Scottish Sanitary Survey Programme

Sanitary Survey Review
Loch Creran
AB 129, 130, 131, 312 and 313
April 2013

Report Distribution - Loch Creran

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Mr Roger Thwaites (Shian Fisheries)	Harvester
Mrs Jane Barrington (East Barrington)	Harvester
Mr Hugo Vajk (Rubha Mor)	Harvester

Partner Organisation

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

Review Specification

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

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

The EURL Good Practice Guide (GPG) for the monitoring of bivalve molluscs harvesting areas 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, the review comprises of a brief desktop search of publicly available information together with a shoreline survey. The review will determine significant changes in:

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

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

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Introduction

In 2007, a Sanitary Survey was conducted at Loch Creran to confirm the location, extent and nature of the shellfisheries there, create an inventory of the potential sources of faecal contamination to the shellfishery, and to recommend production area boundaries and sampling plans for the production areas within the loch.

The output of the Sanitary Survey included a recommended sampling plan for each of the classified production areas in the loch. These are listed in the following four pages alongside any changes to the sampling plan recommended 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 that report.

Sampling Plan – Loch Creran Upper Mussels

	2007 recommendations	2012 review	Changes
PRODUCTION AREA	Loch Creran Upper Mussels		No changes
SITE NAME	Inner Creran		
SIN	AB-313-709-08		
SPECIES	Common mussels		
TYPE OF FISHERY	Aquaculture: longlines		
NGR OF RMP	NM 9566 4371		
EAST	195660		
NORTH	743710		
TOLERANCE (M)	20		
DEPTH (M)	1 m		
METHOD OF SAMPLING	Hand		
FREQUENCY OF SAMPLING	Monthly		
LOCAL AUTHORITY	Argyll and Bute		
AUTHORISED SAMPLER(S)	Andy MacLeod Christine McLachlan William McQuarrie Ewan McDougall Donald Campbell	Fraser Anderson Karen Goodchild William McQuarrie Ewan McDougall Allison Hardie	Change in staff
LOCAL AUTHORITY LIAISON OFFICER	Andy MacLeod	Fraser Anderson	Change in staff
RECOMMENDED PRODUCTION AREA	NM 9550 4400 and NM 9678 4328 and between NM 9407 4265 and NM 9500 4144 extending to MHWS.		No changes

Sampling Plan – Loch Creran Upper Oysters

	2007 recommendations	2012 review	Changes
PRODUCTION AREA	Loch Creran Upper Oysters		No changes
SITE NAME	East - Barrington		
SIN	AB-129-021-13		
SPECIES	Pacific oysters		
TYPE OF FISHERY	Aquaculture: trestles		
NGR OF RMP	NM 9485 4322		
EAST	194850		
NORTH	743220		
TOLERANCE (M)	10		
DEPTH (M)	N/A		
METHOD OF SAMPLING	Hand		
FREQUENCY OF SAMPLING	Monthly		
LOCAL AUTHORITY	Argyll and Bute		
AUTHORISED SAMPLER(S)	Andy MacLeod Christine McLachlan William McQuarrie Ewan McDougall Donald Campbell	Fraser Anderson Karen Goodchild William McQuarrie Ewan McDougall Allison Hardie	Change in staff
LOCAL AUTHORITY LIAISON OFFICER	Andy MacLeod	Fraser Anderson	Change in staff
RECOMMENDED PRODUCTION AREA	NM 9550 4400 and NM 9678 4328 and between NM 9407 4265 and NM 9500 4144 extending to MHWS.		No changes

Sampling Plan – Loch Creran: Rubha Mor

	2007 recommendations	2012 review	Changes
PRODUCTION AREA	Loch Creran: Rubha Mor		No changes
SITE NAME	Rubha Mor		
SIN	AB-130-742-13 and AB-130-022-13		
SPECIES	Pacific oyster		
TYPE OF FISHERY	Aquaculture: trestles		
NGR OF RMP	NM 9171 4065		
EAST	191710		
NORTH	740650		
TOLERANCE (M)	10		
DEPTH (M)	N/A		
METHOD OF SAMPLING	Hand		
FREQUENCY OF SAMPLING	Monthly		
LOCAL AUTHORITY	Argyll and Bute		
AUTHORISED SAMPLER(S)	Andy MacLeod Christine McLachlan William McQuarrie Ewan McDougall Donald Campbell	Fraser Anderson Karen Goodchild William McQuarrie Ewan McDougall Allison Hardie	Change in staff
LOCAL AUTHORITY LIAISON OFFICER	Andy MacLeod	Fraser Anderson	Change in staff
RECOMMENDED PRODUCTION AREA	NM 9300 4200 and NM 9230 4112 and between NM 9110 4112 and NM 9203 4201 extending to MHWS.		No changes

Sampling Plan – Loch Creran: Shian Oysters

	2007 recommendations	2012 review	Changes
PRODUCTION AREA	Shian Oysters		No changes
SITE NAME	Shian Fisheries		
SIN	AB-131-023-13		
SPECIES	Pacific oysters		
TYPE OF FISHERY	Aquaculture: trestles		
NGR OF RMP	NM 9094 4220		
EAST	190940		
NORTH	742200		
TOLERANCE (M)	10		
DEPTH (M)	N/A		
METHOD OF SAMPLING	Hand		
FREQUENCY OF SAMPLING	Monthly		
LOCAL AUTHORITY	Argyll and Bute		
AUTHORISED SAMPLER(S)	Andy MacLeod Christine McLachlan William McQuarrie Ewan McDougall Donald Campbell	Fraser Anderson Karen Goodchild William McQuarrie Ewan McDougall Allison Hardie	Change in staff
LOCAL AUTHORITY LIAISON OFFICER	Andy MacLeod	Fraser Anderson	Change in staff
RECOMMENDED PRODUCTION AREA	NM 9100 4210 and NM 9175 4251 and between NM 9097 4327 - NM 9142 4323 and between NM9030 4200 and NM 9053 4200 and between NM 9033 4240 and NM 9020 4228 extending to MHWS.		No changes

Loch Creran: Shian Mussels

No sampling plan is considered for this area as it has been declassified and harvesting is not expected to occur in the short- to medium-term.

1. Area Description

Loch Creran is a tidal fjordic sea loch on the west coast of Scotland, approximately 15 km from Oban. It is 12.8 km long, has a maximum water depth of 49 m and a flushing time of approximately three days. The loch is divided by sills into four basins and opens into the Lynn of Lorn. Freshwater input is provided via the River Creran at a relatively high rate of 286.3 x 10^6 m^3 yr^{-1} (Edwards and Sharples, 1986). The river flows from Loch Baile Mhic Chailein, 4 km upstream from the head of Loch Creran. An overview map of the area is presented in Figure 1.1 below.

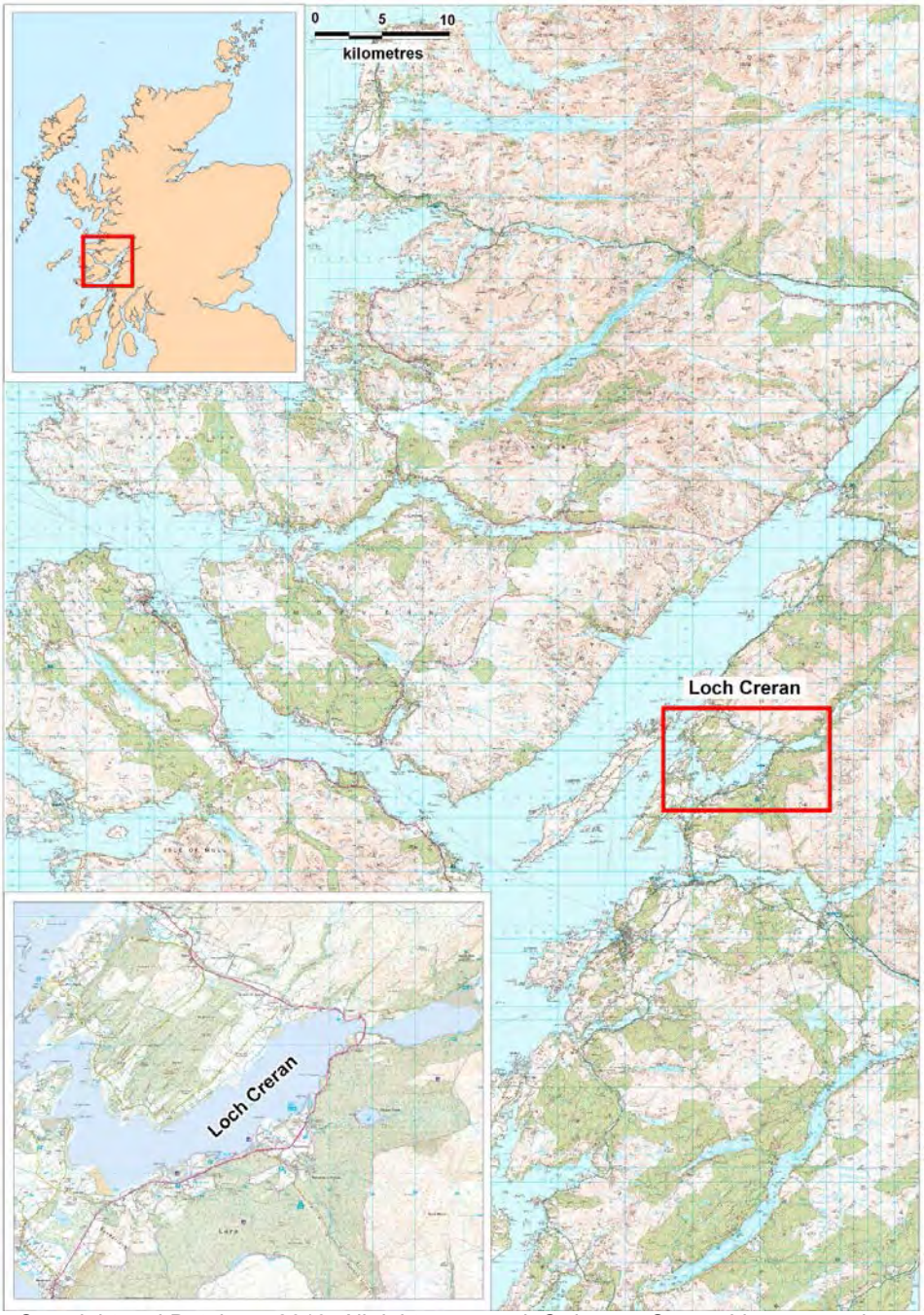

Figure 1.1 Location of Loch Creran

2. Fishery

The current fishery at Loch Creran is comprised of one common mussel farm and three Pacific oyster farms. These fisheries are contained within three geographically distinct production areas, with one area (Loch Creran Upper) classified for two species. The classification listing for the Loch Creran fisheries is shown below in Table 2.1.

Table 2.1 Current classified fisheries at Loch Creran

Production Area	Site Name	SIN	Species
Loch Creran Upper Mussels	Inner Creran	AB-313-709-08	Common mussels
Loch Creran Upper Oysters	East Barrington	AB-129-021-13	Pacific oysters
Loch Creran: Rubha Mor	Loch Creran Ferlochan	AB-130-742-13	Pacific oysters
	Rubha Mor	AB-130-022-13	
Loch Creran: Shian Oysters	Shian Fisheries	AB-131-023-13	Pacific oysters

The production area boundaries and RMPs recommended in the 2007 report are shown in Figure 2.1, in conjunction with the extent of the seabed leases and the fisheries as recorded during the recent shoreline survey.

A second common mussel production area, at Loch Creran: Shian, was present in 2007 but was declassified in 2012.

Loch Creran Upper Mussels

The two mussel farms in Loch Creran Upper Mussels were found to be in a semi-derelict state, with parts of the lines sunk making it difficult to ascertain the true extent of each farm. The southernmost of these two farms appeared to have been shifted to the south and west, in accordance with plans identified by the harvester in 2007. Both farms are operated under the same site name, Inner Creran.

Loch Creran Upper Oysters

This site currently consists of one area of trestles used for growing Pacific oysters (Figure 2.1). The location and extent of the trestles do not appear to have changed since the 2007 report.

Loch Creran: Rubha Mor

Currently oyster cultivation is undertaken along the south shore of the production area where there are two distinct areas of trestles: one large area to the north of Ferlochan and one small area NW of Rubha Mor, near the western production area boundary. Both sites are owned by the same harvester and operated as Rubha Mor.

During the 2007 shoreline survey, the NW site was not active. In 2013, this site was found to have 14 trestles stocked with oysters between 2-3 years old.

In 2007, part of the main area of trestles was operated by a different harvester as Ferlochan site. The current harvester operates both sites as Rubha Mor. Planning permission was granted in 2011 to increase the extent of the Rubha Mor fishery by a further 1625 oyster trestles. In 2012, a change to the RMP was agreed between FSAS and the local authority. It was moved from the location recommended in the 2007 report (NM 9222 4065) westward 525 m to NM 9171 4065. RMP information provided by FSAS identified the point as NM 917 406, however this is only stated to 100 m accuracy and therefore the point given by the local authority is taken to be the more accurate record.

When the site boundaries were re-recorded during the 2013 shoreline survey, the main trestle area was found to have shifted to the NW of its 2007 location. An oyster processing yard was noted at the southeast end of the farm, adjacent to a main road. It was noted that the majority of trestles on the upper shore were not in use, with the few bags situated there mostly full of dead oysters and/or empty shells.

Loch Creran: Shian Oysters

During the 2007 shoreline survey, two main Pacific oyster cultivation sites were noted, with trestles in place adjacent to the pier and around to the western side of the headland at Shian.

During the 2013 shoreline survey, the same two cultivation areas were visited, however extents were estimated as the site was visited when the tide was too high to allow full access to the trestles. Unstocked trestles were also present in the area between the trestles at the Pier and to the west of Shian headland. The western extent of the farm has extended further west since the 2007 survey.

In 2009 an Extended Bacteriological Survey was conducted in order to assess whether contamination levels were different between the two trestle areas. The survey found no statistically significant difference between the two monitoring points, and therefore the nominal RMP at NM 9094 4220 was retained. The Extended Bacteriological Survey report can be found in Appendix 2.

Loch Creran: Shian Mussels

At the time of the 2007 Loch Creran Sanitary Survey Report, a second common mussel fishery (Loch Creran: Shian Mussels) was located north of Sgier Caillich in the Loch Creran Shian production area. It consisted of a mix of rafts and long-lines, though neither contained stock at the time and bagged shellfish had been put in place for sampling purposes.

This fishery was declassified in 2012 and no mussel growing equipment was observed during the recent shoreline survey. A pontoon was still in place, but was not used for growing shellfish.

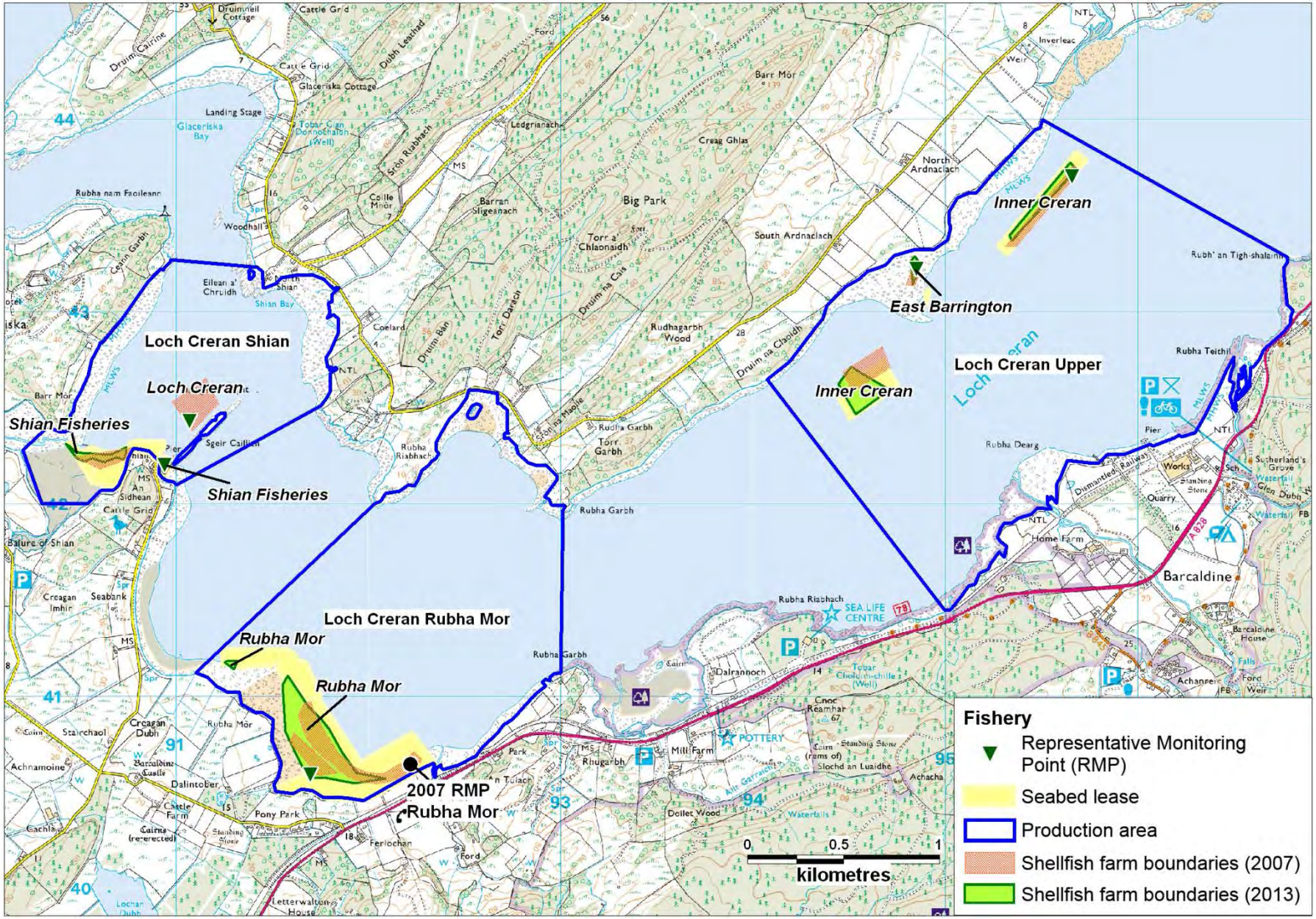

Figure 2.1 Current fishery production areas, with current and historical farm boundaries at Loch Creran

3. Population and Human Sewage Impacts

3.1 Population

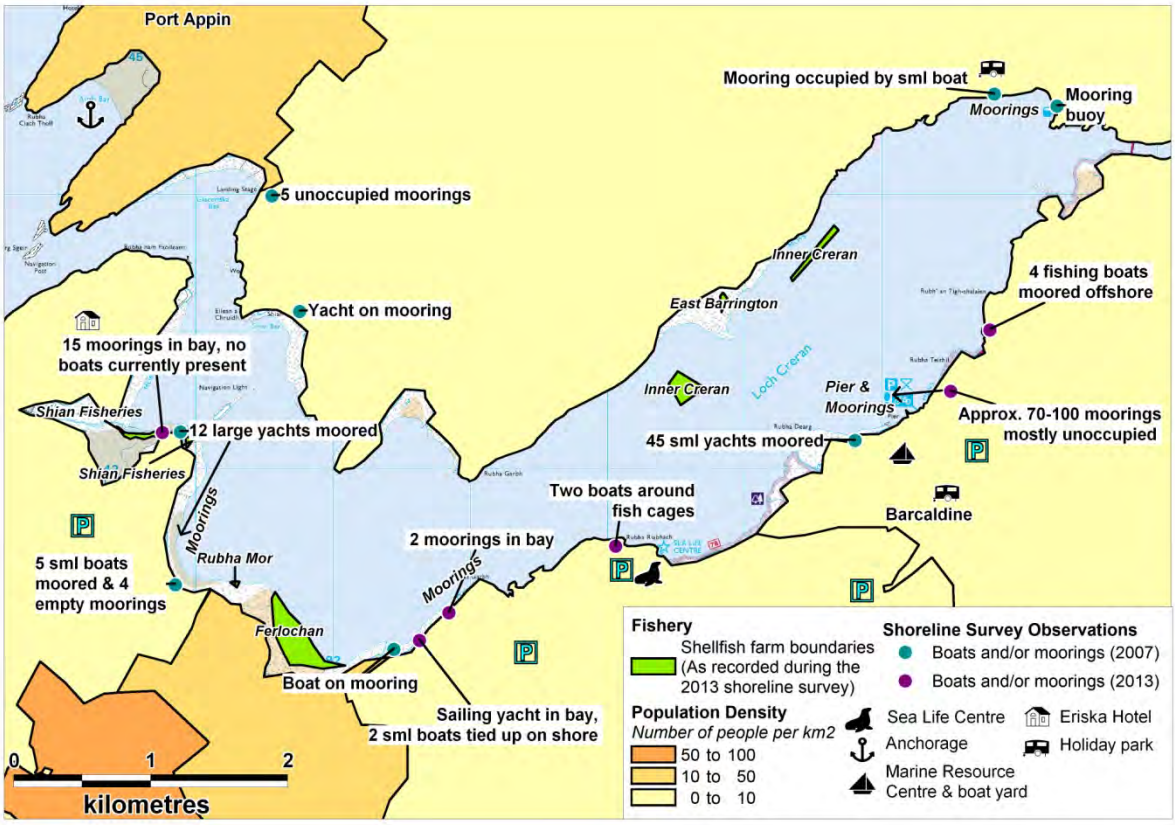

Figure 3.1 Map of human population distribution around Loch Creran

Detailed data from the 2011 census was not yet available at the time of writing this report. Figure 3.1 therefore presents the 2001 census data used in the 2007 survey report, as well as any significant observations made during the 2013 shoreline survey. According to Argyll & Bute Council, the area around Loch Creran saw a 15-20% rise in population from mid-2001 to mid-2010 (http://www.argyll-bute.gov.uk/node/31503).

Since the 2007 Report, 15 approved planning applications were identified for areas around Loch Creran. The applications were downloaded in January 2013 from the Argyll and Bute Council Portal (http://publicaccess.argyll-bute.gov.uk/publicaccess/) and those most likely to indicate a change in human population adjacent to Loch Creran are listed in Appendix 1.

Most applications were for new dwellings with associated septic tanks. The majority of these were located in the Barcaldine area along the south side of Loch Creran and the associated septic tanks were identified as discharging to soakaway. Two applications were made for houses with septic tanks in the Shian area of Loch Creran, with one appearing to be near to the oyster farm. It is not known whether

building associated with the planning permits was completed at the time of writing this report. However, the number of planning applications seems to be consistent with the rise in population reported for the area.

Permission was also granted for a new cookery school building at Eriska Hotel, near Shian and a new amenity block, play area and extension of the opening season for Barcaldine Caravan Park, on the south shore SE of the Inner Creran sites. The extension brings the season from 16th February to the 5th January the following year, making it nearly a year-round operation. The Eriska Hotel also runs a spa and restaurant that are open to non-residents.

During the 2007 shoreline survey a large number of moored yachts and boats were noted, with the majority on the southern shoreline at the Barcaldine moorings and Shian moorings. The 2007 shoreline survey was conducted in July and observations are likely to reflect peak season boating activity. Although fewer yachts were seen during the more recent shoreline survey, it is likely due to the season. Areas of empty moorings were seen. Many of the boats that were observed in the recent shoreline survey appeared to be associated with fishing and the fish farms operating in Loch Creran.

3.2 Sewage Impacts

The 2007 survey identified that there was little in the way of public sewerage provision at Loch Creran, with very small public septic tanks at Barcaldine and at Port Appin, which lies outside Loch Creran.

In 2010, updated information was obtained from SEPA in relation to a survey at an adjacent area. A significant number of additional septic tank registrations had been added between the 2007 survey and the 2010 update, therefore the updated information has been included in Figure 3.2. The majority of consented discharges are to soakaway, however 16 are for discharge directly to the loch. A further 16 are for discharge to watercourses that flow into the loch.

It does not appear that a discharge consent was received for the Eriska Hotel, which would be presumed to have a significant discharge in light of the facilities there. The only consent identified for that location was for a Population Equivalent (PE) of only 5, which is consistent with a single family dwelling and therefore unlikely to represent the full discharge from the hotel.

Septic tanks and outfall pipes observed during the 2007 and 2013 shoreline surveys are listed in Table 3.1, with locations mapped in Figure 3.2.

Application for a pontoon, shower and toilet block on land adjacent to the Barcaldine pier was granted in 2009 and amended in 2010 to change to temporary placement for 24 months. An outfall pipe was observed at this location during the recent shoreline survey (No. 2, Table 3.1) however no flow was seen.

