	10:28	NN 16744 09951	216745	709952			Watercourse running alongside Loch Fyne Oysters Processing Plant through a pipe under the road.
89	10/09/2013	10:33	NN 16744 10069	216745	710069			North west corner of oyster trestles. Coordinate taken 3m from corner of trestles due to rising tide.
90	10/09/2013	10:34	NN 16748 10074	216749	710074			North east corner of oyster trestles. Coordinate taken 3m from corner of trestles due to rising tide.
91	10/09/2013	10:35	NN 16771 10054	216771	710055			South east corner of oyster site.
92	10/09/2013	10:36	NN 16770 10049	216771	710049			South west corner of oyster site.
93	10/09/2013	10:37	NN 16764 10065	216765	710065	Fig 17		Cage with oyster bags. Size: 3 m x 1 m.
94	10/09/2013	10:39	NN 16757 10072	216757	710072		LFSW8	Planned seawater sample.
95	10/09/2013	10:45	NN 16884 10162	216884	710163			Two rows of 23 oyster trestles. West end.
96	10/09/2013	10:45	NN 16887 10167	216888	710168			East end of set of oyster trestles.
97	10/09/2013	10:51	NN 17126 10258	217126	710258			South west corner of oyster site.
98	10/09/2013	10:53	NN 17177 10298	217178	710299			South east corner of oyster site. Sixteen out of 23 in use.
99	10/09/2013	10:56	NN 17174 10308	217174	710309			North east corner of oyster trestles. Coordinate taken from pier 5m from site corner.
100	10/09/2013	10:57	NN 17176 10302	217176	710302		LFSF5	Planned shellfish sample.
101	10/09/2013	11:04	NN 17176 10311	217176	710311		LFSW9	Planned seawater sample.
102	10/09/2013	11:18	NN 17241 10314	217242	710315		LFFW8	Planned freshwater sample. Sample associated with observations in waypoint 103.
103	10/09/2013	11:23	NN 17244 10309	217245	710309			Watercourse measurements - Width: 1.2 m; Depth: 15 cm; Flow: 0.356 m/s; SD: 0.02