Further details can be found in the shoreline survey report in the Appendix 2.

Table 3.1 Observed potential sewage discharges around Loch Creran during the 2007 and 2013 shoreline surveys

Year	No.	Date	NGR	Description
2007	1	29/07/2007	NM 9727 4461	110m orange plastic sewer pipe from large house under construction (not yet connected)
2007	2	29/07/2007	NM 9673 4477	Concrete slab on lawn - might be septic tank cover (no vent observed)
2007	3	21/11/2007	NM 9178 4313	Septic outflow from one house.
2007	4	21/11/2007	NM 9150 4372	Possible septic tank in garden
2007	5	30/07/2007	NM 9090 4224	Presumed septic tank outlet pipe 4" orange plastic running out at least 20m past this point into area of trestles.
2013	1	11/02/2013	NM 9406 4143	House with plastic sewage pipe running down to shore, seawater sample from beyond end of pipe 1 *E.coli* cfu/100ml
2013	2	13/02/2013	NM 9682 4476	Discharge noticed from caravan site - yellow/orange PVC pipe running into sea
2013	3	11/02/2013	NM 9328 4079	Two clay pipes next to house, outflow from larger one.
2013	4	14/02/2013	NM 9085 4180	Septic tank outside fish factory

Discharges of greatest relevance to the fisheries are consented septic tank discharges to Loch Creran in the vicinity of Shian (not observed), the septic tank for the fish factory (outfall not observed) southeast of Shian, and to a watercourse at the southern end of the main Rubha Mor site. A presumed septic tank outlet pipe identified in the 2007 survey was reported to be removed and this was not seen during the 2013 survey. There were no reported or observed discharges within 500 metres of the Inner Creran and East Barrington sites.

Overall, the resident population and numbers of tourists visiting areas surrounding Loch Creran are likely to have increased since the 2007 survey. These are reflected by new dwelling houses, extension of the Barcaldine Holiday Park season, and expansion of facilities offered at both Barcaldine and at Eriska Hotel. The fisheries at greatest risk from contamination from these sources are Shian and Rubha Mor.

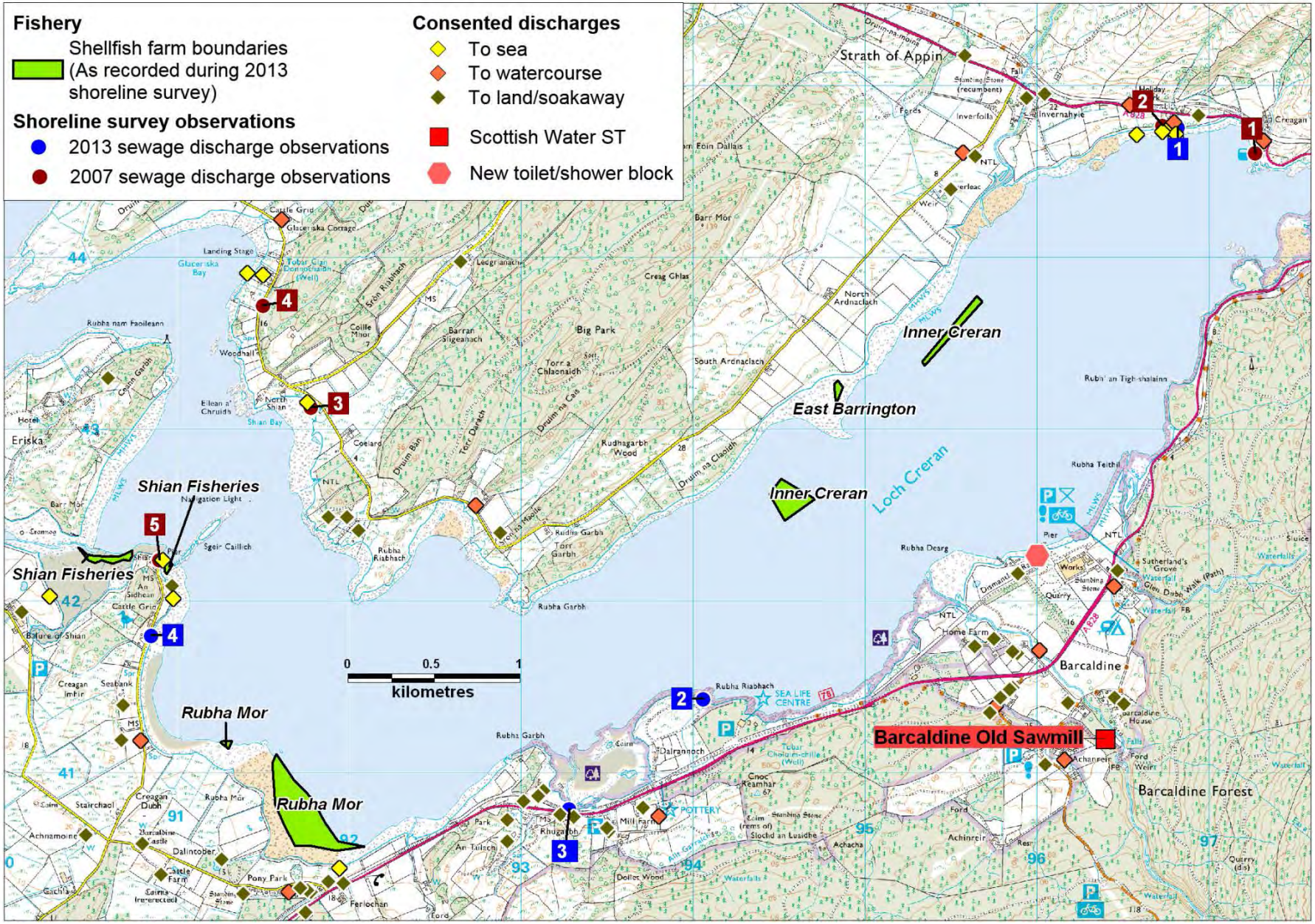

Figure 3.2 Map of Loch Creran consented discharges and observations from shoreline surveys in 2007 and 2013

4. Farm Animal Population and Agricultural Impacts

Due to the small number of individual farms in the area, it was not possible to obtain farm census data for the 2007 survey. A search of the internet provided no information on livestock numbers for the area.

Data on sources of farm pollution were obtained through the shoreline survey. The following data relates only to the time of the site visits on the 11th – 14th February 2013 and in 2007. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 4.1

During the 2007 shoreline survey, livestock concentrations were noted to be low overall however animals and droppings were observed at and below the high tide mark near Barcaldine on the south shore of the loch and at the east end of Rubha Mor, main site. Along the north shore of the loch near the Upper Creran mussel sites and further west across the loch from Shian. Cattle were seen along the north shore east of the mussel farms and stable waste was observed dumped on the shoreline west of the East Barrington oyster farm.

During the 2013 survey, little livestock was observed around Loch Creran. On the northern shore in Upper Loch Creran approximately 15 cows were observed on the beach. On the south shore, 25 sheep were observed at Dalrannoch Farm (see Figure 4.1), though no livestock were noted here in the 2007 survey. Horse manure was also noted in the recent shoreline survey, in fields close to the Rubha Mor fishery.

Livestock were predominantly observed in fenced areas along the southern shoreline of Loch Creran (Figure 4.1). Overall, differences observed between survey years are likely to reflect seasonal changes in livestock distribution and population. The largest contamination implication is for the Inner Creran and East Barrington fisheries on the northeastern shoreline, where livestock continue to have access to the shore year round. In particular the shore based East Barrington site will experience the highest contamination levels, whilst the Inner Creran northeast area is also likely to experience higher levels of contamination than the area to the southwest. Also of significance was the new cow yard and cattle being kept close to the Shian oyster farm to the southwest. Contamination may be washed into the sea above the western extent of the Shian oyster farm, and cause high levels of contamination before mixing with seawater.

The identified changes in agricultural impacts are not considered to have a significant spatial effect across the classified shellfish sites.

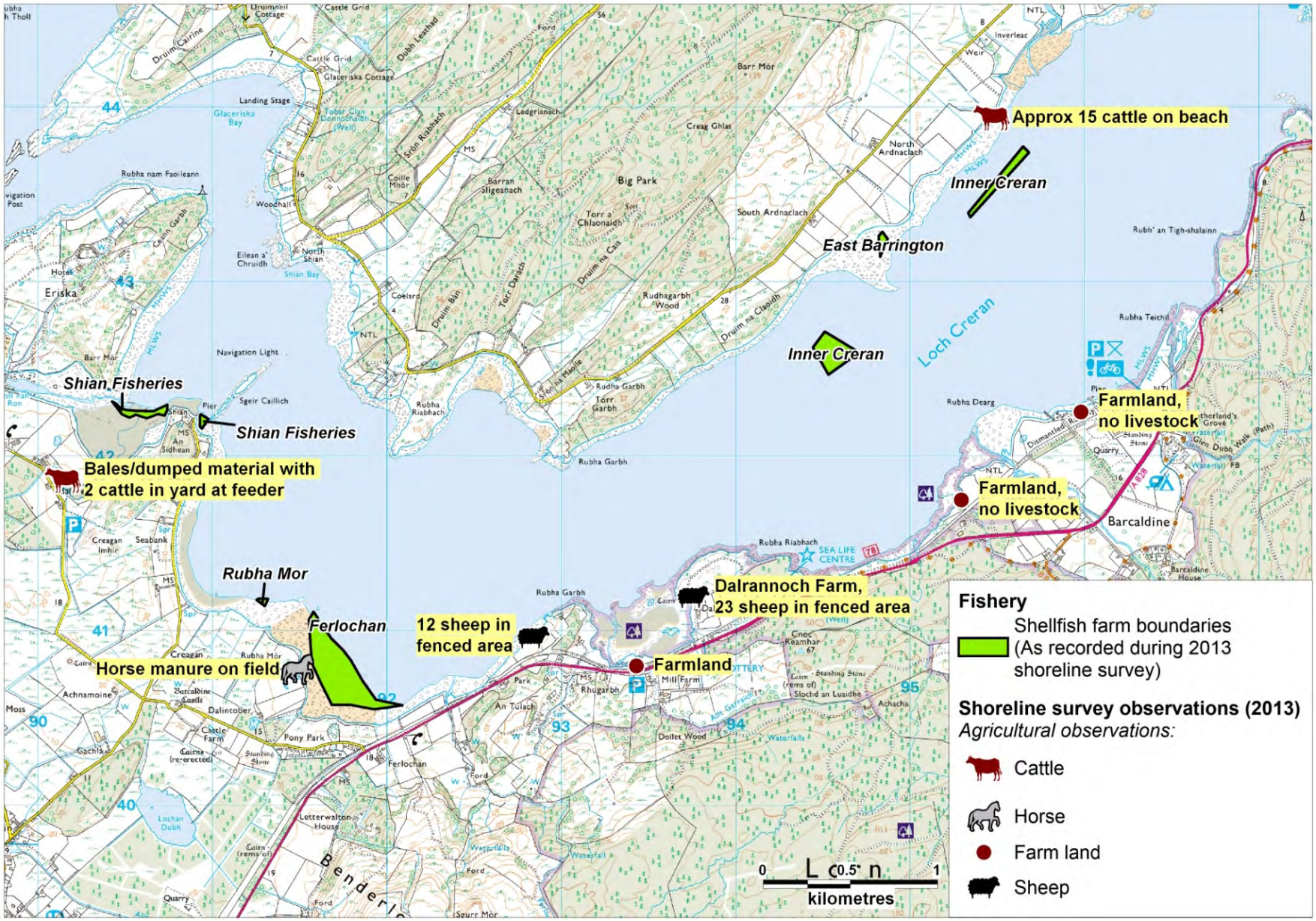

Figure 4.1 Map of livestock and crop concentration and distribution from the 2013 shoreline survey around Loch Creran

5. Wildlife

Information on pollution sources from wildlife has been obtained through the shoreline survey and through a desk based web search. Observation information relates only to the time of the survey 27th February – 1st March 2013. Wildlife observations recorded during the shoreline survey are displayed in Figure 5.1.

A wide variety of wildlife species are likely to contribute to faecal contamination levels found in watercourses and in the loch. In the sanitary survey, the animals found most likely to contribute significantly to faecal contamination at the shellfishery were seals, seabirds and waterfowl, and deer. The original survey did not include Seabird2000 data, and therefore this information has been incorporated for the review.

Seals

No seals were observed during the shoreline survey in either 2007 or 2013.

The National Seal Sanctuary (part of the Scottish Sea Life Sanctuary) is located near Barcaldine. At present the Seal Sanctuary has three resident adult seals and operates a rescue care centre. Around 12 to 15 pups have been taken in annually, reared and then released back into the wild (http://www.sealsanctuary.co.uk/obanbackwild2000todate.html). The number of seals housed at the seal sanctuary near Barcaldine has dropped substantially since the original survey: in 2012 and 2013 only two juvenile seals were released by the Sanctuary. Wild seals rehabilitated by the sanctuary are released to known grey/common seal colonies outside of Loch Creran, in the Argyll and Bute area (Pers. Comm. Peter Coombes, Seal Sanctuary Oban).

It is not known whether the decrease in numbers of juvenile seals handled represents a longer term trend in the number of seals present around the wider area. However, the lower number of animals treated at the sanctuary would mean a reduced impact on water quality around the outlet from the centre.

Birds

Seabird 2000 census data was extracted for the area within a 5 km radius of Loch Creran. The data is summarised in Table 5.1. The census was undertaken between 1998 and 2002 and covered 25 species of seabird that breed regularly in Britain and Ireland. Census outputs are shown in Figure 5.1.

Seabirds were found in three locations within 5 km of Loch Creran. The majority of birds were recorded at Glas Eilean, a rocky islet at the entrance to the loch, SW of Glaceriska Bay. A mix of gull and terns, totalling over 170 pairs, was found to nest at this location (not shown in Figure 5.1). Within the loch, terns were found to nest at Sgier Caillich, near Shian Fisheries, and gulls were found to nest at Barcaldine. Only the tern nests at Sgier Caillich lie close enough to a shellfishery to have a potential impact on water quality there. Any impacts from this nesting area is most likely to impact the eastern section of the oyster farm at Shian.

Table 5.1 Seabird counts within 5 km of Loch Creran

Common name	Species	Location	Count*	Method
Arctic tern	*Sterna paradiseae*	Glas Eilean	48	Occupied nests
Common tern	*Sterna hirundo*	Glas Eilean, Sgier Caillich	55	Occupied nests
Great black-backed gull	*Larus marinus*	Glas Eilean	1	Occupied nests
Common gull	*Larus canus*	Barcaldine	40	Occupied territory
		Glas Eilean	88	Occupied nests
Herring gull	*Larus argentatus*	Glas Eilean	2	Occupied nests

* All counts represent pairs, and therefore should be doubled to get the total number of birds

During the 2007 shoreline survey, overwintering geese were identified as abundant on farm fields and open grassland along the north shoreline near North Ardnaclach and along the southwest shoreline at Shian.

During the recent shoreline survey, birds were the most common wildlife observed, with unidentified seabirds, gulls, oystercatchers, curlews, ducks and geese all recorded on the southern shoreline. Geese and seabirds were seen close to the fishery at Rubha Mor, whilst a small number of gulls and one oystercatcher were also observed close to the Shian oyster fishery. Small numbers of birds were also observed on the shoreline adjacent to the fisheries in Upper Loch Creran.

Deer

Deer inhabit wooded areas, which are present around the shores of Loch Creran; Barcaldine Forest (southern shoreline) and south of Port Appin (northern shoreline) (Donovan, 2006). No population data was available for deer in these areas at the time of this review and deer were not observed during the recent shoreline survey.

Conclusions

Overall, the main species potentially contaminating Loch Creran have not changed since the 2007 report. The spatial impact from seabirds has been re-assessed and that from breeding birds is likely to be highest at the eastern part of the Shian oyster farm. Contamination from seals via the Seal Sanctuary outfall is likely to be lower than was identified during the 2007 survey, with fewer animals treated at the sanctuary.

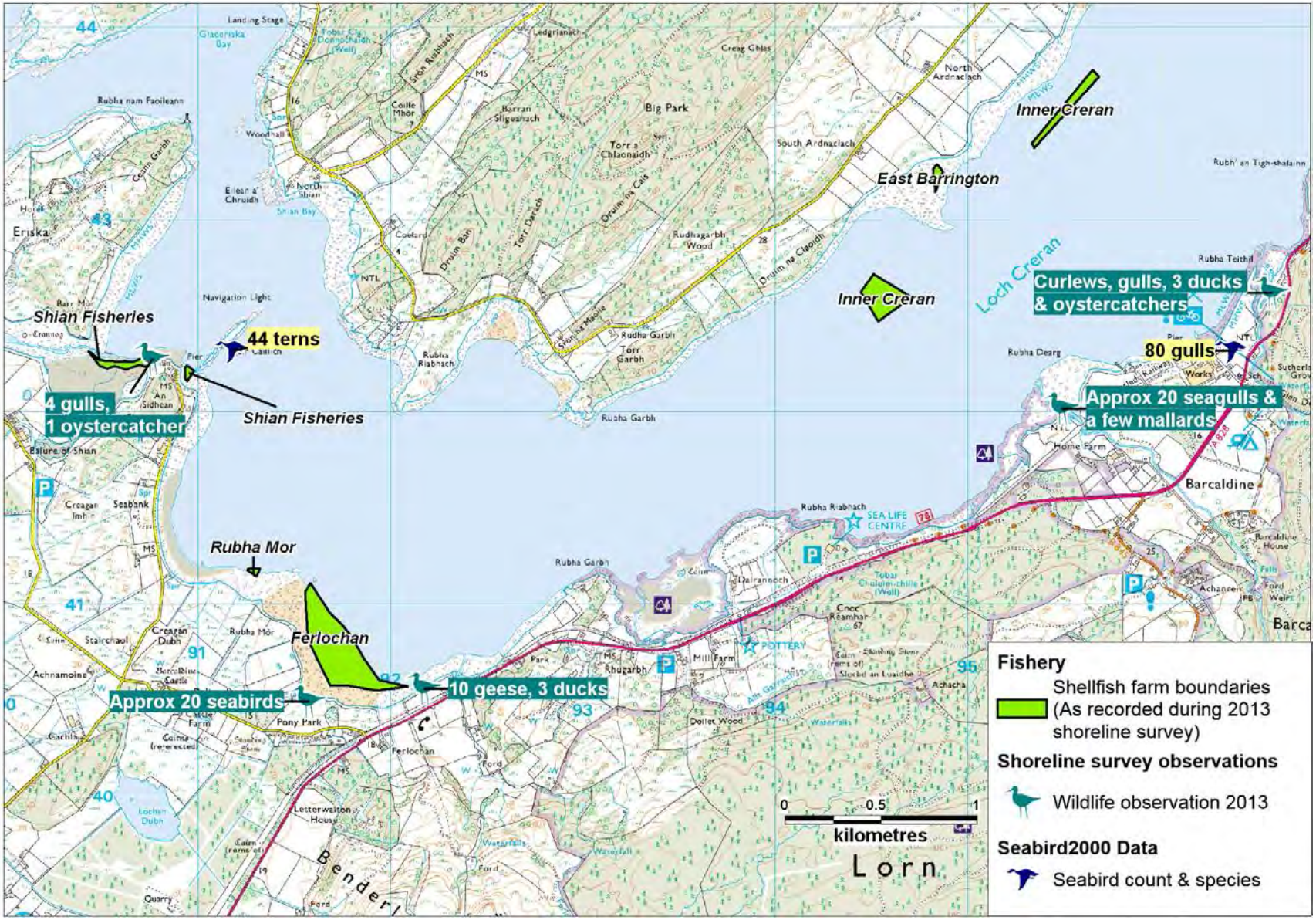

Figure 5.1 Map of wildlife around Loch Creran, including observations made during the recent shoreline survey

6. Watercourses

There are no gauging stations on watercourses feeding into Loch Creran. During the shoreline survey for this review, 27 major watercourses were sampled between 11th and 14th February 2013. Measurements and results for these can be found in Appendix 2. A large number of temporary watercourses and areas of land drainage were also noted in the shoreline survey report.

The majority of these were not specifically measured and sampled during the 2007 shoreline survey. Highlighted rows represent watercourses that were sampled during both surveys.

Conditions 2007 survey: showers, some heavy

Conditions 2013: dry for first 2 days, heavy rain on 13 Feb.

To compare measured flow rates and loadings between surveys, data on watercourse loadings recorded during both the 2007 and 2013 surveys is shown in Table 6.2. The locations at which the watercourse measurements were taken differed somewhat between the years, as shown in Figure 6.1. Loadings shown were calculated based on the spot samples taken during the shoreline surveys.

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

Table 6.1 Watercourse loadings to Loch Creran

No.	Description	Loading (*E. coli*/day)		
		Jul 2007	Nov 2007	Feb 2013
1	Stream at Shian	7.1×10^{8}	-	see No. 2
2	Tributary A at Shian	-	-	1.5×10^{12}
3	Tributary B at Shian	-	-	1.2×10^{9}
4	Stream at Ferlochan	6.6×10^{10}	-	1.6×10^{10}
5	Ferlochan Burn	2.6×10^{10}	-	8.0×10^{9}
6	Sealife Centre outfall	8.2×10^{10}	-	1.8×10^{10}
7	Dearg Abhainn	1.8×10^{12}	-	4.2×10^{11}
8	Abhainn Teithil	-	8.3×10^{8}	$<5.1 \times 10^{9}$
9	Stream at caravan park	2.0×10^{10}	-	3.4×10^{10}
10	An Iola	1.7×10^{12}	2.5×10^{10}	8.8×10^{10}

The stream at Shian was recorded at different locations during the two surveys. In 2007, it was recorded and measured on the intertidal shore. In 2013, two separate tributaries contributing to the same combined flow across the shore were recorded and measured. The bulk of the loading came from Tributary A, which had both a

higher flow and much higher *E. coli* level (30000 cfu/100 ml) than Tributary B at the time of sampling. The total loading was significantly higher than recorded in 2007, which may in part be due to the location at which it was sampled. In any case, this represents a very significant source of faecal contamination to the main area of oyster trestles at Shian.

The loadings estimated in the other watercourses from the 2013 shoreline survey data were all within an order of magnitude of those estimated from the 2007 data and there was no general trend (increase or decrease) across these other watercourses. The differences in Table 6.1 for these other watercourses could therefore simply represent inherent variability of the measurements and laboratory results contributing to the loading estimations.

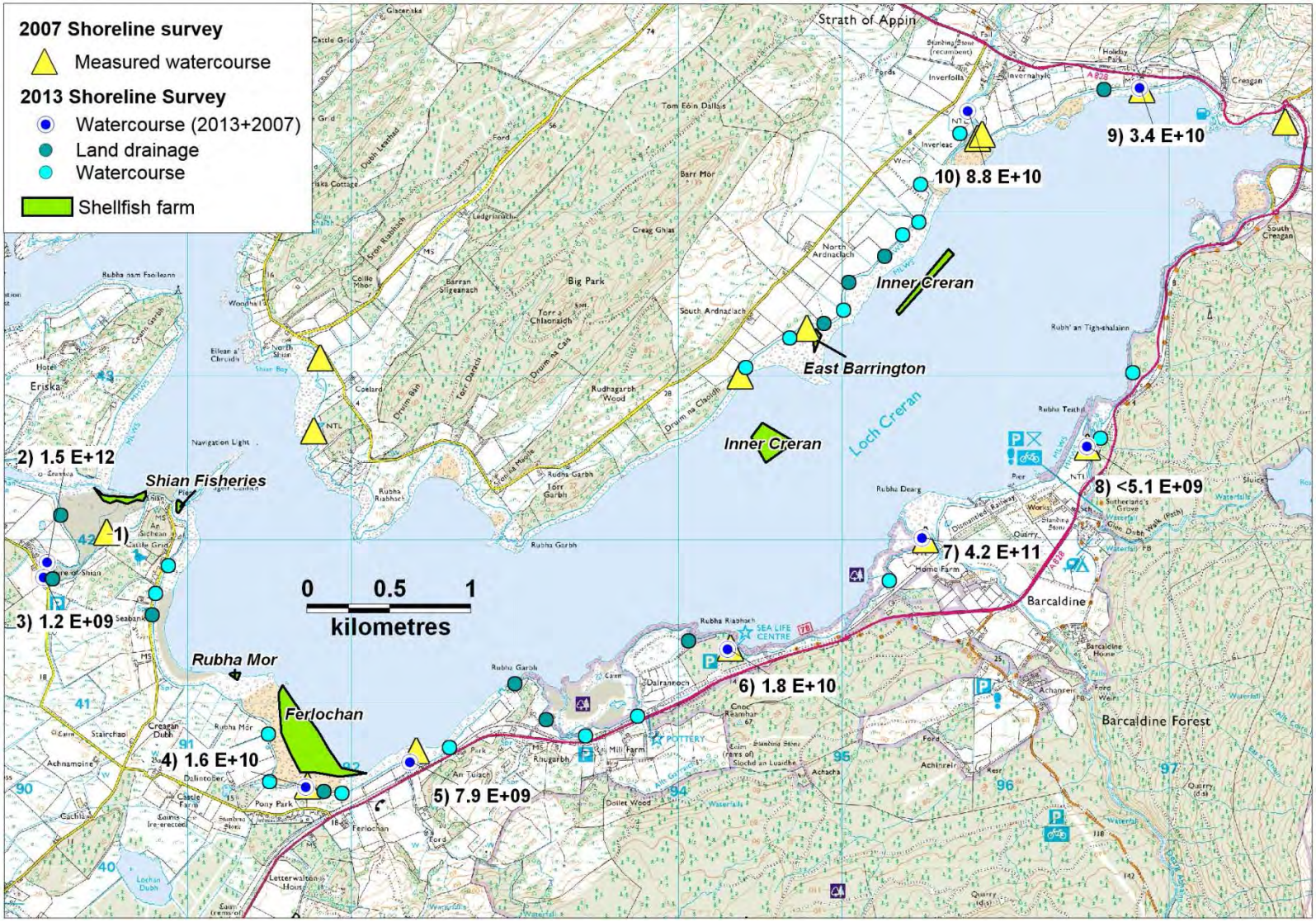

Figure 6.1Watercourse loadings into, measured during the 2012 Shoreline Survey Report

Where the bacterial loading is labelled on the map, the scientific notation is written in digital format, as this is the only format recognised by the mapping software. So, where normal scientific notation for 1000 is $1x10^3$, in digital format it is written as 1E+03.

7. Meteorological data

Meteorological data had been purchased from the Meteorological Office for the survey period 01/01/2003 - 31/12/2006 for the analyses undertaken for the 2007 Sanitary Survey Report. The resulting graphs (for Tiree, see below) have been reproduced in this Review in order to allow for comparisons with a more recent dataset.

Two rainfall datasets were used for the 2007 analyses, both for the period 01/01/2003 – 31/10/2006:

- Rainfall data from Strath of Appin weather station (approximately 0.5 km north of Loch Creran) (with no data available for 131 days in this period).
- Rainfall data for the period from Tiree weather station (approximately 90 km west of Loch Creran) (with no data for 11 days in this period).

Rainfall was recorded in total daily rainfall (mm). Wind roses for Tiree weather station for the period 1996-2005 inclusive were provided by the Meteorological Office. There is no closer wind station to Loch Creran.

Meteorological data for this review was purchased from the Meteorological Office for the period 01/01/2007 – 31/08/2012. The data was provided in October 2012 and therefore values for the whole of that year were not available. Rainfall data from Strath of Appin was again incomplete, with data absent for several months. Rainfall data from Tiree weather station was recorded for 2068 out of the 2070 day and therefore this dataset was used. Wind roses for Tiree weather station for the period 2002-2011 inclusive were provided by the Meteorological Office.

7.1 Rainfall

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

The Tiree weather station datasets for 2003-2006 and 2007-2012 are presented by year in Figures 7.1 and 7.2 respectively.

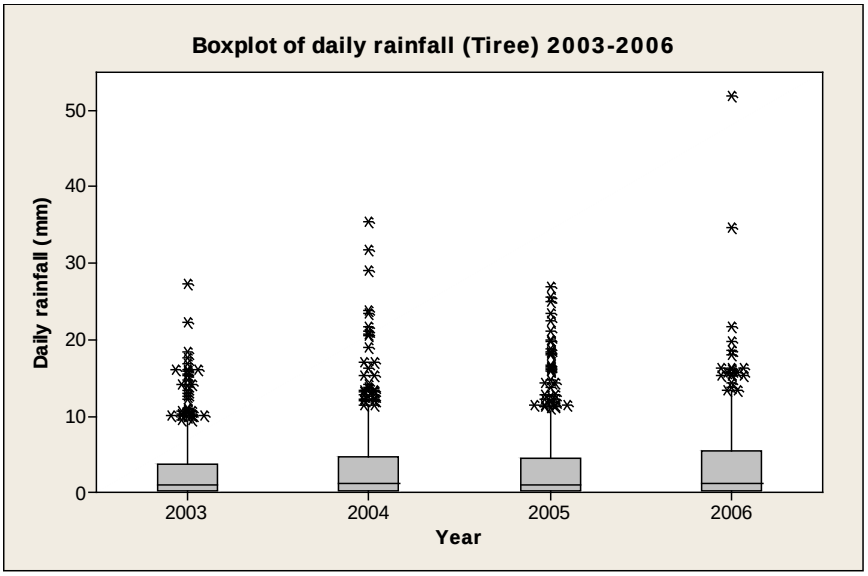

Figure 7.1 Boxplot of daily rainfall at Tiree by year (2003-2006)

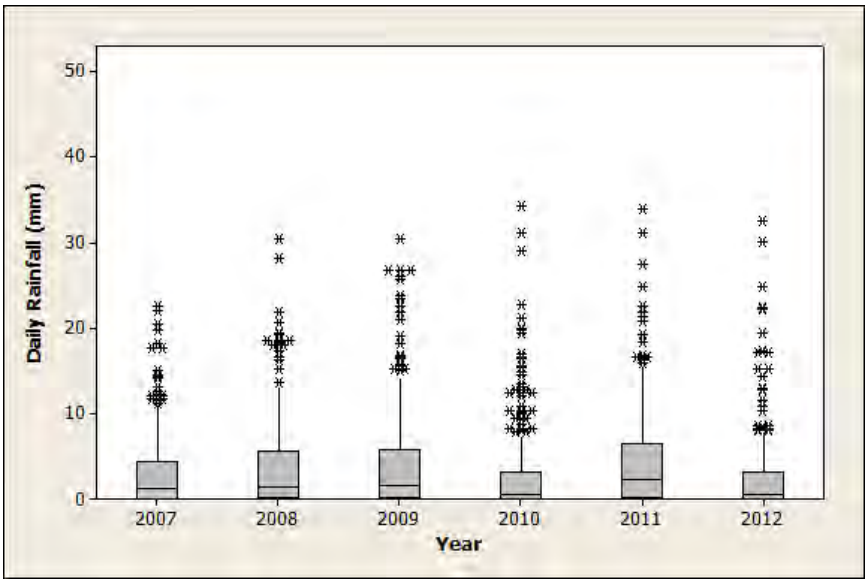

Figure 7.2 Boxplot of daily rainfall at Tiree by year (2007-2012)

In both data sets, the bulk of the observations are below 10 mm rainfall/day. In the second period (2007-2012) there were both wetter and drier years compared to the years in the previous period (2003-2006): 2009 and 2011 were generally wetter and 2010 and 2012 were drier (although the data for the latter year is incomplete).

Box plots of daily rainfall by month are presented for the same two datasets for Tiree weather station are presented in Figures 7.3 and 7.4 overleaf.

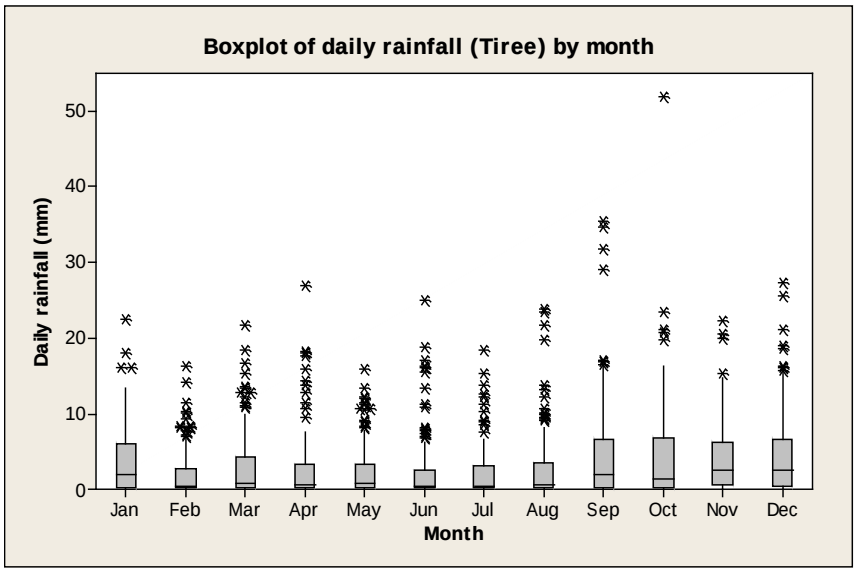

Figure 7.3 Boxplot of daily rainfall at Tiree by month (2003-2006)

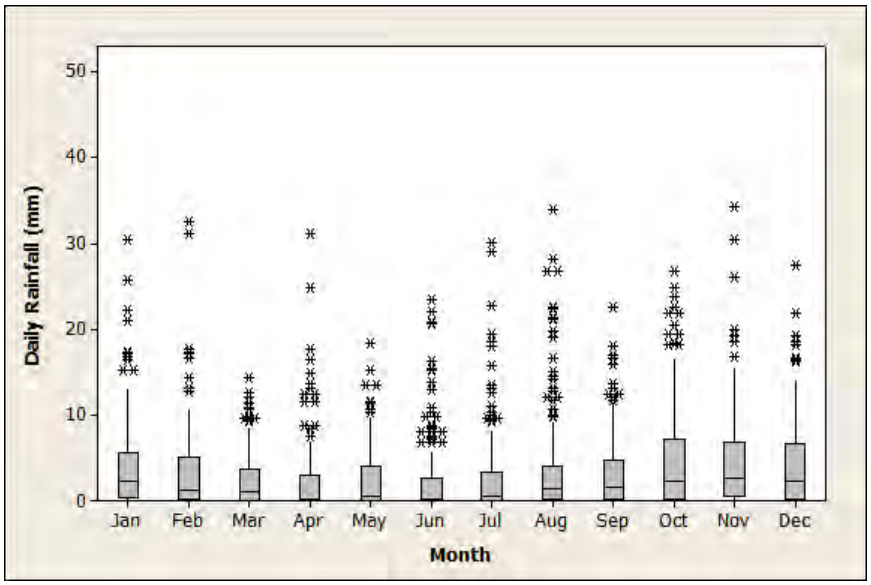

Figure 7.4 Boxplot of daily rainfall at Tiree by month (2007-2012)

February and August were both wetter in the more recent dataset than in the earlier one, while September was drier. There has been a shift in the pattern of events greater than 30 mm day (perhaps due to the fact that there have been more of such events). In the period 2003-2006, these were confined to the months of September and October, whereas in the period 2007-2012 they occurred in several months throughout the year. However, no recurrence has been seen of the extreme event of greater than 50 mm rain in one day that was recorded in October 2006.

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.

Seasonal windroses for Tiree 2003-2006 and 2007-2012 are presented in Figures 7.5 and 7.6. Prevailing winds throughout all four seasons appears to be between south south-east and west south west, with the highest winds recorded in autumn and winter. However, strong northerly winds also occurred in summer. This is trend is seen in both datasets from 1996-2006 and 2007-2011. There are slight variations between years and seasons.

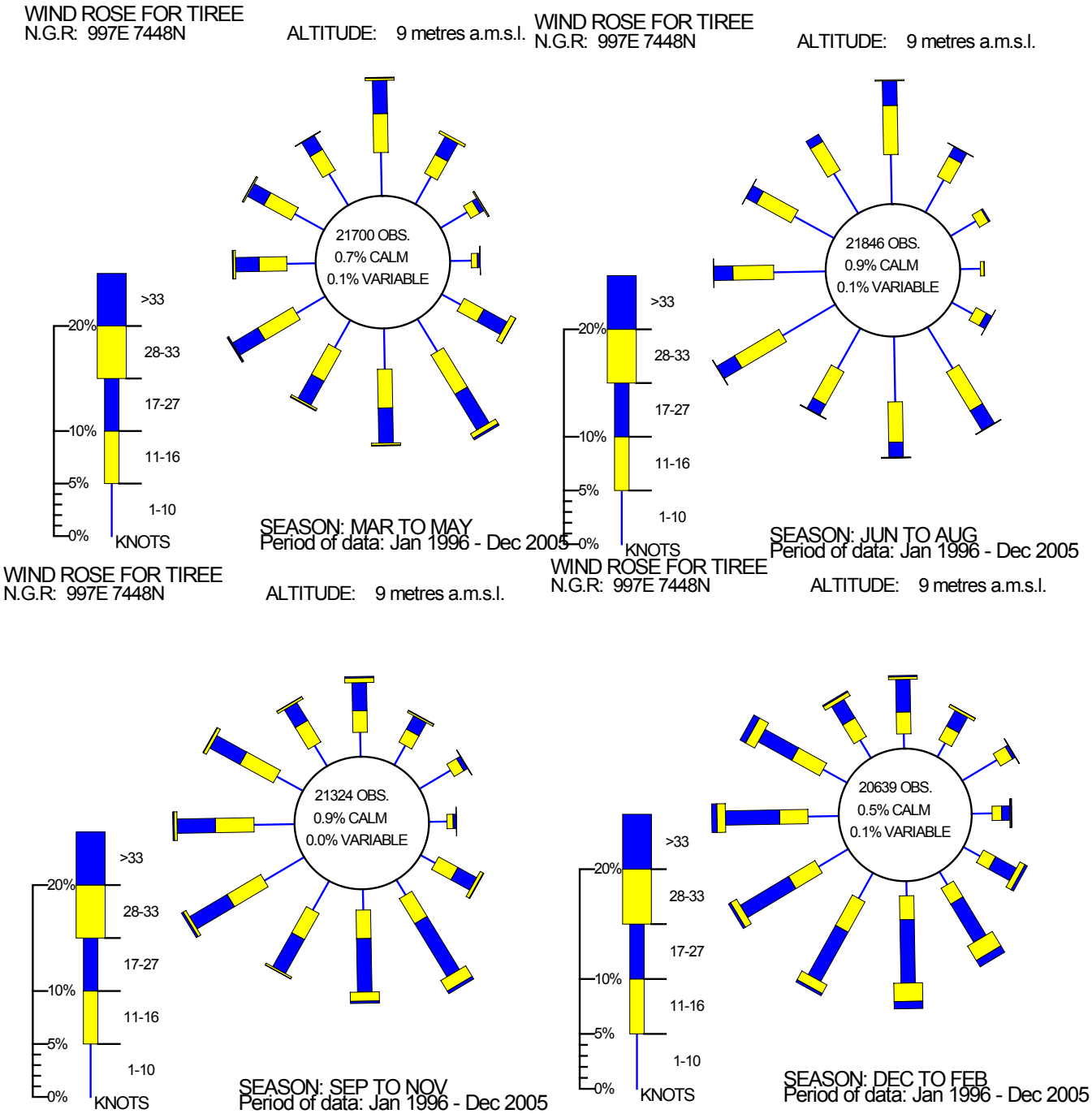

Figure 7.5Seasonal wind roses for Tiree (1996-2005).

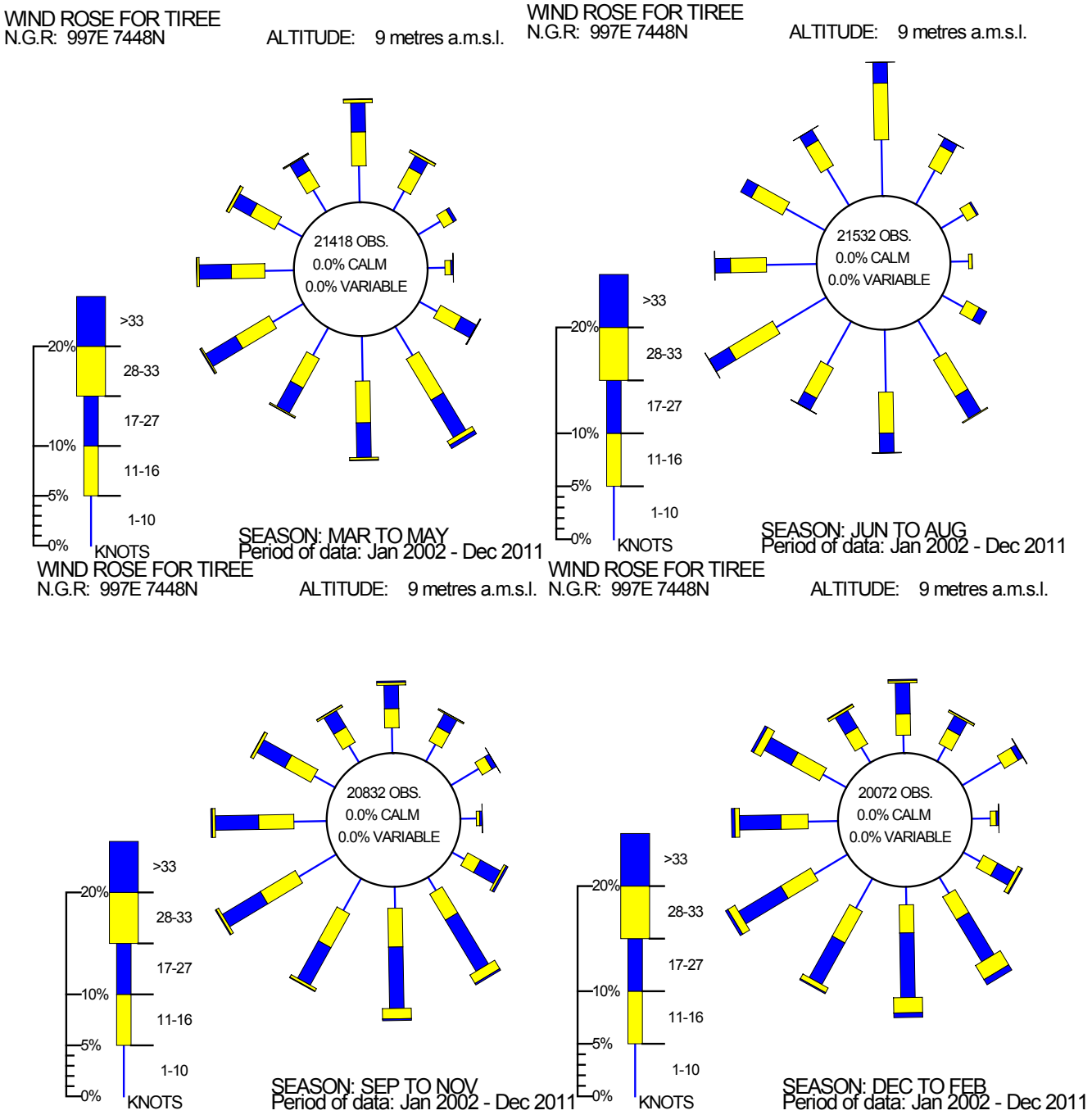

Figure 7.6 Seasonal wind roses for Tiree (2002-2011).

Annual windroses for 2003-2006 and 2007-2012 are shown in Figures 7.7 and 7.8 overleaf.

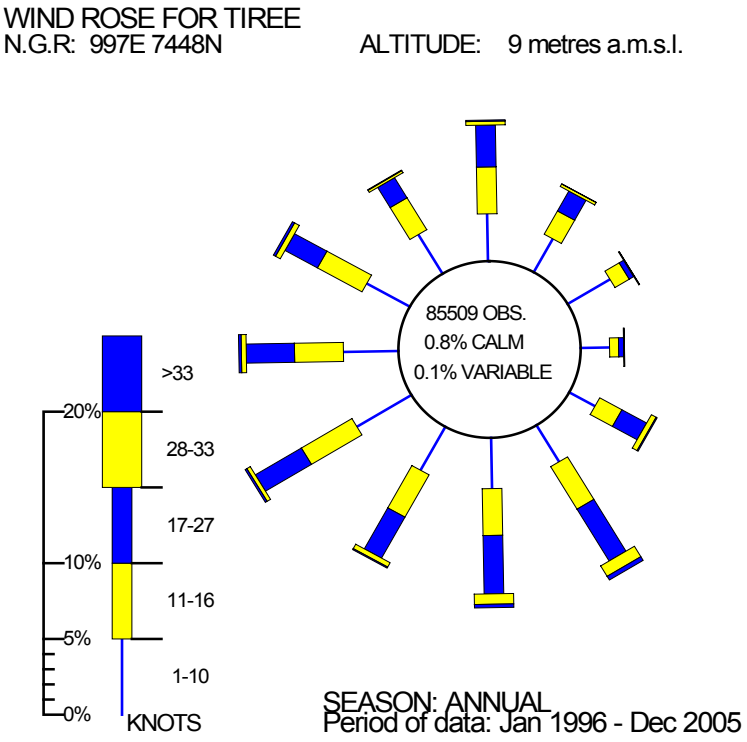

Figure 7.7Annual wind rose for Tiree (1996-2005).

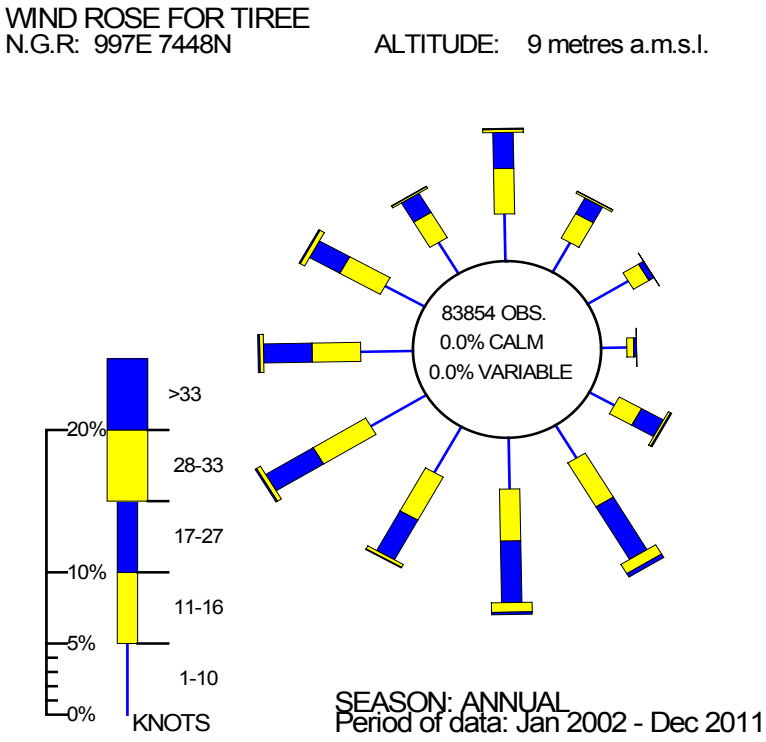

Figure 7.8Annual wind rose for Tiree (2002-2011).

8. Historical *E.* coli Data Mussels

Results for all production areas assigned against Loch Creran between 01/01/2007 and 12/01/2013 were extracted from the FSAS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. Data was extracted from the database in January 2013. Historical *E. coli* data used in the 2007 report had already been extracted and validated. For the purposes of this report, samples pre-dating 2001 were not included in the dataset.

Results from the extended bacteriological study at Shian Fisheries Pacific oyster farm (2009) are included in the extracted and validated historical *E. coli* data for Shian Fisheries Pacific oysters.

All *E. coli* results were reported as most probable number per 100 g of shellfish flesh and intravalvular fluid (MPN/100 g FIL). *E. coli* results for all areas reported as <20 were reassigned a value of 10 *E. coli MPN*/100 g, and those reported as >18000 were assigned a value of 36000 *E. coli MPN*/100 g, for the purposes of statistical evaluation and graphical representation.

Loch Creran Upper Mussels

One sample [S02242-07-W] was recorded on the database as 'rejected' and was deleted. All remaining samples were received at the laboratory within the 48 hr window. Nine samples reported results of <20 *E. coli MPN*/100 g.

Loch Creran Shian Mussels

One sample [S02244-07-W] was recorded on the database as 'rejected' and was deleted. All remaining samples were received at the laboratory within the 48 hr window. Eight samples had an *E. coli* result of <20 *E. coli MPN*/100 g.

8.1 Summary of microbiological results - Common mussels

Summary results are displayed for each production area, followed by classification history, in Tables 8.1-8.4. The lack of samples taken at Loch Creran: Shian Mussels from the latter part of 2011 on reflects the cessation of commercial activity in the area.

In general, the *E. coli* summaries show that the Loch Creran Upper mussel site is more contaminated than the Loch Creran: Shian mussel site. There was no marked difference in the results summary for the Loch Creran Upper site but the Loch Creran: Shian site showed a generally lower level of contamination during the 2007-2011 period than during the 2001-2006 period. This resulted in the classification status for that site improving to year-round Class A from 2009 on.