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
104	10/09/2013	11:24	NN 17245 10308	217245	710309			Watercourse running downhill onto shore.
105	10/09/2013	11:32	NN 17289 10344	217289	710345			South west corner of oyster site.
106	10/09/2013	11:33	NN 17303 10358	217303	710358			South east corner of oyster site.
107	10/09/2013	11:33	NN 17298 10362	217298	710363			North east corner of oyster site.
108	10/09/2013	11:34	NN 17285 10349	217285	710349			North west corner of oyster site.
109	10/09/2013	11:34	NN 17285 10351	217286	710352		LFSF6	Planned shellfish sample.
110	10/09/2013	11:36	NN 17283 10365	217284	710366		LFSW10	Planned seawater sample.
111	10/09/2013	12:00	NN 16820 10043	216820	710043		LFFW9	Unplanned freshwater sample. Sample associated with observations in waypoint 112 and 113.
112	10/09/2013	12:01	NN 16816 10040	216816	710041			Watercourse measurements - Width: 193 cm; Depth: 12 cm; Flow: 0.337 m/s; SD: 0.0019
113	10/09/2013	12:01	NN 16818 10041	216818	710041			Watercourse above was not required to be sampled but due to its proximity to oyster trestles at waypoint 92 and 93 it was sampled.
114	10/09/2013	12:42	NN 19554 12786	219554	712787		LFFW10	Planned freshwater sample. Sample associated with observations in waypoint 115.
115	10/09/2013	12:50	NN 19477 12711	219478	712711	Fig 18		Watercourse (River Fyne) measurements - Depth: 1-1.5 m on average; Flow 1.06m/s estimated using flow stick method; for width there were three waypoints taken on each side of the river: On south side waypoint 116-118 and on north side - waypoint 119-121.
116	10/09/2013	12:57	NN 19496 12697	219496	712698			Waypoints taken on south side of the river for width estimation.
117	10/09/2013	12:58	NN 19495 12695	219496	712695			Waypoints taken on south side of the river for width estimation.
118	10/09/2013	12:59	NN 19494 12694	219494	712694			Waypoints taken on south side of the river for width estimation.
119	10/09/2013	13:01	NN 19453 12725	219453	712725			Waypoints taken on north side of the river for width estimation.
120	10/09/2013	13:01	NN 19452 12728	219453	712729			Waypoints taken on north side of the river for width estimation.
121	10/09/2013	13:02	NN 19452 12729	219453	712729			Waypoints taken on north side of the river for width estimation.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
122	10/09/2013	13:02	NN 19452 12726	219453	712727			Approximately 100 sheep in field next to river. Large watercourse at the head of the loch.
123	10/09/2013	13:15	NN 19117 12156	219118	712156			Small watercourse runs from under the road onto shore. Width is between 1-2 m.
124	10/09/2013	13:30	NN 18938 11936	218939	711936		LFFW11	Planned freshwater sample. Sample associated with measurements in waypoint 125 and 126.
125	10/09/2013	13:33	NN 18939 11937	218939	711937			Watercourse measurements - Width: 60cm; Depth: 7 cm; Flow: 0.223 m/s; SD: 0.020
126	10/09/2013	13:35	NN 18938 11935	218938	711936			Watercourse running from hill under road onto shore. Two sheep in field.
127	10/09/2013	13:51	NN 18419 12331	218420	712332		LFFW12	Planned freshwater sample. Sample associated with observation and measurement in waypoint 128 and 129.
128	10/09/2013	13:53	NN 18429 12317	218429	712318			Watercourse measurements - Width: 1.8 m; Depth: 15 cm; Flow: 0.073 m/s; SD: 0.004
129	10/09/2013	13:56	NN 18416 12338	218417	712339			Watercourse tunnelled under road through small wooded area into loch. Two houses on opposite side of the road. Twelve sheep in field next to houses.
130	10/09/2013	14:10	NN 18898 12650	218899	712651	Fig 19		Septic tank at Loch Fyne Oyster Visitor Centre.
131	10/09/2013	14:13	NN 18892 12633	218893	712633		LFFW13	Planned freshwater sample. Sample associated with observations and measurements in waypoint 132 and 133.
132	10/09/2013	14:16	NN 18892 12634	218893	712634			Watercourse measurements - Width: 1.1m; Depth: 5 cm; flow: 2.21m/s estimated using flow stick method.
133	10/09/2013	14:16	NN 18892 12632	218893	712633	Fig 20		Watercourse running from side of Loch Fyne Restauran indication of sewage fungus present, also smelly. A 100+ gulls, 40 pink footed geese in field between road and loch.

Photographs referenced in the table can be found attached as Figures 4 – 20.

Sampling

Water and shellfish samples were collected at the sites marked in Figure 1.

Both mussel samples were collected from the harvester's boat as requested by the client at the surface of the lines. Salinity profiles were also taken during this survey. Oyster samples were collected from trestles during low tide.

All the samples were transferred to a Biotherm 10 or Biotherm 30 box with ice packs and posted to the Glasgow Scientific Services (GSS) for *E.coli* analysis. All the samples were posted on the day of collection and all the samples were received and analysed the following day. The sample temperatures on arrival at the laboratory were recorded at 2.2°C or 4.9°C.