Table 8.1 Sampling summary results for Loch Creran Upper Mussels

Sampling Summary				
Production area	Loch Creran Upper Mussels			
Site	Inner Creran			
Species	common mussels			
SIN	AB-313-709-08			
Location	Loch Creran			
Years	2001-2006		2007-2013	
Total no. of samples	63		65	
	No. 2001	8	No. 2007	8
	No. 2002	12	No. 2008	11
	No. 2003	12	No. 2009	12
	No. 2004	11	No. 2010	12
	No. 2005	10	No. 2011	11
	No. 2006	10	No. 2012	11
Results Summary				
Minimum	<20		<20	
Maximum	5400		5400	
Median	90		80	
Geometric mean	104		97	
90 Percentile	1190		1300	
95 Percentile	3390		4500	
No. exceeding 230/100g	16 (25%)		18 (28%)	
No. exceeding 1000/100g	7 (11%)		7 (11%)	
No. exceeding 4600/100g	3 (5%)		3 (5%)	
No. exceeding 18000/100g	0 (0%)		0 (0%)	

Table 8.2 Sampling summary for Loch Creran: Shian Mussels

Sampling Summary				
Production area	Loch Creran: Shian			
Site	Loch Creran			
Species	common mussels			
SIN	AB-312-020-08			
Location	Loch Creran			
Years	2001-2006		2007-2013	
Total no. of samples	65		48	
	No. 2001	10	No. 2007	8
	No. 2002	12	No. 2008	11
	No. 2003	12	No. 2009	12
	No. 2004	10	No. 2010	10
	No. 2005	10	No. 2011	7
	No. 2006	11	No. 2012	0
Results Summary				
Minimum	<20		<20	
Maximum	9100		1300	
Median	220		50	
Geometric mean	72		52	
90 Percentile	500		238	
95 Percentile	1300		3326	
No. exceeding 230/100g	15 (23%)		4 (8%)	
No. exceeding 1000/100g	7 (11%)		1 (2%)	
No. exceeding 4600/100g	2 (3%)		0 (0%)	
No. exceeding 18000/100g	0 (0%)		0 (0%)	

Table 8.3 Classification history Loch Creran Upper Mussels

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

Table 8.4 Classification history Loch Creran Shian Mussels

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

8.2 Geographical patterns of results - Mussels

The location of the current nominal RMP and shellfish sampling locations for the sampling period 01/01/2007 – 31/12/2012 are plotted for each production area in Figures 8.1 and 8.2.

Samples for Loch Creran Upper Mussels have all been taken at the north-eastern farm, where the current RMP is located. A large number of samples were taken within the 40 m sampling tolerance, though many were taken > 100 m away from the RMP. The historic RMP was located closer to shore, and no samples were reported against this location. Results from the northeastern end of the farm, near the current RMP, appear to be higher than those from the southwestern end.

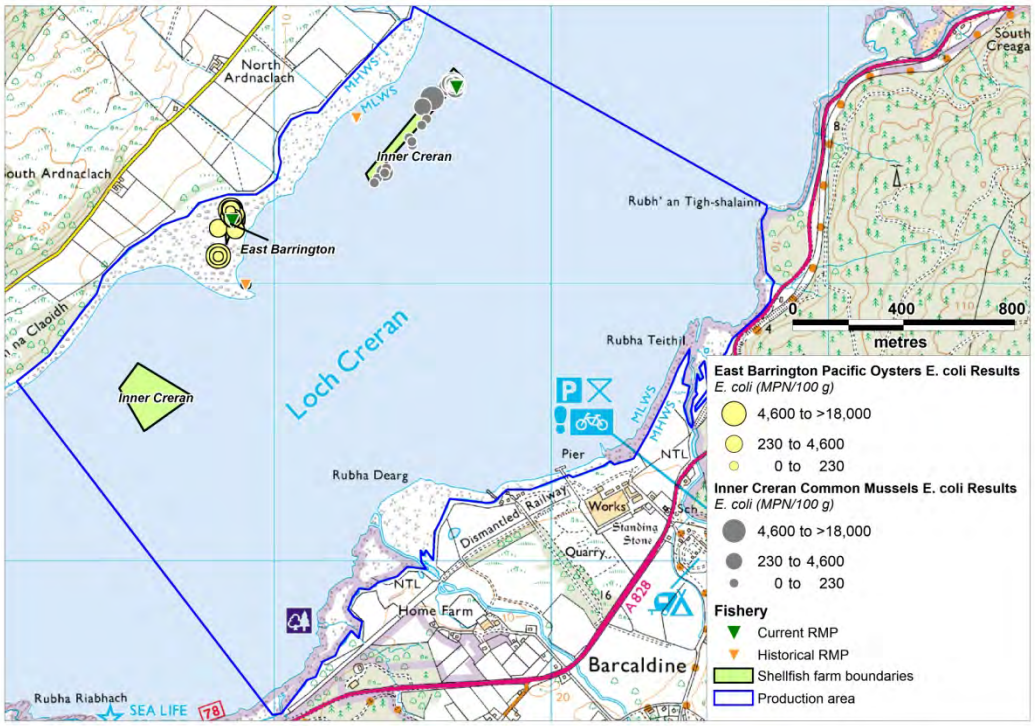

Figure 8.1Geographic distribution of monitoring results for Loch Creran Upper

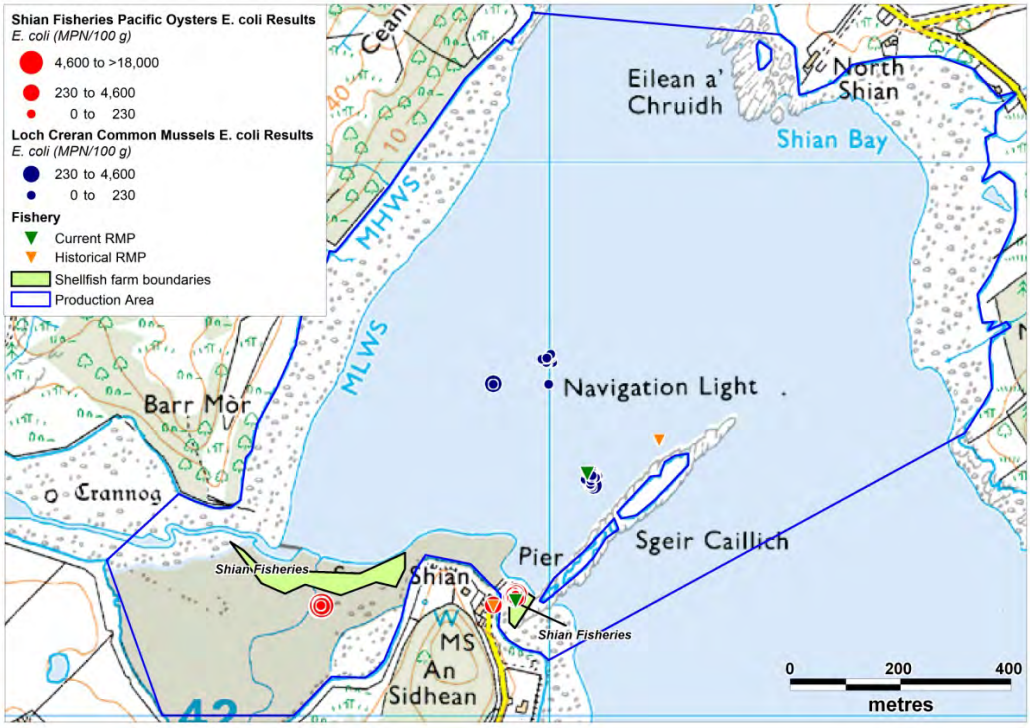

Figure 8.2 Geographic distribution of monitoring results for Loch Creran: Shian Mussels

Samples taken at Shian Mussels farm were taken at two locations; those close to the most recent RMP, and those <300 m northwest, where historically there were mussel lines. The historic RMP is located northeast of the current RMP, and no samples were taken at this site. Samples taken at both locations were all < 4600 *E. coli MPN*/100 g.

8.3 Temporal patterns of results

The trends of *E. coli* sampling results for all the production areas in Loch Creran, have been analysed for the years between the previous sampling period (2001-2006) and the current sampling period (2007-2012). To test for significance differences between samples taken from each production area over the two sampling periods, the following statistical analyses were carried out on the statistical software package Minitab:

- 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 to test for the significant difference in the observed and expected *E. coli* results above certain levels (230 and 1000 *E. coli* MPN/ 100 g) from both sampling periods.

Temporal trends are displayed as scatterplots with lowess lines for each site by production area in Figures 8.3 – 8.4, each followed by results from the statistical analyses. Lowess trendlines allow for locally weighted regression scatter plot smoothing. At each point in the dataset an estimated value is fitted to a subset of the data, using weighted least squares. The approach gives more weight to points near to the x-value where the estimate is being made and less weight to points further away. In terms of the monitoring data, this means that any point on the lowess line is influenced more by the data close to it (in time) and less by the data further away. The trend line helps to highlight any apparent underlying trends or cycles.

Loch Creran Upper Mussels

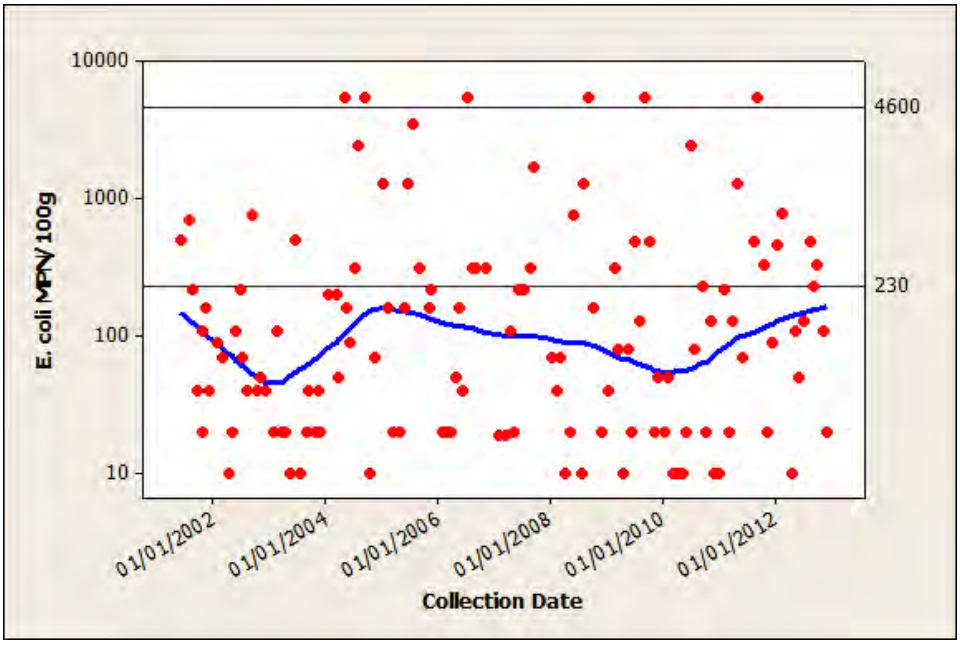

Figure 8.3Scatterplot of Loch Creran Upper Mussels *E. coli* results by date (2001-2012), with a lowess line

The scatterplot and lowess line do not show any overall trend across the period from 2001 to 2012.

Results from the two survey periods were compared in order to determine whether there was a significant change in results since the sanitary survey was undertaken. Results of this analysis are shown in Table 8.5. No significant difference was found between Inner Creran common mussel log_{10}-transformed *E. coli* results from the two survey periods (Two sample t-test, t = 0.24, DF = 125, p = 0.809).

Table 8.5 Chi-squared test results above and below 230 and 1000 *E. coli MPN*/100 g for Loch Creran Upper common mussel *E. coli* results.

		E. coli MPN/100g			*E. coli MPN/100g*		
		≤230	>230	**Total**	≤1000	>1000	**Total**
2000-2006	Observed	47	16	63	56	7	63
2007-2012	Observed	47	18	65	58	7	65
	Total	94	34	128	114	14	128

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 = 0.086, df = 1, p = 0.769).

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 = 0.004, df = 1, p = 0.951).

Loch Creran Shian Mussels

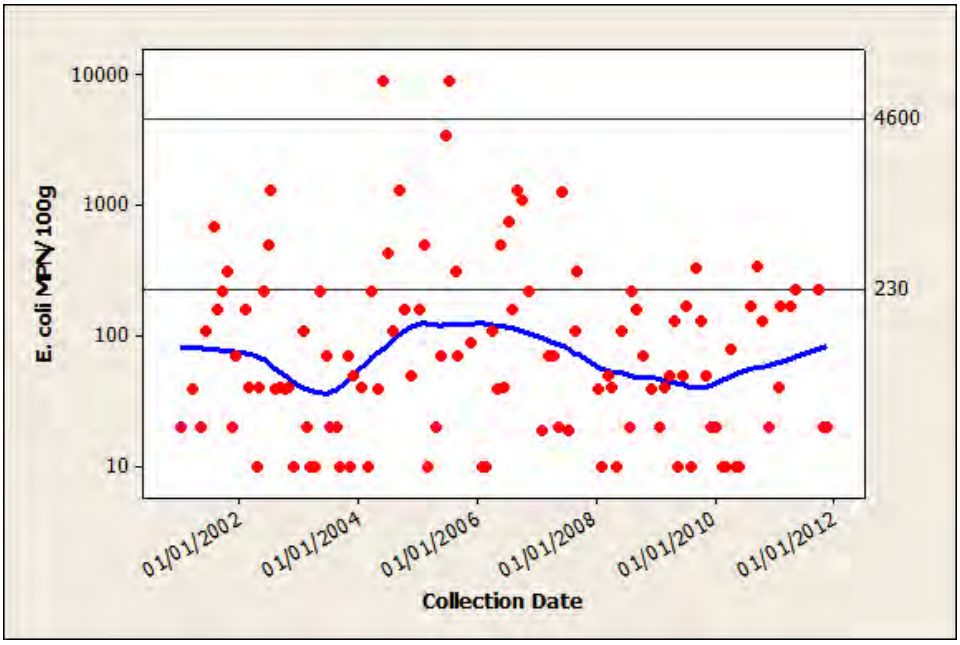

Figure 8.4Scatterplot of Shian Mussels *E. coli* results by date (2001-2012), with a lowess line.

E. coli results showed a change across the period from 2001 to 2012, with higher results being seen prior to 2008. This did not yield any marked change in the lowess trend line.

Results from the two survey periods were compared in order to determine whether there was a significant change in results since the sanitary survey was undertaken. Results of this analysis are shown in Table 8.6. No significant difference was found between Shian Mussels common mussels $\log_{10}$-transformed *E. coli* results from the two survey periods (Two sample t-test, t = 1.42, df = 110, p = 0.159).

Table 8.6 Chi-squared test results above and below 230 and 1000 *E. coli MPN*/100 g for Loch Creran Shian Mussels common mussel *E. coli* results.

		E. coli MPN/100g			*E. coli MPN/100g*		
		≤230	>230	**Total**	≤1000	>1000	**Total**
2001-2006	Observed	50	15	65	58	7	65
2007-2012	Observed	44	4	48	47	1	48
	Total	94	19	113	105	8	113

A statistically significant difference was found between sampling results ≤230 *E. coli MPN*/100 g and >230 *E. coli MPN*/100g between sampling periods (Chi-square test, X^2 = 4.291, df = 1, p = 0.038).

A 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 = 3.167, df = 1, p = 0.075).

Conclusions

In general, the *E. coli* results at Loch Creran: Shian Mussels appeared to be lower than those at Loch Creran Upper. In addition, the incidence of high results at Loch Creran: Shian Mussels was greater prior to 1 January 2008 than after this date. Sampling prior to January 2008 was undertaken at a point approximately 100 m west of any of the more recent results.

With the Loch Creran Upper Mussels site, higher results tended to be seen towards the north-western end of the site in the vicinity of the RMP recommended in the 2007 report.

9. Historical *E.* coli Data Oysters

The oyster *E. coli* results were extracted and validated as described in Section 8 for the mussel results.

Loch Creran Upper Oysters

Two samples [S02346-07-W and INTEGRIN_2010_FSA07-03689] were recorded on the database as 'rejected' and were omitted from the analysis. Sample CEFAS_FSA07-05916 was deleted as no *E. coli* data was recorded. All remaining samples were received at the laboratory within the 48 hr window. Two samples [INTEGRIN_2010_3276 and CEFAS_12/487] had a reported result of <20 *E. coli MPN*/100 g and one sample [INTEGRIN_2010_FSA07-04111] reported a results of >18000 *E. coli MPN*/100 g.

Loch Creran: Rubha Mor

One sample [S00186-07-W] was recorded against the Ferlochan site and for the ease of statistical analysis and geographical analysis it is included into the Rubha Mor dataset.

One sample [S02350-07-W] was recorded on the database as 'rejected' and was deleted. All remaining samples were received at the laboratory within the 48 hr window. Four samples had an *E. coli* result of <20 *E. coli MPN*/100 g.

Loch Creran: Shian Oysters

One sample [S02351-07-W] was recorded on the database as 'rejected' and was deleted. Two samples [INTEGRIN_2009_2524 and INTEGRIN_2010_FSA07-03688] were deleted as no *E. coli* data was recorded. All remaining samples were received at the laboratory within the 48 hr window. Two samples [INTEGRIN_2008_330 and INTEGRIN_2009_1406] had an *E. coli* result of <20 *E. coli MPN*/100 g. One sample [S01833-07-W] plotted on land and was deleted.

Summary results are displayed for each production area, followed by classification history, in Tables 9.1-9.6.

9.1 Summary of microbiological results - Common mussels

Table 9.1 Sampling summary Loch Creran Upper Oysters

Sampling Summary				
Production area	Loch Creran Upper Oysters			
Site	East Barrington			
Species	Pacific oysters			
SIN	AB-129-021-13			
Location	Loch Creran			
Years	2002-2006		2007-2013	
Total no. of samples	56		66	
	No. 2001	-	No. 2007	8
	No. 2002	8	No. 2008	11
	No. 2003	12	No. 2009	12
	No. 2004	12	No. 2010	13
	No. 2005	12	No. 2011	11
	No. 2006	12	No. 2012	11
Results Summary				
Minimum	<20		<20	
Maximum	>18000		>18000	
Median	500		330	
Geometric mean	492		362	
90 Percentile	5400		5180	
95 Percentile	9100		13620	
No. exceeding 230/100g	38 (68%)		39 (59%)	
No. exceeding 1000/100g	20 (36%)		16 (24%)	
No. exceeding 4600/100g	9 (16%)		6 (9%)	
No. exceeding 18000/100g	1 (2%)		1 (2%)	

Table 9.2 Sampling summary Loch Creran: Rubha Mor

Sampling Summary				
Production area	Loch Creran: Rubha Mor			
Site	Rubha Mor			
Species	Pacific oysters			
SIN	AB-130-022-13 and AB-130-742-13			
Location	Loch Creran			
Years	2001-2006		2007-2013	
Total no. of samples	117		69	
	No. 2001	24	No. 2007	10
	No. 2002	23	No. 2008	11
	No. 2003	24	No. 2009	12
	No. 2004	14	No. 2010	12
	No. 2005	12	No. 2011	12
	No. 2006	20	No. 2012	12
Results Summary				
Minimum	10		<20	
Maximum	>18000		9200	
Median	80		110	
Geometric mean	87		128	
90 Percentile	500		790	
95 Percentile	1130		2050	
No. exceeding 230/100g	28 (39%)		21 (30%)	
No. exceeding 1000/100g	6 (8%)		6 (9%)	
No. exceeding 4600/100g	1 (1%)		1 (1%)	
No. exceeding 18000/100g	1 (1%)		0 (%)	

Table 9.3 Sampling summary Loch Creran: Shian Oysters

Sampling Summary				
Production area	Loch Creran: Shian Oysters			
Site	Shian Fisheries			
Species	Pacific oysters			
SIN	AB-131-023-13			
Location	Loch Creran			
Years	2001-2006		2007-2013	
Total no. of samples	71		71	
	No. 2001	11	No. 2007	8
	No. 2002	11	No. 2008	11
	No. 2003	14	No. 2009	17
	No. 2004	12	No. 2010	12
	No. 2005	12	No. 2011	11
	No. 2006	11	No. 2012	12
Results Summary				
Minimum	<20		<20	
Maximum	9100		9200	
Median	110		330	
Geometric mean	97		146	
90 Percentile	730		1007	
95 Percentile	1300		2370	
No. exceeding 230/100g	17 (24%)		35 (49%)	
No. exceeding 1000/100g	6 (8%)		10 (14%)	
No. exceeding 4600/100g	2 (3%)		3 (4%)	
No. exceeding 18000/100g	0 (0%)		0 (0%)	

The Loch Creran Upper Oyster production area appeared to be more contaminated than the other two sites. Neither Loch Creran Upper Oyster or Loch Creran: Shian showed any marked difference between sampling periods. On the contrary, Loch Creran: Shian Oysters showed generally higher contamination during 2007-2012 compared with 2001-2006, although the maximum results obtained during the two periods were essentially the same.

The Loch Creran Upper Oyster production area has been classified as year-round Class B since 2009 while the other two areas have been classified as seasonal A/Bs with the worse classification tending to occur in the summer/autumn period.

Table 9.4 Classification status for Loch Creran Upper Oysters

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

Table 9.5 Classification status for Loch Creran: Rubha Mor

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

Table 9.6 Classification status for Loch Creran: Shian Oysters

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

9.2 Geographical patterns of results

The location of the current nominal RMP and shellfish sampling locations for the sampling period 01/01/2007 – 31/12/2012 are plotted for each production area in Figures 9.1-9.3. Results from the original extended bacteriological survey for Loch Creran: Shian Oysters are also considered.

Loch Creran Upper Oysters

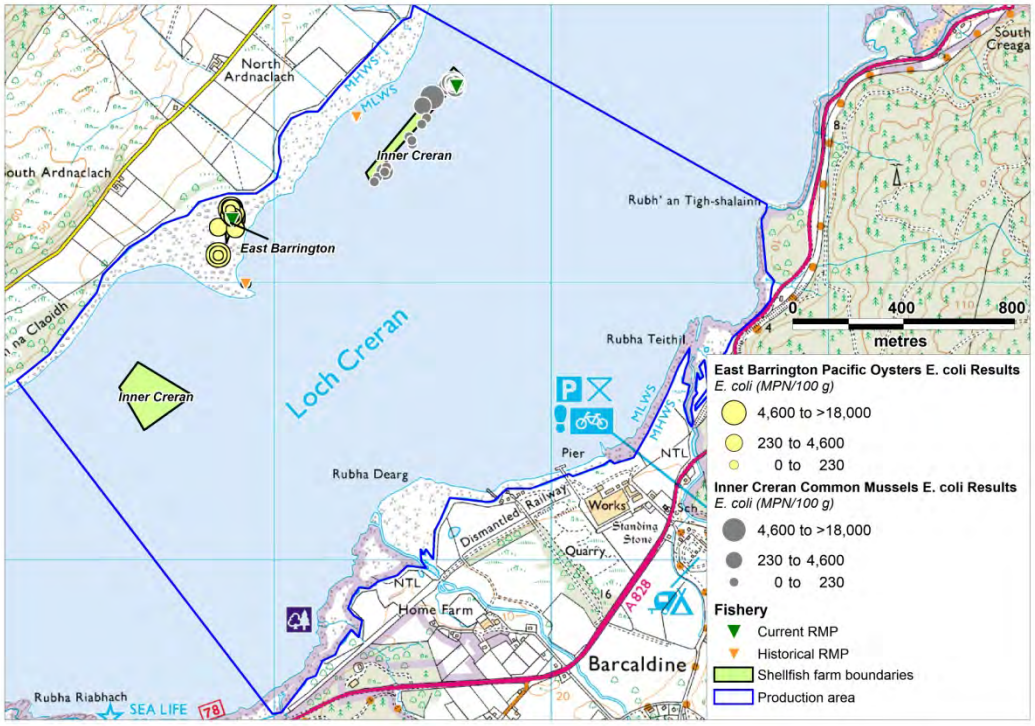

Figure 9.1 Sample results and locations of Loch Creran Upper Oysters

Since 2008 all sampling locations plot within the 20 m sampling tolerance around the current RMP, though samples taken in 2007 plot 100 m southwest, closer to the historical RMP, presumably due to a lead-in time for implementation of the 2007 recommendations. One 2007 sample was taken at the historical RMP and returned a result of <230 *E. coli MPN*/100 g. There does not appear to be a clear geographic trend in results.

Loch Creran: Rubha Mor

All sampling for the Rubha Mor fishery has taken place at the main site, where the current and historic RMPs are located. The majority of samples were taken outside of the 20 m sampling tolerance. The historic RMP was located closer to the shore, west of the current RMP and outside the current shellfish farm boundaries. Samples have come from three distinct areas: in the centre of the loch, an area within 100 m of the RMP and an area approximately 500 m east of the current RMP and adjacent to the oyster processing yard.

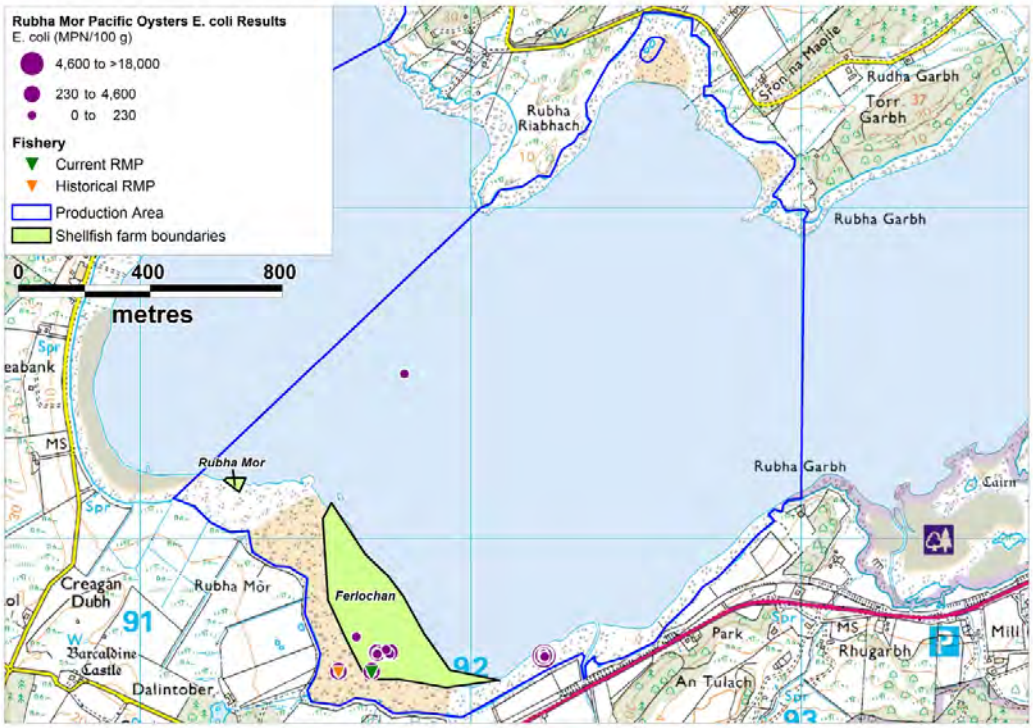

Figure 9.2 Sample results and locations for Loch Creran: Rubha Mor

Only one sample was reported from the location in the loch, and as this area would be too deep for trestles it is presumed to be an error and most likely to have come from the main Rubha Mor oyster farm.

Samples were taken near the RMP in 2008 and 2012, all of which returned results <4600 *E. coli MPN*/100 g. Samples were taken from near the processing yard between 2009 and 2011, and returned the highest recorded results for the site (>18000 *E. coli MPN*/100 g). Although there are currently no oyster trestles located adjacent to the processing yard, this location is within the area of trestles as observed during the 2007 shoreline survey.

Loch Creran: Shian Oysters

Samples taken from Shian Fisheries oyster farm have been taken at three different locations. The current RMP is located on the eastern side of Shian, adjacent to the pier and plots within the eastern site of the farm at NM 9094 4220. The majority of results have been reported from this location. The historic RMP was located at NM 909 422, higher up the shore and southwest of the current RMP. Samples taken from this location appeared to be lower than those taken from the current RMP, though it is not clear whether this was due to spatial or temporal factors.

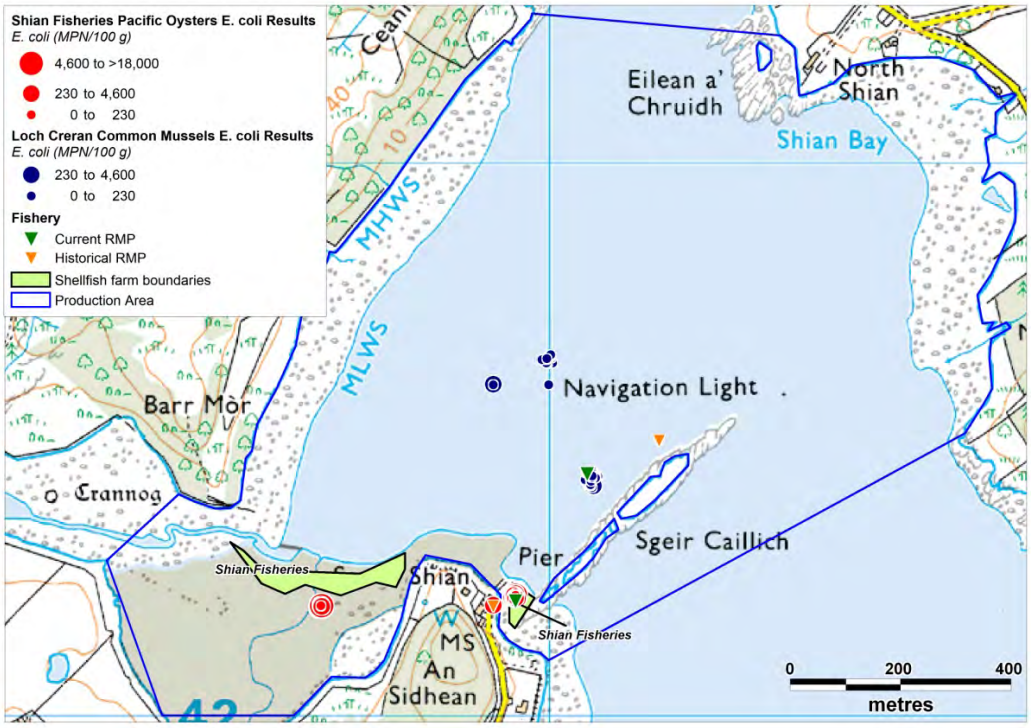

Figure 9.3Sample results and locations for Loch Creran: Shian Oysters

Samples were also taken from the western area of trestles during the extended bacteriological survey undertaken in 2009, which found no statistically significant difference between *E. coli* results from the east and west sides of the fishery.

8.3 Temporal patterns of results

The trends of *E. coli* sampling results for all the oyster production areas in Loch Creran, have been analysed in the same manner as described in Section 8.3 for mussels.

Temporal trends are displayed in the form of scatterplots with lowess lines for each production area in Figures 9.4 – 9.6, each followed by results from the statistical analyses.

Loch Creran Upper Oysters

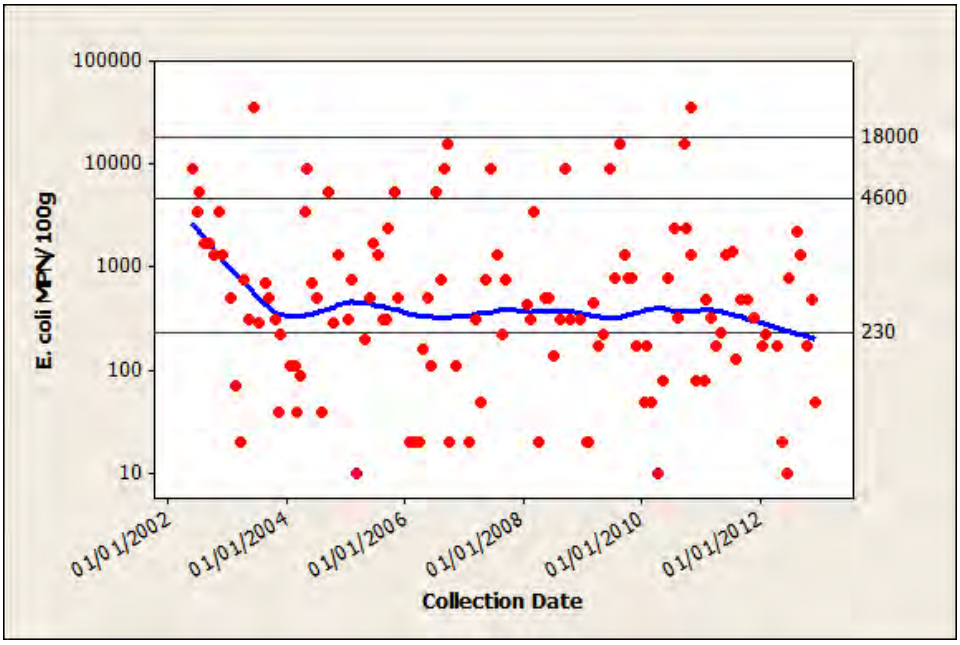

Figure 9.4 Scatterplot of East Barringon Pacific oyster *E. coli* results by date (2002-2012), with a lowess line

The general trend has been for the extent of contamination to be stable across the years 2001-2012 although there was an intial drop in the lowess line after 2002: the results of samples taken in 2002 were all >1000 *E. coli MPN*/100 g. Two samples were >18000 *E. coli MPN*/100 g and were taken in 2003 and 2010 respectively.

Results from the two survey periods were compared in order to determine whether there was a significant change in results since the sanitary survey was undertaken. Results of this analysis are shown in Table 9.7. No significant difference was found between East Barrington Pacific oyster log_{10}-transformed *E. coli* results from the two survey periods (Two sample t-test, t = 0.87, df = 112, p = 0.387).

Table 9.7 Chi-squared test results above and below 230 and 4600 *E. coli* MPN/100 g for East Barrington Pacific oyster *E. coli* results

		E. coli MPN/100g			*E. coli MPN/100g*		
		≤230	>230	**Total**	≤4600	>4600	**Total**
2001-2006	Observed	18	38	56	47	9	56
2007-2012	Observed	27	39	65	60	6	66
	Total	45	77	122	107	15	122

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 = 1.000, df = 1, p = 0.317).

No statistically significant difference was found between sampling results ≤4600 *E. coli MPN*/100 g and >4600 *E. coli MPN*/100 g between sampling periods (Chi-square test, X^2 = 1.369, df = 1, p = 0.242).

Loch Creran: Rubha Mor

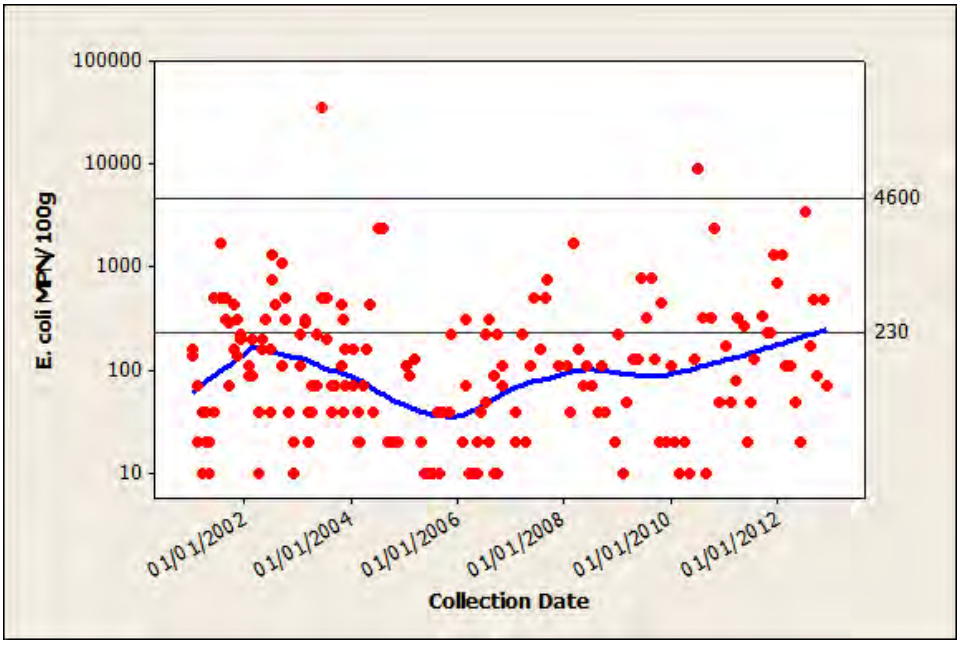

Figure 9.5 Scatterplot of Loch Creran: Rubha Mor Pacific oyster *E. coli* results by date (2001-2012), with a lowess line

There is no overall change in contamination over the whole period 2001-2012 but a dip in the lowess line around 2005 and 2006 is associated with all samples during the period being ≤ 310 *E. coli* MPN/100 g. The one result >4600 *E. coli MPN*/100 g occurred during 2010.

Results from the two survey periods were compared in order to determine whether there was a significant change in results since the sanitary survey was undertaken. Results of this analysis are shown in Table 9.8. Due to the low number of results exceeding 4600 *E. coli* MPN/100 g, this analysis was undertaken on results exceeding 1000 *E. coli*. A significant difference was found between $\log_{10}$-transformed *E. coli* results from the two survey periods (Two sample t-test, t = -1.68, df = 142 , p = 0.096).

Table 9.8 Chi-squared test results above and below 230 and 1000 *E. coli MPNl* 100 g for Loch Creran: Rubha Mor Pacific oyster *E. coli* results

		E. coli MPN/100g			*E. coli MPN/100g*		
		≤230	>230	**Total**	≤1000	>1000	**Total**
2001-2006	Observed	89	28	117	111	6	117
2007-2012	Observed	48	21	69	63	6	69
	Total	137	49	186	174	12	186

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 = 0.946, DF = 1, p = 0.331).

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 = 0.915, DF = 1, p = 0.339).

Loch Creran Shian

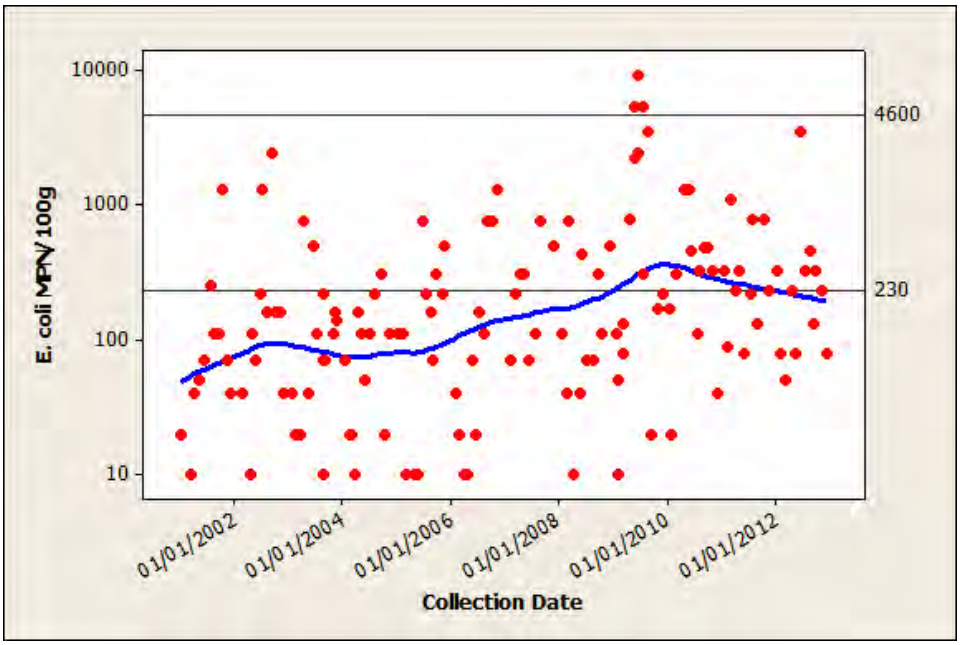

Figure 9.6Scatterplot of Shian fisheries Pacific oyster *E. coli* results by date (2001-2012), with a lowess line

There is an overall upward trend in results over the period 2001-2012, as illustrated by the lowess line in Figure 9.6. This is associated with and increase in the proportion of results exceeding 230 *E. coli* MPN/100 g and a decrease in the proportion of very low results from 2009 onward.

Results from the two survey periods were compared in order to determine whether there was a significant change in results since the sanitary survey was undertaken. Results of this analysis are shown in Table 9.9. Due to the low number of results exceeding 4600 *E. coli* MPN/100 g, this analysis was undertaken on results exceeding 1000 *E. coli*. A significant difference was found between log-transformed *E. coli* results from the two survey periods (Two sample t-test, t = -4.44, df = 139, p = <0.001).

Table 9.9 Chi-squared test results above and below 230 and 1000 *E. coli MPN*/100 g for Loch Creran Shian Pacific oyster *E. coli* results

		E. coli MPN/100g			*E. coli MPN/100g*		
		≤230	>230	**Total**	≤1000	>1000	**Total**
2001-2006	Observed	58	13	71	67	4	71
2007-2012	Observed	36	35	71	61	10	71
	Total	94	48	142	128	14	142

A 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 = 15.232, df = 1, p = <0.001).

A 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 = 2.853, df = 1, p = 0.091).

Conclusions

In general, the oysters at Loch Creran Upper Oysters have produced higher *E. coli* results than those at the other two production areas.

Loch Creran Upper Oysters

There is no obvious spatial pattern in the *E. coli* results and no significant difference in the level of the results between the two sampling periods of 2001-2006 and 2007-2012.

Loch Creran: Rubha Mor

Samples taken nearest to the processing yard in 2009 and 2011 yielded the highest results. There was no significant difference in the level of the results between the two sampling periods of 2001-2006 and 2007-2012.

Loch Creran: Shian Oysters

There is no obvious spatial pattern in the *E. coli* results. However, there is evidence of an increase in the level of results over time with a significant difference between the two sampling periods of 2001-2006 and 2007-2012.

10. Movement of contaminants

Additional information on the bathymetry of Loch Creran, not presented in the 2007 sanitary survey report, was found in a study by Black *et al.* (2000) that was obtained during an internet search for information. This information is illustrated in Figure 10.1.

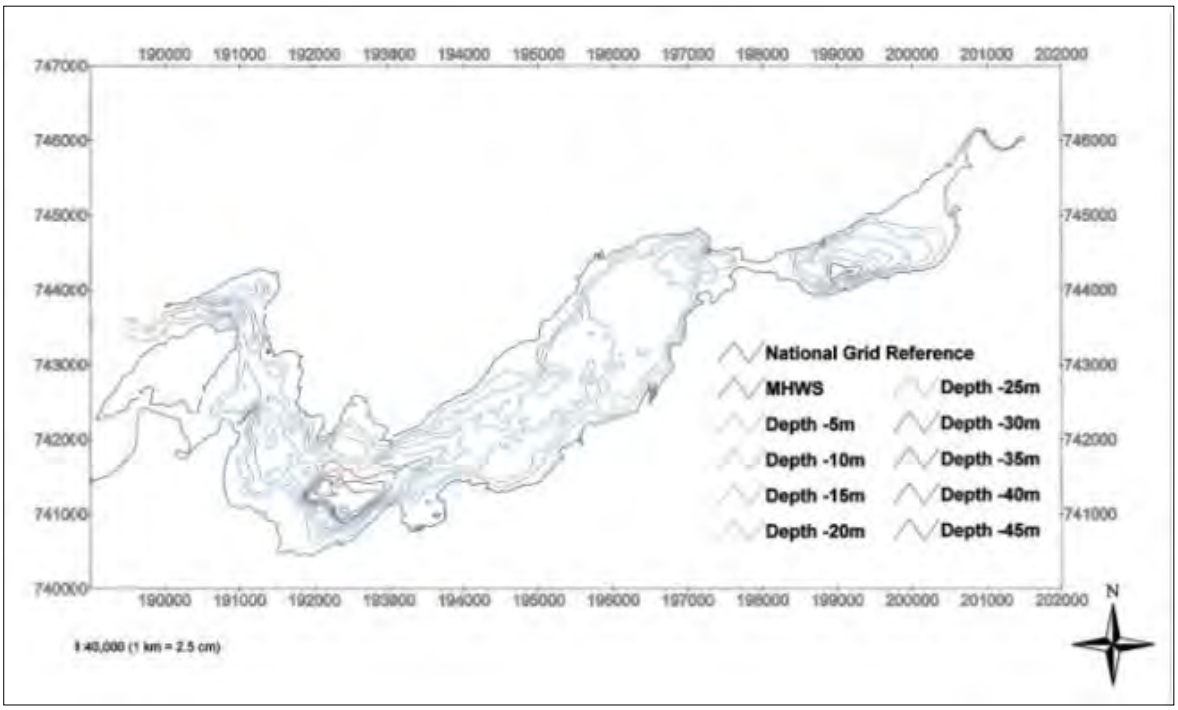

Figure 10.1. Loch Creran bathymetry overlay with national grid coordinates (Black *et al.,* 2000)

As illustrated in Figure 10.1 the seabed adjacent to all fisheries is relatively shallow. Depth increases rapidly with increasing distance from the shoreline within the Loch Creran: Rubha Mor and Upper Loch Creran production areas. Comparatively the seabed is relatively shallow around the Shian oyster farm. The deepest area of Loch Creran is found adjacent Ferlochan in the second basin, at a depth of -45 m (Figure 10.1). This additional information is unlikely to largely impact the overall tidal dynamics of Loch Creran. However this information does illustrate how mixing and dilution and overall movement of contaminants will vary locally.

Overall tidally driven dilution will remain greatest at the mouth of Loch Creran, and will decrease with increasing distance from the entrance. Tidal currents will therefore be most effective at diluting contamination in the Shian production area and weakest in the Upper Loch Creran production area. Overall total flushing time is estimated at 3 days, though is likely to take longer in deeper areas of the basin. Wind direction is also expected to continue to move material in surface waters from near shore to offshore areas, increasing the potential for dilution of contaminants.

In general therefore, hydrography at Loch Creran is likely to remain largely unchanged since the 2007 Report.

11. Overall Assessment

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

Human sewage Impacts

An increase in human sewage impact is suggested by planning applications mainly along the southern shoreline at Barcaldine and at Shian. The majority of the homes in this area have septic tanks discharging to soakaway. However, a new outfall pipe was observed discharging adjacent to the east end of the main area of trestles at Shian Fisheries. This may be a relocation of the outfall pipe that had been identified adjacent to oyster trestles a short distance to the east during the previous survey. Oyster and seawater samples taken adjacent to this pipe indicated low levels of contamination at the time.

The numbers of people visiting Loch Creran is also likely to have increased, with applications made to increase tourist facilities at the Eriska Hotel and the extension of the Barcaldine Caravan Park open season. A large number of yacht mooring sites remain in operation in Loch Creran, though at the time of the recent survey many were unoccupied. Boat/yachts moorings continue to pose a risk from overboard sewage discharges, particularly at the Shian oyster farm.

There were no reported or observed discharges within 500 metres of the Inner Creran and East Barrington sites.

Agricultural impacts

Adjacent to the Upper Loch Creran production area on the northern shore, livestock continue to have access to the shoreline year round. Faecal matter on the shoreline is likely to be the principal source of faecal contamination to the Barrington oyster farm. It is also likely that the northeast area of the Inner Creran mussel farm will be exposed to higher contamination levels from livestock compared to the southwest cultivation area, due to its close proximity to the main livestock aggregations on the shoreline.

Livestock continue to be reared on fenced farmland on the southeast shoreline, though contamination is unlikely to directly impact the nearest fishery at Rubha Mor. Horse manure noted on a field adjacent to the main Rubha Mor site suggests that surrounding fields are used to keep horses, or is used by horse riders.

A farm yard was noted to the southwest of Loch Creran that lies adjacent to the western extent of the Shian oyster farm. Although a very small number of cattle were noted at the time of the recent survey, their droppings are likely to be washed into the sea during/following rainfall and will wash across the oyster trestles on the intertidal area to the west of Shian. Livestock may also increase during the

summer, or animals may have been out if sight during the recent survey. Overall contamination from this source to the Shian oyster farm is therefore uncertain.

Wildlife Impacts

Fewer seals are currently kept at the Seal Sanctuary than previously, and therefore their contribution to contamination levels in the stream/outflow from the sanctuary will be lower.

Seabirds were noted on land adjacent to the Rubha Mor site and a nesting colony of common terns is now known to be present close to Shian oyster farm. These fisheries are therefore likely to experience higher levels of contamination from seabirds than previously recognised in the 2007 report. However, compared with other sources arising from onshore, contamination arising from the tern colony is likely to have a relatively minor impact. Contamination from this source will be highest during the summer breeding season.