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

$$\text{Salinity (ppt)} = 0.0018066 \times \text{Cl (mg/L)}$$

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	*E. coli* (cfu/100ml)	Salinity (ppt)
1	09/09/2013	LFFW1	NN 17344 10356	Freshwater	780	
2	09/09/2013	LFFW2	NN 17652 10858	Freshwater	71000	
3	09/09/2013	LFFW3	NN 17959 10907	Freshwater	40	
4	09/09/2013	LFFW4	NN 18094 10990	Freshwater	50000	
5	10/09/2013	LFFW5	NN 16027 09546	Freshwater	30	
6	10/09/2013	LFFW6	NN 16334 09815	Freshwater	50	
7	10/09/2013	LFFW7	NN 16742 09951	Freshwater	<10	
8	10/09/2013	LFFW8	NN 17241 10314	Freshwater	20	
9	10/09/2013	LFFW9	NN 16820 10043	Freshwater	<10	
10	10/09/2013	LFFW10	NN 19554 12786	Freshwater	90	
11	10/09/2013	LFFW11	NN 18938 11936	Freshwater	20	
12	10/09/2013	LFFW12	NN 18419 12331	Freshwater	<10	
13	10/09/2013	LFFW13	NN 18892 12633	Freshwater	<1000	
14	09/09/2013	LFSW1	NN 17383 10496	Seawater	53	22.76
15	09/09/2013	LFSW2	NN 17654 10870	Seawater	47	24.39
16	09/09/2013	LFSW3	NN 17870 11069	Seawater	49	17.07
17	09/09/2013	LFSW4	NN 18106 11082	Seawater	7300	8.18
18	09/09/2013	LFSW5	NN 16073 09843	Seawater	74	24.03
19	09/09/2013	LFSW6	NN 16717 10245	Seawater	23	24.75
20	10/09/2013	LFSW7	NN 16262 09835	Seawater	25	26.56
21	10/09/2013	LFSW8	NN 16757 10072	Seawater	9	23.49
22	10/09/2013	LFSW9	NN 17176 10311	Seawater	5	25.11
23	10/09/2013	LFSW10	NN 17283 10365	Seawater	37	18.07

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	*E. coli* (MPN/100g)	Sample Depth
1	09/09/2013	LFSF1	NN 17384 10495	Oyster	3500	-
2	09/09/2013	LFSF2	NN 16073 09842	Mussel	700	Surface
3	09/09/2013	LFSF3	NN 16719 10244	Mussel	490	Surface
4	10/09/2013	LFSF4	NN 16261 09836	Oyster	2400	-
5	10/09/2013	LFSF5	NN 17176 10302	Oyster	1700	-
6	10/09/2013	LFSF6	NN 17285 10351	Oyster	3500	-

Salinity Profiles

Salinity profiles were taken at two locations in the production area, one at each end of the mussel lines. The gathered data will be sent to customer as agreed previously on a separate Excel sheet.

Shoreline Survey Photographs

Figure 4. River onto shore Ardkinglas House. Associated with waypoint 2. Location of sample LFFW1.

Figure 5. Oyster bed. Associated with waypoint 3.

Fig 6. Panfish waste pipe. Associated with waypoint 19. Location of sample LFFW2.

Figures 7. Pipe running far out to sea at Panfish. Associated with waypoint 21. Location of sample LFSW2.

Fig 8. Watercourse diversion through large plastic pipe. Associated with waypoint 31. Location of sample LFFW3.

Figure 9. Clay outfall pipe into river. Associated with waypoint 40. Location of sample LFFW4.

Figure 10. Metal pipe from houses, no discharge. Associated with waypoint 49.