Seasonal Variation

The classifications for Loch Creran fisheries vary between production areas and species. In general the classifications for all fisheries have reflected seasonal changes in faecal loadings, with worse classifications between the months of June and September. This may coincide with higher visitor numbers to surrounding tourist attractions, as well as moored boat/yachts, wildlife numbers, livestock population and behaviour, and changes in rainfall.

Watercourses

Spatial contamination impacts from watercourses have changed slightly since the 2007 report, with the highest *E. coli* loading now reported as entering into Loch Creran to the southwest, close to the western extent of the Shian oyster farm. In the 2007 report this watercourse returned a moderate contamination loading and An Iola was recorded to have the highest *E. coli* loading. It is unclear whether the higher loading recorded in the recent survey simply reflects a temporal change in land usage with season. Several other low freshwater inputs to this area will also add to overall contamination levels directly impacting Shian oyster farm.

Overall freshwater inputs to the Rubha Mor sites and the Inner Creran and East Barrington sites have not significantly changed spatially or temporally since the 2007 report.

Movement of contaminants

No information was obtained to suggest that the bathymetry and hydrodynamics have significantly changed since the 2007 sanitary survey report.

Analysis of Results

Historical *E. coli* results

Mussels: In general, the *E. coli* results at Loch Creran: Shian Mussels appeared to be lower than those at Loch Creran Upper. At the Loch Creran Upper Mussels

site, higher results tended to be seen towards the north-western end in the vicinity of the RMP recommended in the 2007 report. The incidence of high results at Loch Creran: Shian Mussels was greater prior to 1 January 2008 than after this date.

Oysters: Loch Creran Upper Oysters had generally higher *E. coli* results than the other two production areas. Within production areas, the only obvious spatial pattern was seen at Loch Creran: Rubha Mor, where higher results were seen in samples taken nearer the processing yard. The only significant temporal change over time was seen at Loch Creran: Shian Oysters where the more recent results have been generally higher than those assessed during the 2007 santiary survey report.

Shoreline survey samples

Shellfish sampling conducted during the recent shoreline survey showed the following:

- *E. coli* levels in Pacific oysters at Shian Fisheries did not differ between the east and west extents of the farm, with both results returning low samples at <20 *E. coli* MPN/100 g.
- Sample results were higher at the Rubha Mor west site (330 *E. coli* MPN/100 g) than at the Rubha Mor east site where both samples returned results below the limit of detection. A classification sample taken on 11 February from the RMP at the Rubha Mor east site also returned a result less than the limit of detection.
- *E. coli* levels at Inner Creran mussel farm did not differ with depth, or between the southwest and northeast areas, with almost all samples returning results below the limit of detection except one, which returned a result of 20 *E. coli* MPN/100 g.
- *E. coli* levels at East Barrington were moderate, with a sample result returned at 330 *E. coli* MPN/100 g.

Conclusions

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

- The river An Iola discharging within 1.5 km of and on the same shore as the Loch Creran East and Inner Creran sites (East Barrington and Inner Creran sites). Cattle were also observed on the shoreline and by the river here.
- Land run-off from improved pasture in the immediate vicinity of the Loch Creran East and Loch Creran West Rubha Mor (Rubha Mor) oyster sites.
- Consented septic tank discharges that were reported to discharge to sea around the Shian area. Although pipes were not seen during the shoreline survey, if these discharges are still present and functioning they would pose a significant source of faecal contamination to the vicinity. This may

contribute to the *E. coli* contamination and, even if the *E. coli* output is too low to affect the classification status, is a potential source of pathogens.

- The large yachts moored within a few hundred metres of the declassified Shian Mussels site and the active Shian Fisheries Pacific oyster sites were certainly large enough to provide overnight accommodation and discharges from these may impact these two sites.

In the recommendations in the 2007 report, the boundaries of the Upper Loch Creran production area were modified to exclude the direct contamination risks posed by An Iola although this would not have affected any potential impact at the existing shellfish farms themselves. Cefas was informed that the septic tank outflow pipe identified near to Shian oyster farm in the 2007 report had been removed, though a new pipe was found discharging very close to the original pipe location during the recent survey. The sample taken from seawater adjacent to this pipe suggested contamination, at the time of the 2013 shoreline survey, was low or quickly mixed and diluted. The remaining faecal contamination sources identified in the 2007 report continue to pose a potential risk to the fisheries in Loch Creran.

In addition, temporal differences were found in water samples between the previous and recent survey from a watercourse that enters into Loch Creran from the southwest. The differences are likely to reflect temporal changes in land use in the surrounding catchment area. In the 2009 bacteriological study, contamination levels on the western side of the fishery were not found to differ from contamination levels on the eastern side of the farm. However this study did not cover the autumn and winter seasons. It is recommended that a bacteriological survey is carried out prior to the next review between August and January, so as to ascertain whether contamination levels highlighted in this review are impacting the oysters at Shian Fisheries oyster farm.

12. Recommendations

No evidence of significant changes to spatial distribution of contamination entering Loch Creran was found in the recent review. The three production area boundaries, RMPs, tolerances, depths (where applicable) and frequencies should remain the same as stated in the 2007 reports' recommendations and are as follows:

Loch Creran Upper Mussels and Loch Creran Upper Oysters

The production area is that bounded by lines drawn between NM 9550 4400 and NM 9678 4328 and between NM 9407 4265 and NM 9500 4144 extending to MHWS.

The mussel RMP should remain at NM 9566 437, at a depth of 1 m. The tolerance of 40 metres should be applied

The Pacific oyster RMP should remain at NM 9485 4322, with a tolerance of 10 m applied.

Loch Creran Rubha Mor

The production area is bounded by lines drawn between NM 9300 4200 and NM 9230 4112 and between NM 9110 4112 and NM 9203 4201 extending to MHWS.

The RMP for the Pacific oyster site at Rubha Mor should be retained at the location agreed between the local authority and FSAS, NM 9171 4065, with a tolerance of 10 m. The grid reference for this RMP should be updated in FSAS documentation to the full 8-figure reference.

Loch Creran Shian

The production area is bounded by lines drawn between NM 9100 4210 and NM 9175 4251 and between NM 9097 4327 - NM 9142 4323 and between NM 9030 4200 and NM 9053 4200 and between NM 9033 4240 and NM 9020 4228 extending to MHWS.

The nominal RMP for the Pacific oyster site at Shian Fisheries is at NM 9094 4220, with a tolerance of 10 m.

Monthly monitoring at both mussel and oyster sites is recommended due to the variability of historical monitoring results.

13. References

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14. List of Figures and Tables

Appendices

1. List of planning applications
2. Table of Watercourse Loadings
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4. Shoreline Survey Report

Appendix 1: List of planning Applications

Planning applications expected to change the human population and overall faecal loading to Loch Creran are listed in Table 1.

Table 1 List of planning applications to the Argyll and Bute Council, to land surrounding Loch Creran

Date	Reference No.	Planning Application
Mar-12	12/00043/MFF	Extension of the oyster trestles at Benderloch - 1625 more oyster trestles
Mar-09	09/00397/LIB	North Shian Farm alterations and extension
Feb-09	09/00179/OUT	Erection of dwelling house at Shian Benderloch
Oct-08	08/01843/DET	Erection of a dwelling house southwest of Ledgrainach
Feb-11	11/00178/PP	Erection of a detached building for staff training and guest cookery demo's at Erisk Hotel
Jul-08	08/01328/DET	Erisk Hotel extension of spa accommodation
Nov-12	12/02509/NMA	Erection of a single storey dwellingshouse and temporary caravan
Oct-12	12/02282/NMA	Plot 4 Mill Farm Barcaldine new dwellinghouse and septic tank installation
Sep-12	12/02039/PP	Dwellinghouse and septic tank at PA37 1SG
Aug-12	12/01823/PNFOR	West of the Scottish Natural Heritage offices a new chemical store and 10,000 litre Ure tank
Nov-11	11/02209/PP	Barcaldine Castle dwellinghouse and minuments room, septic tank and soakaway - decision pending
Sep-11	11/01899/PPP	West of mill farm dwellinghouse and septic tank
Sep-11	11/01645/PP	North of mill farm house new dwellinghouse and septic tank
Sep-11	11/01240/PP	Plot 5: land east of mill farm house new dwelling house and septic tank.
Oct-10	10/01727/PP	New amenity block, play area and extension of the opening season for Barcaldine Caravan Park.
Aug-10	10/01365/PP	Barcaldine Castle new detached building with two en-suite bedrooms
May-10	10/00776/PP	Temporary shower and toilet block for 24months at Foreshore NW of Marine Resource Centre, Barcaldine
Feb-10	10/00335/PP	Dwellinghouse and residential annex/garage on land NE of Mill Farm house
Feb-10	10/00310/PPP	Plot 4 mill farm house Barcaldine new dwelling-house
Dec-08	08/02201/DET	Two dwellinghouses SW of Ranalds

Appendix 2: Table of Watercourse Loadings

No	NGR	Description	Width (m)	Depth (m)	Flow (m^3/d) (2 s.f.)	*E. coli* (cfu/ 100 ml)	Loading (*E. coli* day)
1	NM 9678 4302	Burn	2.70	0.13	2370	<100	$<2.4x10^9$
2	NM 9658 4262	Burn through culvert	1.45	0.20	1580	<100	$<1.6x10^9$
3	NM 9650 4257	River	5.93	0.11	5070	<100	$<5.1x10^9$
4	NM 9549 4201	Dearg Abhainn	6.17	0.25	26000	1600	$4.2x10^{11}$
5	NM 9529 4175	Burn	5.50	0.16	10200	900	$9.2x10^{10}$
6	NM 9430 4133	Burn	1.60	0.65	9170	200	$1.8x10^{10}$
7	NM 9375 4092	Burn into culvert	0.80	0.15	990	<1000	$<9.9x10^9$
8	NM 9343 4080	Burn	3.40	0.16	3140	<100	$<3.1x10^9$
9	NM 9260 4073	Small stream	0.25	0.10	73	20000	$1.5x10^{10}$
10	NM 9236 4064	Ferlochan Burn	4.50	0.07	3970	200	$8.0x10^9$
11	NM 9194 4045	Small river	1.10	0.09	5320	100	$5.3x10^9$
12	NM 9172 4049	Stream	1.22	0.10	1640	1000	$1.6x10^{10}$
13	NM 9150 4052	Small stream	1.60	0.11	1660	<100	$<1.7x10^9$
14	NM 9149 4081	Small stream	0.37	0.10	340	200	$6.7x10^8$
15	NM 9682 4476	Stream	0.90	0.14	6710	500	$3.5x10^{10}$
16	NM 9577 4462	An Iola	5.40	0.18	29200	300	$8.8x10^{10}$
17	NM 9572 4448	Burn	0.60	0.10	2080	8000	$1.7x10^{11}$
18	NM 9548 4417	Allt an Uruisge	3.90	0.20	13000	200	$2.6x10^{10}$
19	NM 9547 4394	Stream	-	-	9	3000	$2.6x10^8$
20	NM 9537 4386	Stream/land drainage	1.00	0.23	5110	6300	$3.2x10^{11}$
21	NM 9501 4340	Stream	0.16	0.08	18	<100	$<1.8x10^7$
22	NM 9468 4323	Stream	-	0.03	0.02	1800	$3.9x10^5$
23	NM 9014 4186	Stream	0.50	0.34	5010	30000	$1.5x10^{12}$
24	NM 9012 4177	Stream through culvert	0.60	0.32	1160	100	$1.2x10^9$
25	NM 9088 4184	Small stream	0.10	0.03	-	<1000	Not determined
26	NM 9080 4167	Stream	0.72	0.13	1380	<100	$<1.4x10^9$
27	NM 9441 4305	Stream	-	-	9	<100	$<8.6x10^6$

Appendix 3: Extended Bacteriological Survey Report for Shian Fisheries Oyster Farm (2009)

Loch Creran Shian: Shian Oysters SIN: AB 131 023 13

Results of extended bacteriological survey

Background

As a result of comments received from the harvester, Mr. Roger Thwaites, the following approach was recommended in the sanitary survey report as regards monitoring Pacific oysters (*Crassostrea gigas*) at Loch Creran Shian:

> "For oysters, it is recommended that the RMP be retained at NM 9094 4220. This location allows for the greatest protection of public health as it is likely to more highly impacted by nearby sources of faecal contamination than other locations on the fishery. As the discharge nearest this location has been removed, it is further recommended that an extended bacteriological survey be undertaken at the existing RMP and at a second monitoring point on the western oyster site at NM 9057 4221 with 6 samples to be taken at monthly intervals.
>
> Once the bacteriological survey has been completed, the data will be reviewed to determine which point reflected the higher levels of contamination from potential sources of pollution. This will then be identified as the RMP for ongoing monitoring. "

The extended bacteriological survey was undertaken in 2009, with monthly monitoring samples collected at the two agreed locations for six months between February and July 2009. For the purposes of reporting, the original recommended RMP is denoted Location 1 (NM 9094 4220), and the alternate monitoring point Location 2 (NM 9057 4221). A sampling tolerance of 10 m was recommended. The actual grid references sampled fall within the allowed tolerance. The results of that monitoring follow in Table 1. The locations of the two monitoring points relative to the oyster fishery are shown mapped in Figure 1.

Table 1 Results of extended bacteriological survey at Shian Fisheries

Collection Date	Grid Reference		*E. coli* (MPN/100g)	
	Location 1	Location 2	Location 1	Location 2
09/02/2009	NM 90940 42219	NM 90588 42200	<20	50
09/03/2009	NM 90940 42220	NM 90588 42199	130	80
27/04/2009	NM 90938 42218	NM 90589 42198	790	790
25/05/2009	NM 90938 42215	NM 90589 42199	2200	5400
22/06/2009	NM 90940 42218	NM 90588 42200	9200	2400
20/07/2009	NM 90939 42217	NM 90588 42198	310	5400

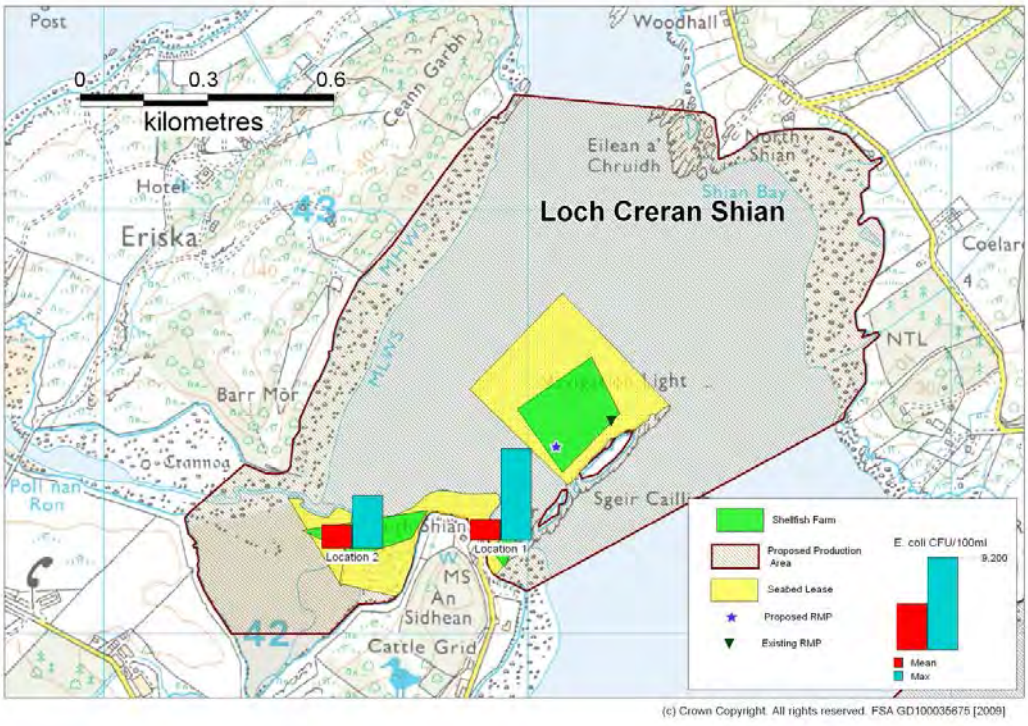

Figure 1 Map of sample locations with mean and maximum results

Using a paired samples T-test, no statistically significant difference was found between mean sample results at the two locations (T=-0.52, P=0.628). At both locations, results exceeded the threshold for Class A in April, May, June and July, 2009.

Exceedence of the Class B threshold occurred at Location 1 in June 2009 (9200 *E. coli* MPN/ 100g) and at Location 2 in May and July 2009 (5400 *E. coli* MPN/ 100g). As it is not clear which of these two sampling locations reflects the worst-case levels of contamination at the fishery, further sampling was requested.

Therefore, it is recommended that a single RMP for AB 131 023 13 be retained at NM 9094 4220. The sampling frequency is still recommended to remain monthly due to the variation observed in the results, and all other parameters are to remain as originally set forth in the sanitary survey report and sampling plan.

Appendix 4: Shoreline Survey Report 2013

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

Document Number	B0067_Shoreline 0005
Revision	Issue 02
Date	22/03/2013

Revision History

Revision	Changes	Date
A	Issue for internal review	27/02/2013
01	Incorporation of comments at rev A and first formal issue to CEFAS	01/03/2013
02	Revised issue to CEFAS resolving comments on revision 01	22/03/2013

	Name & Position	Date
Author	Lars Brunner, John Hausrath, Andrea Veszelovszki	27/02/2013
Checked	John Hausrath	22/03/2013
Approved	John Hausrath	22/03/2013

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

Shoreline Survey Report

Production area:	Loch Creran Upper Loch Creran Rubha Mor Loch Creran Shian	
Site name:	Inner Creran East Barrington Ferlochan – Rubha Mor Shian Fisheries	
SIN:	Inner Loch Creran East-Barrington Loch Creran West Ferlochan/Rubha More Shian Fisheries Loch Creran West	AB-313-709-08 AB-129-021-13 AB-130-742-13 AB-130-022-13 AB-131-023-13 AB-312-020-08
Species:	Mussels (*Mytilus edulis*) and Pacific Oyster (*Crassostrea gigas)*	
Harvester(s):	Inner Loch Creran/Loch Creran West - Mr Stan Dobrovolski (site manager: Mr Richard Deedman) Rubha Mor/Loch Creran Ferlochan - Mr Hugo Vajk East Barrington - Mrs Jane Barrington Shian Fisheries - Mr Roger Thwaites	
Local Authority:	Argyll & Bute Council	
Status:	Existing area	
Date Surveyed:	11th – 14th February 2013	
Surveyed by:	Andrea Veszelovszki, Eilidh Cole, Lars Brunner, Ivan Ezzi, Alison Clarke, Debbie Brennan	
Existing RMP:	Loch Creran Upper Mussels NM 9566 4371 Loch Creran Upper Oysters NM 9485 4323 Loch Creran: Rubha Mor NM 9222 4065 Loch Creran: Shian NM 9094 4221	
Area Surveyed:	*Loch Creran Shian* – shoreline south from Eriska Sound round bay and headland to south of Seabank Farm *Loch Creran Rubha Mor* – shoreline from Sea Life Centre westward to Rubha Mor headland *Loch Creran Upper* - Southern shore, from Rubha Teithil to Rubha Dearg and north shore from Creagan to South Ardnaclach with associated offshore cultivation Sites visited by boat: all mussel growing areas – Inner Loch Creran and Loch Creran West, with access by boat provided by Mr Richard Deedman (Rented from MRC in Barcaldine and skippered by John Hamilton).	

Weather

No significant precipitation over 48 hours preceding survey.

Monday the 11th of February:

Cold and sunny morning with about 30% scattered cloud cover and 4 degrees C. Northerly wind with wind speed of about 6 km/h, sea state calm (sea state: 1). By early afternoon full cloud cover and stronger winds.

Tuesday the 12th of February 2013:

No overnight precipitation. Cold morning with 100% cloud cover. Sea state zero (calm with no wind). Temperature about 9 degrees ˚C. Reduced cloud cover with intermittent sunny periods later on.

Wednesday, 13th of February 2013:

No overnight precipitation. 100% cloud cover with heavy rain, snow and sleet during the morning. The temperature was between 3-5 degrees ˚C with increasing wind during the day. Sea state 4 later increasing into sea state 5 by the afternoon.

Thursday, 14th of February 2013:

95% cloud cover with light easterly wind with intermittent showers. Temperature ranged between 5-7 degrees C. Sea state 2

Fishery

Loch Creran is a fjordic sea loch on the west coast of Scotland, north of Oban. The surveyed extent of the loch consists of three production areas and within there is a mixture of common mussels (*Mytilus edulis*) and Pacific oyster (*Crassostrea gigas*) cultivation. The oysters are kept on trestles and at present, the cultivation of these outweights the cultivation of mussels.

The Shian (western) area of the loch is under cultivation with Pacific oyster, as is the Rubha Mor area of the loch. The area on the Shian side that was used for mussel cultivation is now declassified and all lines and equipment were removed.

In the eastern sector of the loch, Pacific oysters are cultivated on the North shore (opposite Barcaldine), while two areas in the same sector are also used for mussel production. Both of these areas are currently largely out of use, and in a semi-derelict condition with inverted lines and many buoys missing. Under new management some of the lines have been repaired with this work planned to continue into the near future.

Sewage Sources

The whole of the lower basin of Loch Creran has human activity present, although the population density is low and there are no major settlements within the loch's watershed. In the Shian sector of the loch, only isolated houses were present on the survey route, and of these, no direct discharge pipes were observed. Farm run-off from Balure of Shian (NM 9018 4183) and from the fish farm factory at South Shian (NM 9092 4185) were the most likely pollution sources from this area.

In the Rubha Mor section, there were no direct discharges onto the shore, although some livestock was present on the upper fields. In addition the quarry depot at Rubha Garbh provided a lot of industrial activity, but was unlikely to be directly polluting as it was merely a shipping point for personnel and material to the nearby quarry at Glensanda, rather than an industrial enterprise in its own right.

In the Loch Creran Upper production area, there were no noted discharge pipes on the shore, although there was industrial activity present at the Marine Resource Centre (MRC) at Barcaldine (NM 961 422) and a medium size caravan park on the north shore at Creagan (NM 967 447) and at Sutherland's Grove (NM 966 422).

Seasonal Population

There is likely to be a small to moderate increase in population during the summer months in the survey area, and what increase there is will be concentrated in the caravan parks noted above at Creagan and Sutherland's Grove, which are only open during the summer months. There are likely to be some second homes in the area - which is quite common in this part of the country - that will be occupied intermittently.

Boats/Shipping

Loch Creran has regular small to medium sized shipping traffic. This traffic is dominated by activity at the Glensanda depot at Rubha Garbh and the Marine Resource Centre (MRC) at Barcaldine. Rubha Garbh is the main depot for the quarry at Glensanda and provides all deliveries of staff and materials to site, but no actual industrial activity occurs at Rubha Garbh. The MRC at Barcaldine has a marina/boatyard, a fish farm base, and several other small scale industrial activities, with activity increasing markedly during the summer months. The marina at MRC provides between 70-100 moorings, and had 6 boats on long term mooring during the survey.

There are many individual moorings located throughout the loch, including at all 3 production areas, but most were unoccupied during the survey period.

Farming and Livestock

The shores of Loch Creran are largely agricultural and a variety of sheep, cattle and horses were seen during the survey walk, although well dispersed and in small numbers. At North Ardnaclach farm (NM 952 437) it was noted that the cattle feed trailers (feeding approximately 15-20 head) were parked on the upper intertidal area of the beach having the effect of introducing cattle faecal matter directly onto the foreshore at a point that was only 100 – 200 m distance away from some of the mussel longlines. In addition the oyster cultivation site was only around 500m further SW along the foreshore.

Land Use

The land use in the area is predominantly agricultural, with small areas of industrial use (the MRC, Rubha Garbh depot and the fish factory at South Shian). On the hillsides of the southern shore there are large areas of plantation forestry, whereas the hills on the northern shore have a native forest cover. Some of the agricultural activity on the southern shore,

especially in the Rubha Mor area, appears to be csrofting, which may suggest intermittent grazing by livestock.

Land Cover

The predominant land cover around Loch Creran is grassland and bog areas on the lower slopes, with forestry cover on the hillsides behind. There is little crop cultivation other than grass for sileage.

Watercourses

There are numerous watercourses of different sizes discharging into the loch within the survey area. The largest of these are the Dearg Abhainn and the Abhainn Teithil which discharge into the Loch in the Barcaldine area. On the northern shore the largest discharge is the An Iola river which discharges into the loch just south of Inverfolla. There are numerous areas of ground seepage around the loch, complicated by a recurrent band of clay in the upper intertidal area that forces water to discharge above it rather than seep through.

Wildlife/Birds

Birds were noted on each of the survey days, although numbers were small overall. The largest bird presence was of gulls, followed by oystercatchers and cormorants. There were no particular focal areas for bird activity.

Shoreline survey maps

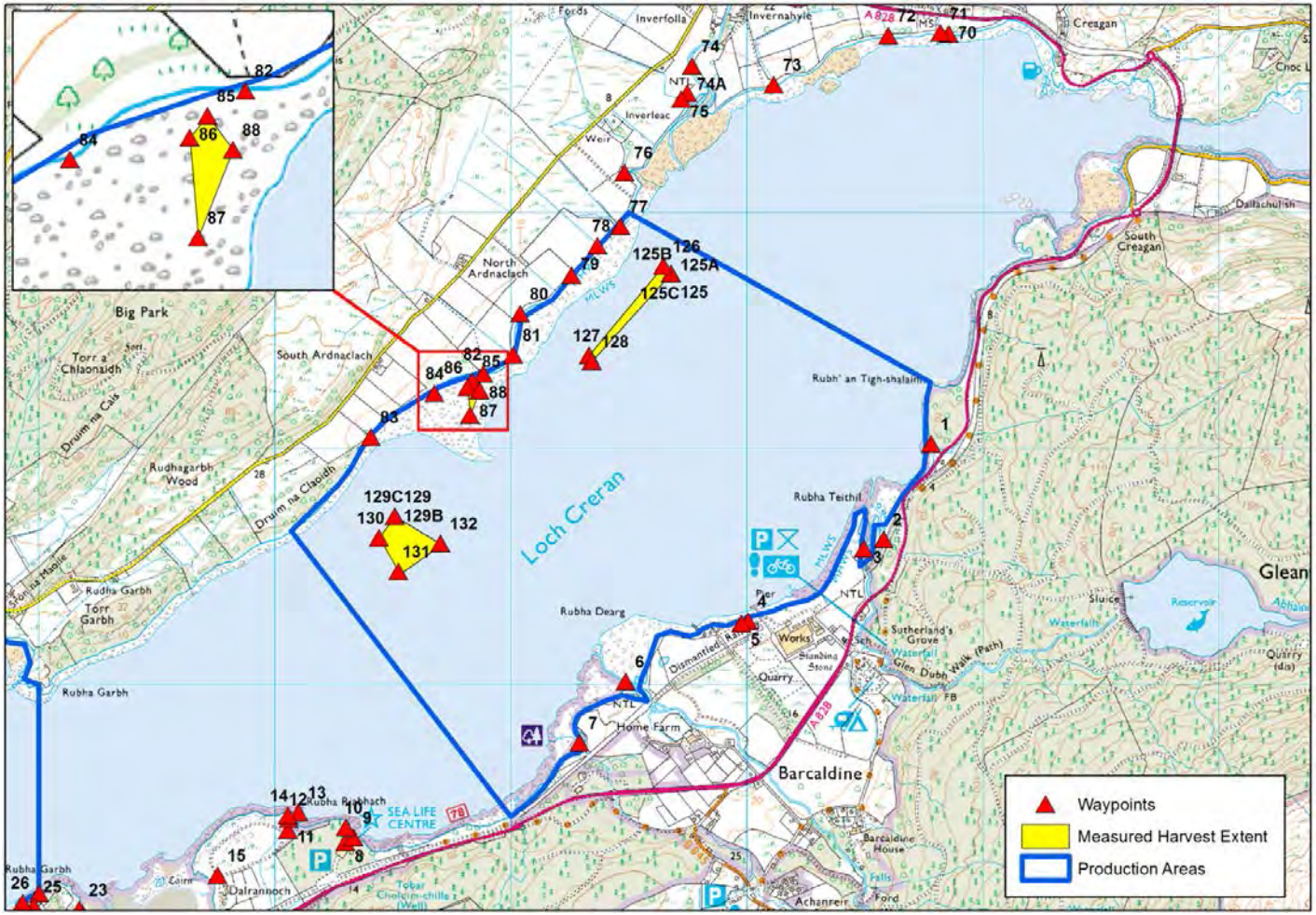

Figure 1. Loch Creran Upper waypoints

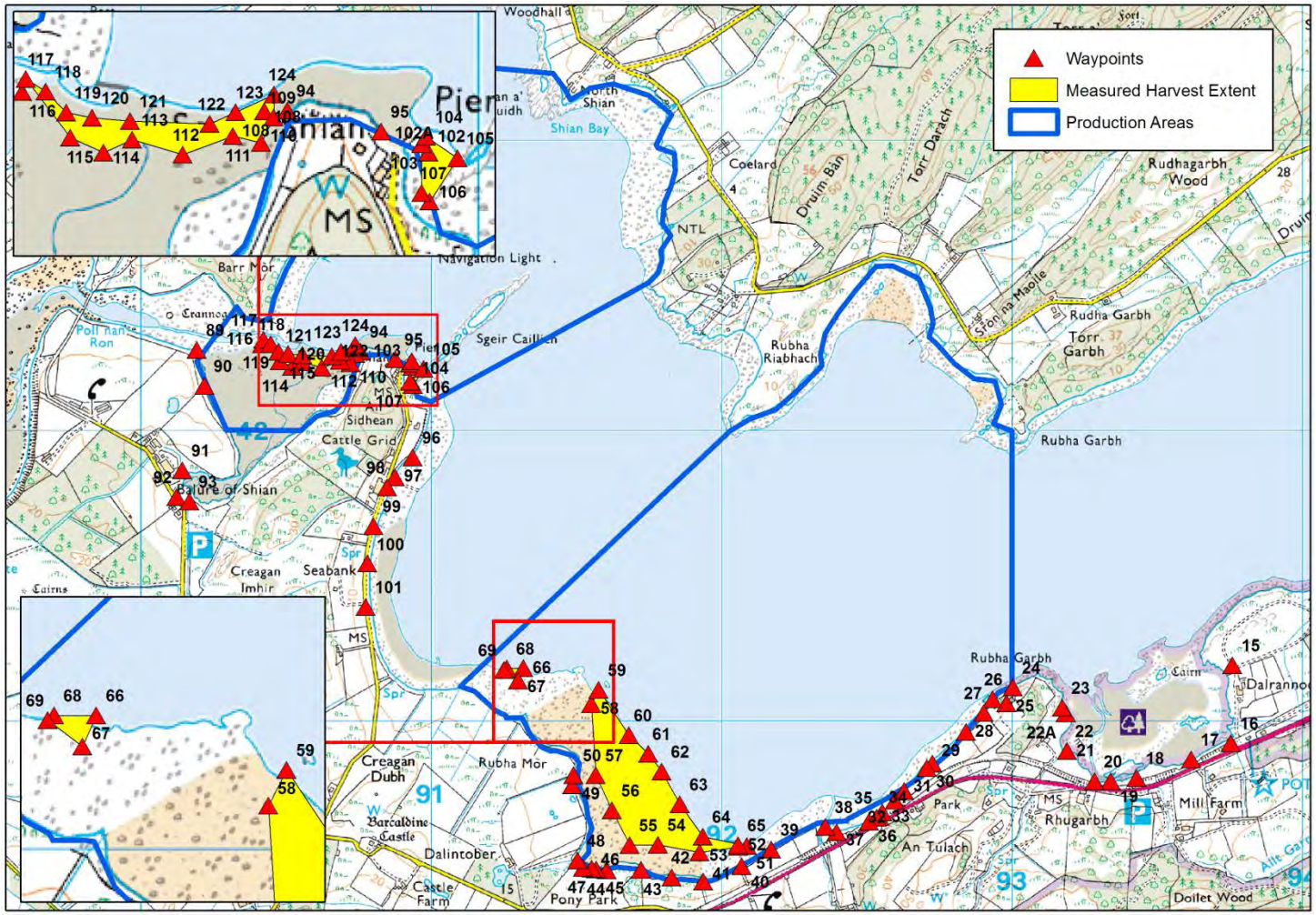

Figure 2. Loch Creran Lower waypoints

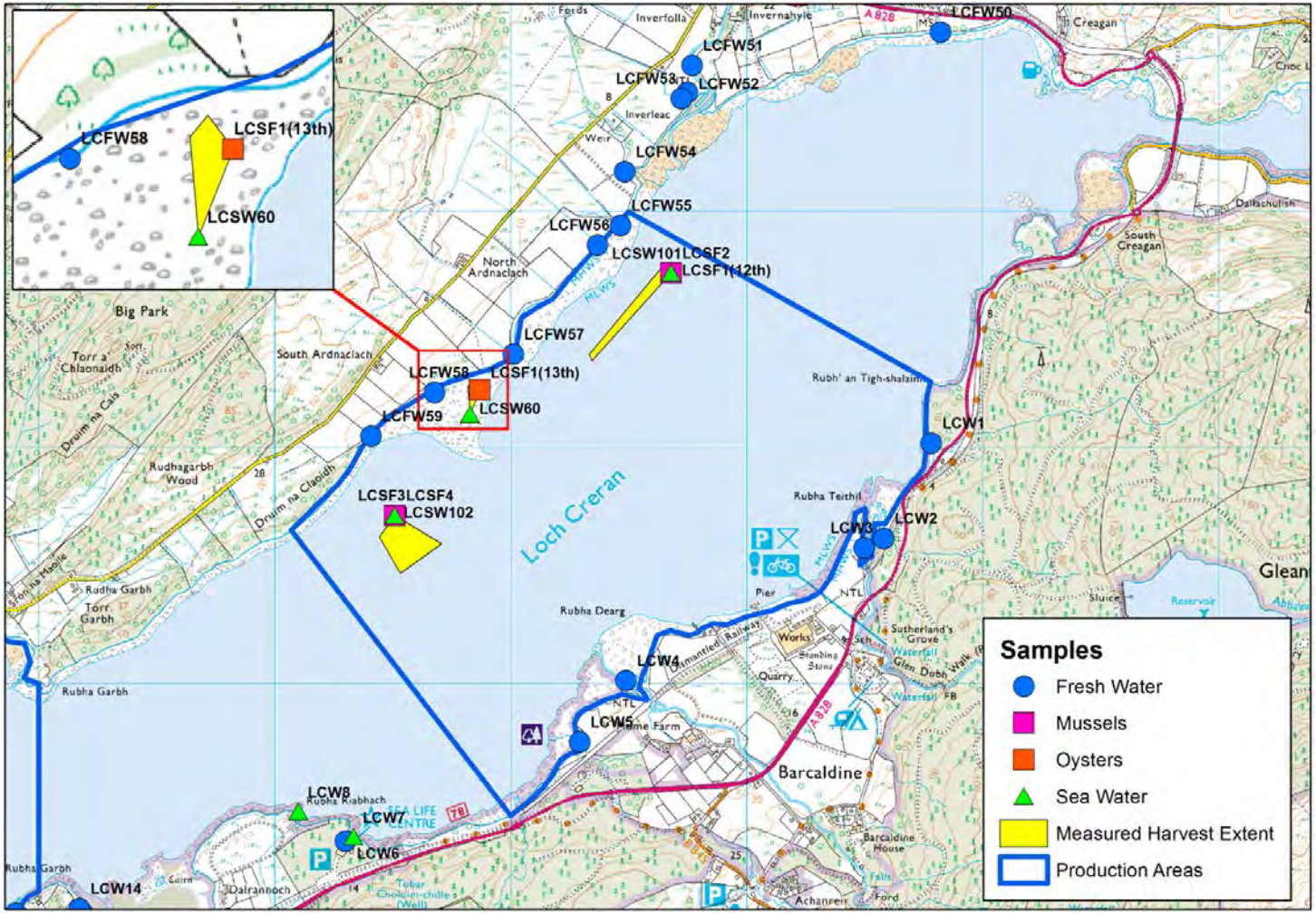

Figure 3. Loch Creran Upper samples

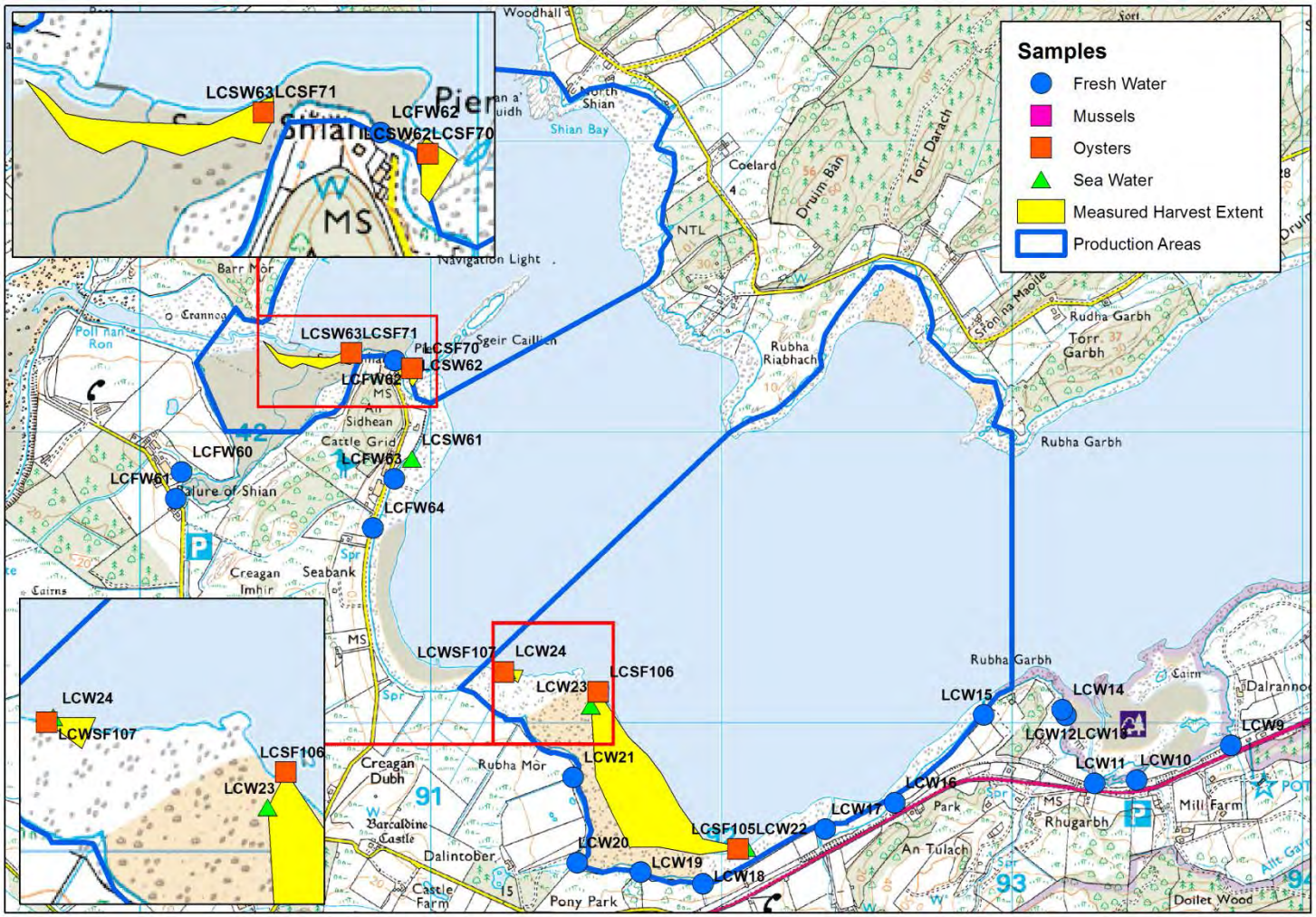

Figure 4. Loch Creran Lower samples

Table 1. Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	11/02/2013	9:36	NM 96783 43020	196783	743020	Fig 5	LCW1	Burn running over shore to loch. In loch 4 fishing boats moored offshore. No habitation in area, no seabirds. Burn measurements: Width: 2.7m; Depth: 13cm; Flow: 0.078 m/s, SD: 0.015
2	11/02/2013	10:04	NM 96582 42615	196582	742615	Fig 6,7	LCW2	Burn runs through culvert c. 100m from shore. Few seabirds: curlews, gulls, 3 goldeneye ducks and oystercatchers. Measurements 1: Width: 90 cm; Depth: 11cm; Flow: 0.118 m/s, SD: 0.006; Measurement 2 (further away from culvert: Width: 2m; Depth: 29cm; Flow: 0.007 m/s; SD: 0.003
3	11/02/2013	10:17	NM 96498 42574	196498	742575	Fig 8	LCW3	River flowing down to shore. Actual width of river at time of survey: 5.93 m; width of river bed: 15.5m; lots of small ponds in the area, smaller burns joining into river. Depth 1: 10cm; Flow: 0.065 m/s, SD: 0.006 Depth 2: 12 cm; Flow: 0.114 m/s, SD: 0.005 Along the shore from here there are about 70-100 moorings mostly unoccupied at this time of the year. Onshore the company Fusion Marine Ltd. assembling fish cages. MRC pontoon and Scottish Sea Farms pier.
4	11/02/2013	10:48	NM 96008 42267	196009	742268			Caravan park with about 15 non-static caravans. There are also about 8 holiday cabins next to caravan park. No outflows found in area.
5	11/02/2013	10:51	NM 95979 42257	195979	742258	Fig 9		Plastic pipe by caravan park pontoon. Probably land drainage, no outflow. Farmland adjacent to caravan park and holiday homes. No livestock.
6	11/02/2013	11:07	NM 95489 42013	195489	742014	Fig 10	LCW4	River running into loch from under road. With: 6.17 m (17.67m total width of bank); Depth 1: 25 cm; Flow: 0.307 m/s; SD: 0.064 Depth 2: 25 cm; Flow: 0.082 m/s; SD: 0.012 Seabirds in area: about 20 seagulls and a few mallards
7	11/02/2013	11:24	NM 95293 41752	195293	741753		LCW5	Farmland, no livestock. Burn flowing onto shore. Width: 5.5m; Depth: 16cm; Flow: 0.134m/s; SD: 0.006
8	11/02/2013	12:27	NM 94301 41332	194302	741332	Fig 11	LCW6	Sea Life Centre (SLC). Three burns and/or land runoff from two pipes and one natural burn joined into a bigger flow.Width:1.6 m; Depth: 6-7cm; Flow: 0.102 m/s; SD: 0.002