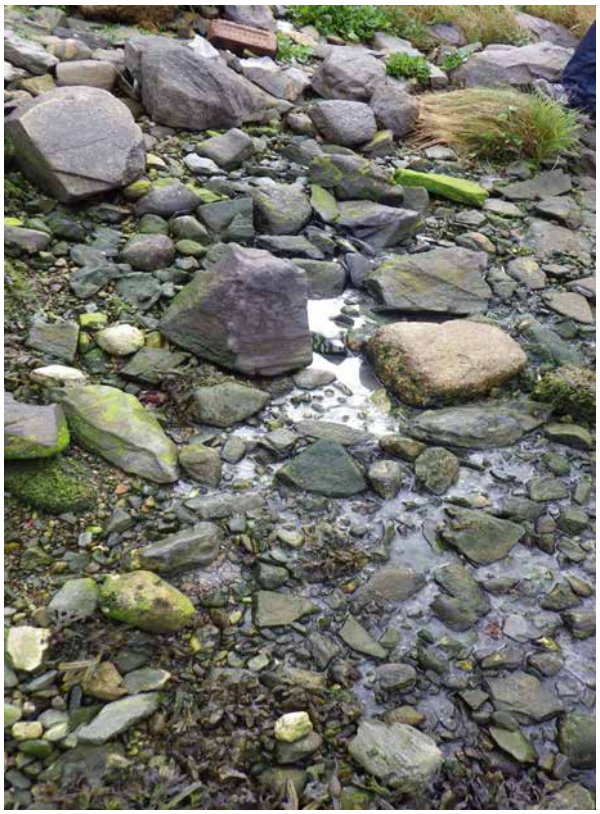

Fig 11. Water onto shore from unknown source. Associated with waypoint 52.

Figure 12. Small watercourse running onto shore. Associated with waypoint 54.

Figure 13. The set of ten mussel lines. Associated with waypoint 55.

Figure 14. East end of oyster trestles. Associated with waypoint 75.

Figure 15. Inlet and outlet pipes from Loch Fyne Oysters. Associated with waypoint 85.

Figure16. Watercourse running from side of Loch Fyne Oysters. Associated with waypoint 87. Location of sample LFFW7.

Fig 17. Oyster trestle and cage. Associated with waypoint 93.

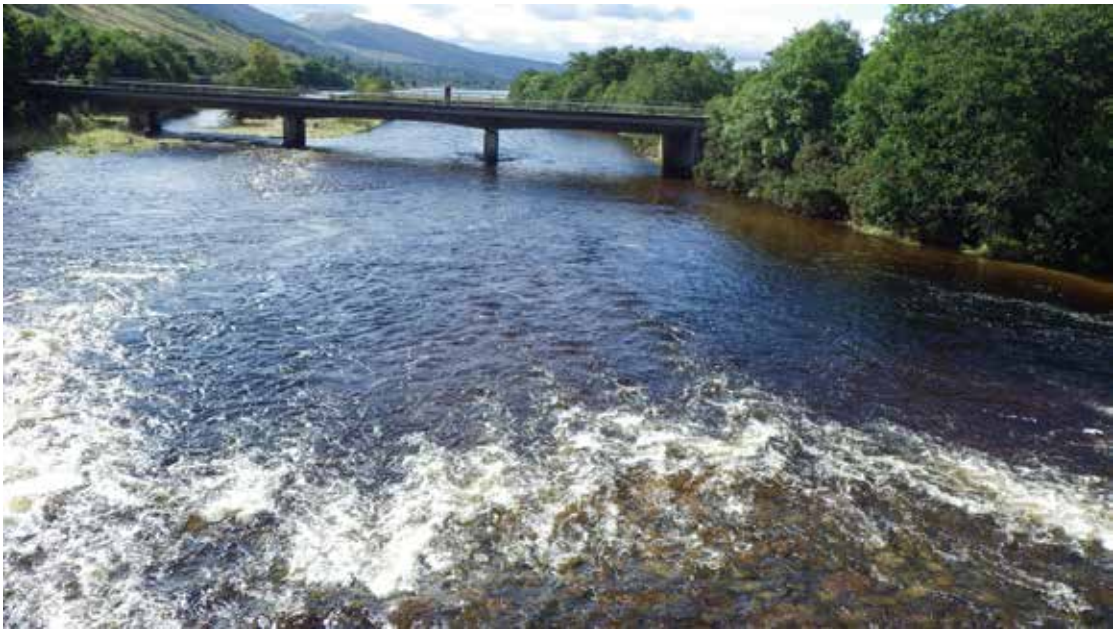

Fig 18. River Fyne at head of loch. Associated with waypoint 115.

Fig 19. Septic tank at Loch Fyne Oyster Restaurant. Associated with waypoint 130.

Fig 20. Watercourse running from side of Loch Fyne Restaurant Indication of sewage fungus present. Associated with waypoint 133.