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
9	11/02/2013	12:38	NM 94335 41351	194335	741351		LCW7	Seawater sample taken at Sea Life Centre at location where burn runs into the sea.
10	11/02/2013	12:41	NM 94302 41394	194303	741394	Fig 12		Pipes are running down from SLC to shore through wooded area with a pump attached at the end of one. Possibly seawater is pumped up to SLC to aquariums and maybe they pump out used seawater back into sea.
11	11/02/2013	12:53	NM 94058 41382	194058	741382			Small burn running onto shore through wooded area, no habitation nearby. Not measured or sampled but it is most likely a permanent watercourse.
12	11/02/2013	12:58	NM 94060 41431	194061	741431	Fig 13		House on shore, most likely holiday home with plastic sewage pipe running down to shore with a very few drops of outflow, not sufficient to sample.
13	11/02/2013	13:01	NM 94101 41458	194102	741459		LCW8	Seawater sample taken at end of pipe.
14	11/02/2013	13:05	NM 94057 41445	194057	741446			Fish farm (possibly Scottish Sea Farms site) offshore from house (waypoint number 12) with 14 cages, 4 without netting - possibly empty? Two boats around fish cages.
15	11/02/2013	13:15	NM 93760 41192	193760	741192			Dalrannoch farm with 23 sheep in a fenced area around farm, no outflows or manhole covers visible.
16	11/02/2013	13:22	NM 93753 40923	193754	740924	Fig 14	LCW9	Small burn runs into bay through culvert. Slight smell on approach. Width of culvert: 80 cm; Depth: 15cm; Flow: 0.095 m/s; SD: 0.013
17	11/02/2013	13:31	NM 93618 40867	193619	740867			Large metal pipe from under the road A828 runs into bay. There are houses on the other side of the road. Pipe Ø: 35 cm, no outflow.
18	11/02/2013	13:37	NM 93430 40803	193430	740803		LCW10	Burn flowing from farmland under the road to shore. Measurements: Width: 3.4 m Depth 1: 18 cm; Flow: 0.055 m/s; SD: 0.009 Depth 2: 13 cm; Flow: 0.082 m/s; SD: 0.017
19	11/02/2013	13:43	NM 93340 40792	193340	740793			Small burn very shallow and rocky joining into larger burn (waypoint number 18)
20	11/02/2013	13:47	NM 93284 40793	193285	740793	Fig 15	LCW11	Two clay pipes next to house, outflow from larger one. Pipe Ø large: 35 cm; estimated flow: 60 ml/s; pipe Ø small: 18 cm.
21	11/02/2013	13:54	NM 93191 40897	193191	740898			Small burn very shallow running down between houses from shore. Not sampled.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
22	11/02/2013	13:57	NM 93186 41026	193187	741027	Fig 16	LCW12	Oyster processing yard with lots of oyster shells around. Black plastic pipe runs onto shore from processing yard. Pipe Ø : 18 cm; Depth of flow: ~3cm, Flow: 1.47 m/s
22A	11/02/2013	13:57	NM 93186 41026	193187	741027	Fig 17	LCW13	Oyster processing yard with lots of oyster shells around. Small pipe protruding from yard wall/fence. Pipe Ø: 6 cm, very small discharge
23	11/02/2013	14:03	NM 93174 41045	193174	741046	Fig 18, 19	LCW14	Second large plastic discharge pipe from processing yard. Pipe Ø: 15 cm; Depth: 2cm; Flow: 1.359 m/s; SD: 0.005 Green pipe runs from yard to shore and back. Possibly water supply for shellfish processing.
24	11/02/2013	14:11	NM 93003 41115	193004	741115			Small stream running down cliff onto shore just adjacent to Yeoman's pier.
25	11/02/2013	14:15	NM 92981 41060	192982	741061	Fig 20		Yeoman's office and pier.(Rubha Garbh/Glensanda)
26	12/02/2013	9:21	NM 92934 41075	192934	741076			Yeoman's pier. (Same as before, team marked it again on second day)
27	12/02/2013	9:29	NM 92904 41028	192904	741028		LCW15	Black plastic pipe flowing onto shore. Pipe Ø: 18 cm; estimated flow: 5 ml/s
28	12/02/2013	9:37	NM 92842 40962	192842	740962			Sheep (12) in fenced area. Nearby 4 caravans next to access to main road. 2 mooring in bay.
29	12/02/2013	9:42	NM 92726 40854	192727	740854			White plastic pipe with little outflow. Two houses beyond field.
30	12/02/2013	9:47	NM 92707 40838	192707	740839			Grey plastic pipe with no outflow coming from the edge of field onto shore.
31	12/02/2013	9:50	NM 92629 40759	192629	740759			Big white house beyond field next to road. Sailing yacht in bay, 2 small boats tied up on shore. 7 unused oyster bags on shore.
32	12/02/2013	9:54	NM 92598 40725	192598	740726		LCW16	Small stream running from field onto shore. Width: 25 cm; Depth: 10 cm; Flow: 0.034 m/s; SD: 0.004
33	12/02/2013	10:01	NM 92554 40685	192555	740686			Rusty metal pipe from under rocks onto shore, no flow. Pipe Ø: 6 cm.
34	12/02/2013	10:03	NM 92544 40670	192545	740670			Stack of approx. 60-70 oyster bags with empty shells.
35	12/02/2013	10:06	NM 92534 40667	192535	740667			Clay drainage pipes (~4) running out of wall on shore probably from road next to it. No flows.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
36	12/02/2013	10:08	NM 92508 40653	192509	740654			Road bridge, telephone cables running out of pipe. Blocked culvert, no flow. Empty oyster bags on shore.
37	12/02/2013	10:19	NM 92396 40617	192397	740617	Fig 21		Oyster processing yard. Fully functional but a lot of redundant machinery (tractors, vans, land rovers, etc.)
38	12/02/2013	10:22	NM 92357 40636	192358	740636		LCW17	River running into loch. Width: 4.5 m; Depth 1: 7 cm; Flow: 0.0140 m/s; SD: 0.004 Depth 2: 7 cm; Flow: 0.277 m/s; SD: 0.005
39	12/02/2013	10:40	NM 92171 40556	192172	740557			Ten geese in field next to road, 3 ducks in water.
40	12/02/2013	10:44	NM 92069 40500	192070	740501			House next to road beyond shore and field.
41	12/02/2013	10:51	NM 91938 40447	191938	740447		LCW18	Small river running onto shore. Four houses back from shore beyond field. River width: 1.1 m Depth: 9 cm; Flow: 0.622 m/s; SD: 0.036
42	12/02/2013	11:02	NM 91829 40461	191829	740461			Small, very slow flowing stream/ land drainage.
43	12/02/2013	11:06	NM 91723 40487	191723	740487		LCW19	Stream flowing from fields onto shore. Width: 1.22 m; Depth: 10 cm; Flow: 0.156 m/s; SD: 0.004
44	12/02/2013	11:17	NM 91605 40486	191606	740487			Seven houses back from shore beyond field.
45	12/02/2013	11:19	NM 91569 40489	191570	740490			Empty oyster bags and tubes on shore. About 20 seabirds around.
46	12/02/2013	11:23	NM 91553 40492	191553	740492			Plastic pipe with no flow. Pipe Ø: 8cm.
47	12/02/2013	11:25	NM 91524 40494	191525	740495			Empty oyster bags, some with empty shells in them. Thin black plastic pipes not in use coiled up.
48	12/02/2013	11:30	NM 91504 40520	191504	740520	Fig 22	LCW20	Oyster farm equipment. Small stream running from fields to shore. Width: 1.6 m; Depth: 11 cm; Flow: 0.109 m/s; SD: 0.003 Three small tributaries running into one mean stream.
49	12/02/2013	11:46	NM 91486 40778	191487	740778			Extent of Pony Park between waypoints 48 and 49. No ponies seen but droppings on field.
50	12/02/2013	12:05	NM 91491 40813	191491	740814		LCW21	Small stream. Width: 37 cm; Depth: 10 cm; Flow: 0.105 m/s; SD: 0.004
51	12/02/2013	13:20	NM 92088 40570	192089	740570	Fig 23	LCW22	Easternmost waypoint of oyster cultivation.
52	12/02/2013	13:25	NM 92058 40567	192059	740568		LCSF105	Eastern oyster sample.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
53	12/02/2013	13:31	NM 91925 40547	191926	740548			Waypoint along oyster farm.
54	12/02/2013	13:34	NM 91782 40573	191782	740574			Waypoint along oyster farm.
55	12/02/2013	13:37	NM 91684 40572	191685	740573			Waypoint 55. Uppermost trestles on beach not in active use. Some bags of mostly dead oysters/empty shells.
56	12/02/2013	13:41	NM 91623 40692	191623	740693			Waypoint 56 along the boundary of oyster farm.
57	12/02/2013	13:44	NM 91568 40813	191568	740813			Waypoint 57 along the boundary of oyster farm.
58	12/02/2013	13:48	NM 91552 41058	191552	741059	Fig 24	LCW23	Waypoint 58 marks the upper shore, western end of cultivation area.
59	12/02/2013	13:50	NM 91577 41107	191578	741107		LCSF106	Waypoint 59 marks the lower western end of farm.
60	12/02/2013	14:11	NM 91681 40951	191681	740952			Waypoints 60-65 are marking the lower tidal area of the oyster farm.
61	12/02/2013	14:12	NM 91748 40887	191748	740888			Waypoints 60-65 are marking the lower tidal area of the oyster farm.
62	12/02/2013	14:14	NM 91795 40826	191795	740826			Waypoints 60-65 are marking the lower tidal area of the oyster farm.
63	12/02/2013	14:18	NM 91857 40713	191858	740713			Waypoints 60-65 are marking the lower tidal area of the oyster farm.
64	12/02/2013	14:20	NM 91936 40602	191937	740602			Waypoints 60-65 are marking the lower tidal area of the oyster farm.
65	12/02/2013	14:23	NM 92056 40572	192057	740573			Waypoints 60-65 are marking the lower tidal area of the oyster farm.
66	12/02/2013	14:46	NM 91318 41181	191318	741182	Fig 25		Eastern lower tidal boundary of oyster farm.
67	12/02/2013	14:47	NM 91299 41139	191300	741140			Eastern higher tidal boundary of newly occupied area of farm.
68	12/02/2013	14:48	NM 91260 41181	191261	741182		LCW24	Western lower tidal boundary of newly occupied area of farm.
69	12/02/2013	14:49	NM 91252 41175	191252	741175		LCWSF107	Western higher tidal boundary of farm. Stock here is 2-3 years old oysters. 14 trestles at moment.
70	13/02/2013	9:51	NM 96857 44755	196858	744755			Start of 3rd day survey.
71	13/02/2013	9:54	NM 96822 44761	196823	744762	Fig 26	LCFW50	Discharge noticed from caravan site - yellow/orange PVC pipe running into subtidal, not possible to sample due to tidal state. Stream with width: 90 cm; Depth: 14cm; Flow: 0.616 m/s; SD: 0.013
72	13/02/2013	10:10	NM 96601 44748	196601	744749			Stream flowing - with chalets above - no discharge or signs of agriculture visible in field, no sample taken.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
73	13/02/2013	10:23	NM 96116 44541	196116	744542			As above with abandoned pipe on shore - no sign of any upper piping on shore side.
74	13/02/2013	10:37	NM 95769 44620	195770	744621		LCFW51	Stream to shore. Width: 5.4 m Depth 1: 23 cm; Flow: 0.163 m/s; SD: 0.019 Depth 2 : 31 cm; Flow: 0.317 m/s; SD: 0.016 Depth 3: 50 cm; Flow: 0.564 m/s; SD: 0.016
74A	13/02/2013	10:53	NM 95750 44505	195750	744505	Fig 27	LCFW52	Plastic corrugated pipe, possibly land drain but definite smell from pipe. Sampled, possibly contaminated.
75	13/02/2013	11:02	NM 95723 44479	195723	744479		LCFW53	Burn with turbid water, possibly contaminated with red substance in it. Width: 0.6 m; Depth: 10 cm; Flow: 0.402 m/s; SD: 0.012
76	13/02/2013	11:17	NM 95484 44169	195484	744170		LCFW54	Burn running onto shore. Width: 3.9 m Depth 1: 18 cm; Flow: 0.252 m/s; SD: 0.027 Depth 2: 21 cm; Flow: 0.134 m/s; SD: 0.018
77	13/02/2013	11:30	NM 95466 43940	195467	743941	Fig 28	LCFW55	Cows noted on beach (approx. 15). Feeder is located on upper intertidal some faecal matter around feeder, cows have free entry back onto field. Stream with very low flow, possibly less than 1L/10s and runs through sand so flow is variable. Sample taken as low down on beach as possible to show effect of above.
78	13/02/2013	11:42	NM 95369 43858	195369	743859		LCFW56	Stream or land drain running off field with cows present. Stream width: 1m; Depth: 23 cm; Flow: 0.257 m/s; SD: 0.022
79	13/02/2013	11:52	NM 95258 43733	195259	743734			Land drain discharging onto shore. Standard 12 cm diameter pipe.
80	13/02/2013	11:59	NM 95042 43571	195042	743571			Land drain (x3) where stream discharge should have been. Each 6-8 cm in diameter with minimal iron tainted flow due to low flow and being land drain. No samples taken.
81	13/02/2013	12:07	NM 95012 43396	195012	743397		LCFW57	Stream. Width: 16 cm; Depth: 8cm; Flow: 0.016 m/s; SD: 0.016
82	13/02/2013	12:19	NM 94885 43315	194885	743316			Land drain next to oyster farm compound.
83	13/02/2013	12:43	NM 94409 43048	194410	743049		LCFW59	Stream at SW end of sample area sampled (while waiting for tide to fall). Stream was difficult to measure due to running through bog and tree roots and sand - estimated flow is 100 ml per second.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
84	13/02/2013	12:50	NM 94677 43233	194678	743234		LCFW58	Stream discharge onto beach. Water is dirty although suspected particulate matter rather than contamination. Flow again was difficult to measure due to similar situation as above. Estimated 1m flow in 4 seconds at 3cm depth.
85	13/02/2013	12:57	NM 94840 43285	194840	743286			Northern upper tidal boundaries of farm area.
86	13/02/2013	12:58	NM 94819 43259	194819	743260			Western upper tidal boundaries of farm area.
87	13/02/2013	12:59	NM 94829 43141	194829	743142		LCSW60	Seawater sample taken at location.
88	13/02/2013	13:01	NM 94870 43245	194871	743245		LCSF1(13th)	Oyster sample at location.(Eastern boundary of oyster bed).
89	14/02/2013	9:40	NM 90193 42278	190194	742278			Start of 4th day of the survey.
90	14/02/2013	9:42	NM 90220 42153	190221	742154			Small stream running off field - no visible contamination all along section of former flood defence mound. Now cuts have been made into it at regular intervals to allow ground drainage to flow out.
91	14/02/2013	9:58	NM 90143 41863	190143	741863	Fig 29	LCFW60	Stream flowing past from land boundary - bales/dumped material with 2 cows in yard at feeder. Width: 50 cm; Depth: 34 cm; Flow: 0.341 m/s; SD: 0.004
92	14/02/2013	10:10	NM 90124 41771	190125	741771		LCFW61	Stream running through culvert under road. Width: 60 cm; Depth: 32 cm; Flow: 0.070 m/s; SD: 0.010
93	14/02/2013	10:19	NM 90168 41755	190168	741756			Stream running off land - not sampled.
94	14/02/2013	10:37	NM 90757 42273	190757	742273			15 moorings visible in bay, no boats present at time. One large pontoon visible. 5 seabirds (4 gulls, 1 oystercatcher)
95	14/02/2013	10:42	NM 90877 42246	190877	742246	Fig 30	LCFW62	Yellow/orange PVC pipe running onto upper beach. Estimated flow: 20 ml in 2 seconds with a constant flow. Oyster shed and associated materials stored in compound in upper shore.
96	14/02/2013	11:03	NM 90937 41907	190938	741907		LCSW61	Sea water sample taken adjacent to salmon farm.
97	14/02/2013	11:08	NM 90875 41839	190876	741840		LCFW63	Scottish Sea Farms factory. Small stream running under road. 10 cm diameter, 3 cm deep.
98	14/02/2013	11:17	NM 90849 41804	190849	741804	Fig 31		Septic tank outside fish factory.
99	14/02/2013	11:21	NM 90802 41670	190802	741671		LCFW64	Stream running off hillside in a 26 cm diameter pipe. Stream width: 72 cm; Depth: 13 cm; Flow: 0.171 m/s; SD: 0.007

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
100	14/02/2013	11:29	NM 90781 41542	190781	741543			Stream in culvert under the road, not sampled.
101	14/02/2013	11:32	NM 90775 41392	190776	741393			End of survey walk.
102	14/02/2013	13:54	NM 90937 42219	190937	742220		LCSW62	Sea water samples taken at oyster farm boundary. Not exact location of boundary due to high tide preventing access.
102A	14/02/2013	13:54	NM 90937 42219	190937	742220		LCSF70	Oyster samples taken at oyster farm boundary. . Not exact location of boundary due to high tide preventing access.
103	14/02/2013	13:59	NM 90928 42230	190929	742231			Boundaries of cultivation area. . Not exact location of boundary due to high tide preventing access.
104	14/02/2013	13:59	NM 90934 42239	190934	742240			Boundaries of cultivation area. . Not exact location of boundary due to high tide preventing access.
105	14/02/2013	14:00	NM 90974 42212	190974	742212			Boundaries of cultivation area. . Not exact location of boundary due to high tide preventing access.
106	14/02/2013	14:01	NM 90938 42157	190939	742157			Boundaries of cultivation area. . Not exact location of boundary due to high tide preventing access.
107	14/02/2013	14:01	NM 90928 42168	190929	742168			Boundaries of cultivation area. . Not exact location of boundary due to high tide preventing access.
108	14/02/2013	14:06	NM 90728 42272	190728	742272		LCSW63	Sea water sample taken.
108A	14/02/2013	14:06	NM 90728 42272	190728	742272		LCSF71	Oyster sample taken.
109	14/02/2013	14:07	NM 90739 42264	190740	742264			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
110	14/02/2013	14:07	NM 90723 42232	190724	742232			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
111	14/02/2013	14:08	NM 90687 42240	190688	742241			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
112	14/02/2013	14:09	NM 90623 42217	190623	742217			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
113	14/02/2013	14:10	NM 90559 42236	190559	742236			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
114	14/02/2013	14:11	NM 90522 42219	190523	742220			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
115	14/02/2013	14:11	NM 90479 42238	190480	742238			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
116	14/02/2013	14:12	NM 90418 42297	190419	742297			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
117	14/02/2013	14:12	NM 90423 42313	190423	742313			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
118	14/02/2013	14:13	NM 90448 42297	190448	742298			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
119	14/02/2013	14:13	NM 90474 42270	190475	742271			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
120	14/02/2013	14:14	NM 90508 42263	190508	742264			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
121	14/02/2013	14:15	NM 90556 42260	190557	742260			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
122	14/02/2013	14:18	NM 90658 42256	190658	742256			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
123	14/02/2013	14:19	NM 90691 42271	190691	742271			Extent of second cultivation area. . Not exact location of boundary due to high tide preventing access.
124	14/02/2013	14:19	NM 90739 42294	190740	742294			Extent of second cultivation area. Not exact location of boundary due to high tide preventing access. Between the two sites there are trestles but they are mostly empty.
125	12/02/2013	10:03	NM 95681 43740	195681	743740			S8 Harvest area 1st CTD (YSI CastAway) at NE corner - extents of harvest area not clear to due missing buoys, section of the lines being submerged, etc.
125A	12/02/2013	10:03	NM 95681 43740	195681	743740	Fig 32	LCSF1(12th)	S8 Harvest area upper depth mussel sample at NE corner
125B	12/02/2013	10:03	NM 95681 43740	195681	743740		LCSF2	S8 Harvest area lower depth mussel sample at NE corner
125C	12/02/2013	10:03	NM 95681 43740	195681	743740		LCSW101	S8 Harvest area sea water sample at NE corner

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
126	12/02/2013	10:23	NM 95648 43774	195649	743774			S8 Harvest area 2nd CTD at NW corner
127	12/02/2013	10:31	NM 95332 43393	195333	743394	Fig 33		S8 Harvest area 3rd CTD at SW corner
128	12/02/2013	10:34	NM 95345 43368	195345	743369			S8 Harvest area 4th CTD at SE corner
129	12/02/2013	10:50	NM 94509 42712	194510	742713			S10 Harvest area 1st CTD at NE corner - extents of harvest area not abundantly clear to due missing buoys, section of the lines being submerged, etc.
129A	12/02/2013	10:50	NM 94509 42712	194510	742713		LCSF3	S10 Harvest area upper depth mussel sample at NE corner
129B	12/02/2013	10:50	NM 94509 42712	194510	742713		LCSF4	S10 Harvest area lower depth mussel sample at NE corner
129C	12/02/2013	10:50	NM 94509 42712	194510	742713		LCSW102	S10 Harvest area sea water sample at NE corner (surface sample)
130	12/02/2013	11:01	NM 94442 42621	194443	742622			S10 Harvest area 2nd CTD at NW corner
131	12/02/2013	11:13	NM 94526 42480	194526	742480	Fig 34		S10 Harvest area 3rd CTD at SW corner
132	12/02/2013	11:17	NM 94703 42596	194704	742597			S10 Harvest area 4th CTD at SE corner

Photographs referenced in the table can be found attached as Figures 5-34.

Sampling

Water samples were collected at sites marked on the map shown in Figures 3 and 4. Samples were transferred to either Biotherm 10 or Biotherm 25 boxes with ice packs and shipped to Glasgow Scientific Services (GSS) for *E.coli* analysis. All samples were shipped on the day of collection and all of them were received and analysed the following day. The sample temperatures on arrival to the laboratory ranged between 1.6 ˚C and 5.4 ˚C.

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

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

In Loch Creran two types of shellfish samples were collected. Oyster samples were taken at low tide in the intertidal zone and mussel samples were collected using a small boat rented from MRC by the site manager and kindly provided for us at the Inner Loch Creran site.

Table 2. Water sample results

No.	Date	Sample	Grid Ref	Type	*E. coli* (cfu/100ml)	Salinity (ppt)
1	11/02/2013	LCW1	NM 96783 43020	Fresh Water	<100	
2	11/02/2013	LCW2	NM 96582 42615	Fresh Water	<100	
3	11/02/2013	LCW3	NM 96498 42574	Fresh Water	<100	
4	11/02/2013	LCW4	NM 95489 42013	Fresh Water	1600	
5	11/02/2013	LCW5	NM 95293 41752	Fresh Water	900	
6	11/02/2013	LCW6	NM 94301 41332	Fresh Water	200	
7	11/02/2013	LCW7	NM 94335 41351	Sea Water	41	30.3
8	11/02/2013	LCW8	NM 94101 41458	Sea Water	1	28.4
9	11/02/2013	LCW9	NM 93753 40923	Fresh Water	<1000	
10	11/02/2013	LCW10	NM 93430 40803	Fresh Water	<100	
11	11/02/2013	LCW11	NM 93284 40793	Fresh Water	<100	
12	11/02/2013	LCW12	NM 93186 41026	Fresh Water	<100	
13	11/02/2013	LCW14	NM 93174 41045	Fresh Water	<100	
14	12/02/2013	LCW15	NM 92904 41028	Fresh Water	<100	
15	12/02/2013	LCW16	NM 92598 40725	Fresh Water	20000	
16	12/02/2013	LCW17	NM 92357 40636	Fresh Water	200	
17	12/02/2013	LCW18	NM 91938 40447	Fresh Water	100	

No.	Date	Sample	Grid Ref	Type	*E. coli* (cfu/100ml)	Salinity (ppt)
18	12/02/2013	LCW19	NM 91723 40487	Fresh Water	1000	
19	12/02/2013	LCW20	NM 91504 40520	Fresh Water	<100	
20	12/02/2013	LCW21	NM 91491 40813	Fresh Water	200	
21	12/02/2013	LCW22	NM 92088 40570	Sea Water	0	33.1
22	12/02/2013	LCW23	NM 91552 41058	Sea Water	0	32.5
23	12/02/2013	LCW24	NM 91260 41181	Sea Water	0	33.1
24	13/02/2013	LCFW50	NM 96822 44761	Fresh Water	500	
25	13/02/2013	LCFW51	NM 95769 44620	Fresh Water	300	
26	13/02/2013	LCFW53	NM 95723 44479	Fresh Water	8000	
27	13/02/2013	LCFW54	NM 95484 44169	Fresh Water	200	
28	13/02/2013	LCFW55	NM 95466 43940	Fresh Water	3000	
29	13/02/2013	LCFW56	NM 95369 43858	Fresh Water	6300	
30	13/02/2013	LCFW57	NM 95012 43396	Fresh Water	<100	
31	13/02/2013	LCFW59	NM 94409 43048	Fresh Water	<100	
32	13/02/2013	LCFW58	NM 94677 43233	Fresh Water	1800	
33	13/02/2013	LCSW60	NM 94829 43141	Sea Water	8	28.2
34	14/02/2013	LCFW60	NM 90143 41863	Fresh Water	30000	
35	14/02/2013	LCFW61	NM 90124 41771	Fresh Water	100	
36	14/02/2013	LCFW62	NM 90877 42246	Fresh Water	<1000	
37	14/02/2013	LCSW61	NM 90937 41907	Sea Water	11	32.9
38	14/02/2013	LCFW63	NM 90875 41839	Fresh Water	<1000	
39	14/02/2013	LCFW64	NM 90802 41670	Fresh Water	<100	
40	14/02/2013	LCSW62	NM 90937 42219	Sea Water	300	32.9
41	14/02/2013	LCSW63	NM 90728 42272	Sea Water	7	32.3
42	12/02/2013	LCSW101	NM 95681 43740	Sea Water	0	32.7
43	12/02/2013	LCSW102	NM 94509 42712	Sea Water	0	32.7
44	11/02/2013	LCW13	NM 93186 41026	Fresh Water	<100	
45	13/02/2013	LCFW52	NM 95750 44505	Fresh Water	<1000	

Table 3. Shellfish sample results

No.	Date	Sample	Grid Ref	Type	Location on Line	*E. coli* (MPN/100g)
1	12/02/2013	LCSF105	NM 92058 40567	Oyster		<20
2	12/02/2013	LCSF106	NM 91577 41107	Oyster		<20
3	12/02/2013	LCWSF107	NM 91252 41175	Oyster		330
4	13/02/2013	LCSF1(13th)	NM 94870 43245	Oyster		330
5	14/02/2013	LCSF70	NM 90937 42219	Oysters		<20
6	14/02/2013	LCSF71	NM 90728 42272	Oysters		<20
7	12/02/2013	LCSF1(12th)	NM 95681 43740	Mussels		<20
8	12/02/2013	LCSF2	NM 95681 43740	Mussels		20
9	12/02/2013	LCSF3	NM 94509 42712	Mussels		<20
10	12/02/2013	LCSF4	NM 94509 42712	Mussels		<20

Photographs

Figure 5. Burn running onto shore. Waypoint 1.

Figure 6. Burn running through culvert onto shore. Waypoint 2.

Figure 7. Burn breaking up on shore and enters the sea at about 100 metres from culvert. Waypoint 2.

Figure 8. River flowing down to shore on wide riverbed, also breaking up into two smaller parts. Waypoint 3.

Figure 9. Plastic pipe with no discharge at pontoon by caravan park. Waypoint 5.

Figure 10. River running onto shore from under road. Waypoint 6.

Figure 11. Sea Life Centre (SLC). Three burns/land drains joined up into a larger stream. Waypoint 8.

Figure 12. Pipes run up and down on shore next to SLC with pump attached near water. Waypoint 10.

Figure 13. Sewage pipe running from house on shore into sea. Waypoint 12.

Figure 14. Small burn runs into bay through culvert. Waypoint 16.

Figure 15. Clay pipes on shore next to house. Waypoint 20.

Figure 16. Oyster processing yard with outflows. Waypoint 22.

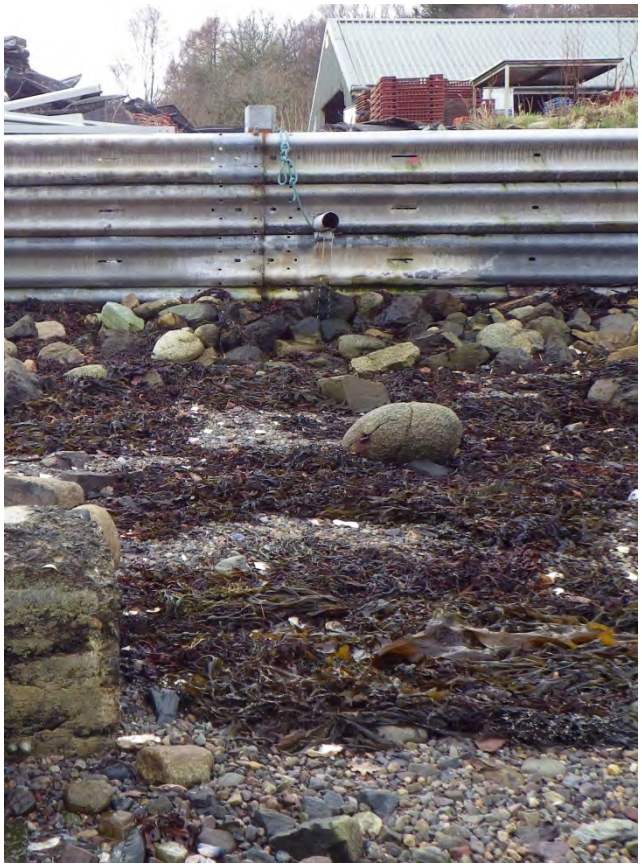

Figure 17. Small pipe from yard wall/fence with discharge. Waypoint 22A.

Figure 18. Second large outflow from processing farm. Waypoint 23.

Figure19. Pipework running to and from processing yard. Waypoint 23.

Figure 20. Rubha Garbh/Yeoman pier. Ferries provide transport to Glensanda quarry. Waypoint 25/26.

Figure 21. Oyster processing yard. Waypoint37.

Figure 22. Oyster farm equipment with streams running onto shore. Waypoint 48.

Figure 23. Easternmost waypoint of oyster cultivation. Waypoint 51.

Figure 24. Upper shore at the western end of cultivation area. Waypoint 58.

Figure 25. Eastern lower tidal boundary of oyster cultivation area. Waypoint 66.

Figure 26. Discharge pipe at caravan site. Waypoint 71.

Figure 27. Plastic corrugated pipe possibly land drain with smell. Waypoint 74A.

Figure 28. Feeder and cows on shore with faecal matter. Waypoint 77.

Figure 29. Stream running past land boundary, two cows on other side of building. Waypoint 91.

Figure 30. PVC pipe running onto shore from oyster shed. Waypoint 95.

Figure 31. Septic tank outside Scottish Sea Farms. Waypoint 98.

Figure 32. NE corner of S8 mussel harvest area. Waypoint 125A.

Figure 33. SW corner of S8 harvest area, looking NE direction. Waypoint 127.

Figure 34. SW corner of S10 harvest area. Waypoint 131.