Scottish Sanitary Survey Report

Sanitary Survey Report
Loch Sunart
HL-206-1237-08
February 2014

Cefas

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

Report Title	Loch Sunart Sanitary Survey Report
Project Name	Scottish Sanitary Survey
Client/Customer	Food Standards Agency Scotland
Cefas Project Reference	C5792C
Document Number	C5792C_2013_13
Revision	V1.0
Date	06/02/2014

Revision History

Revision number	Date	Pages revised	Reason for revision
0.1	6/12/2013	All	Draft for external consultation
1.0	06/02/2014	Title,1,7,10,13,16,32,41,43,44,45,48, Appendix 7	Clarification of sewage discharge section and correction of typographic errors in line with consultation responses

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Partner Organisations

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

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Appendices

I. Executive Summary

Under (EC) Regulation 854/2004, which sets forth specific rules for the organisation of official controls on products of animal origin intended for human consumption, sanitary surveys of production areas and their associated hydrological catchments and coastal waters are required in order to establish the appropriate representative monitoring points (RMPs) for the monitoring programme.

The purpose of the sanitary survey is to demonstrate compliance with the requirements stated in Annex II (Chapter II Paragraph 6) of Regulation (EC) 854/2004. The sanitary survey results in recommendations on the location of RMPs, the frequency of sampling for microbiological monitoring, and the boundaries of the production areas deemed to be represented by the RMPs. A sanitary survey was undertaken on the classified mussel fishery at Loch Sunart on the basis recommended in the European Union Reference Laboratory publication: "Microbiological Monitoring of Bivalve Mollusc Harvesting Area Guide to Good Practice: Technical Application" (http://www.crlcefas.org/gpg.asp). The sanitary survey was by a standard application for classification. As part of the sanitary survey process, a provisional RMP assessment was undertaken in March 2013. The area was subject to a fast-track classification for a four month period ending on 19th November 2013.

Loch Sunart is located in Highland Lochaber on the west coast of Scotland. The loch is generally aligned east to west and is almost 31 km in length. The fishery is located towards the head of the loch and comprises a number of mussel lines. Some of the lines are presently used for spat collection while others are populated with adult mussels.

The main potential sources of contamination are sewage discharges associated with Strontian and other small settlements to the north east of the fishery as well as watercourses located towards the head of the loch. There are also a small number of private discharges and watercourses on the southern shore in the vicinity of the mussel lines but present evidence from classification monitoring and shoreline survey sample results is that these constitute a smaller risk to the fishery.

Particle transport in the loch has been estimated to be in the order of a few hundred metres. Tidal currents will be modified by wind (which tends to flow along the loch) and an estuarine circulation during periods of significant freshwater input. There is evidence of a significant surface freshwater layer after heavy rainfall.

Summary of recommendations

It is recommended that the production area be defined to exclude sources towards the head of the loch and the mouth of Liddesdale Burn. The RMP should be located towards the northeastern extent of the mussel lines in order to reflect contamination coming from the identified sources to the northeast of the fishery. Sampling should be undertaken from near the top of the lines at that point due to the significant freshwater influence at the surface of the loch in the area of the fishery.

II. Sampling Plan

Production Area	Loch Sunart
Site Name	Liddesdale
SIN	HL-206-1237-08
Species	Common mussels
Type of Fishery	Longline
NGR of RMP	NM 7830 6012
East	178300
North	760120
Tolerance (m)	40
Depth (m)	≤1
Method of Sampling	Hand
Frequency of Sampling	Monthly
Local Authority	Highland Council: Lochaber
Authorised Sampler(s)	Stephen Lewis
Local Authority Liaison Officer	Alan Yates
Production area boundaries	The area bounded by lines drawn from NM 7761 6060 to NM 7739 5999 to NM 7808 5981 and from NM 7886 6112 to NM 7869 5979 and extending to MHWS between NM 7761 6060 and NM 7886 6112 and between NM 7808 5981 and NM 7869 5979.

III. Report

1. General Description

Loch Sunart is a sea loch on the west coast of Scotland, within the Lochaber district of the Highland Council. The loch forms a boundary between the Morvern and Ardnamurchan peninsulas. A map showing the location of Loch Sunart is presented in Figure 1.1.

The loch is generally aligned east to west and opens to the Sound of Mull. It is almost 31 km in length and has a maximum depth of 124 m.

The surrounding area is sparsely inhabited. The nearest settlement is Strontian on the north shore which has an approximate population of 350.

This survey is being undertaken on the common mussel fishery at Loch Sunart on the basis recommended in the European Union Reference Laboratory publication: “Microbiological Monitoring of Bivalve Mollusc Harvesting Area Guide to Good Practice: Technical Application” (http://www.crlcefas.org/gpg.asp). This production area was a newly identified fishery that had been subject to a provisional Representative Monitoring Point (pRMP) assessment in March 2013 and was thus scheduled for a more extensive assessment and report under the Scottish sanitary survey programme.

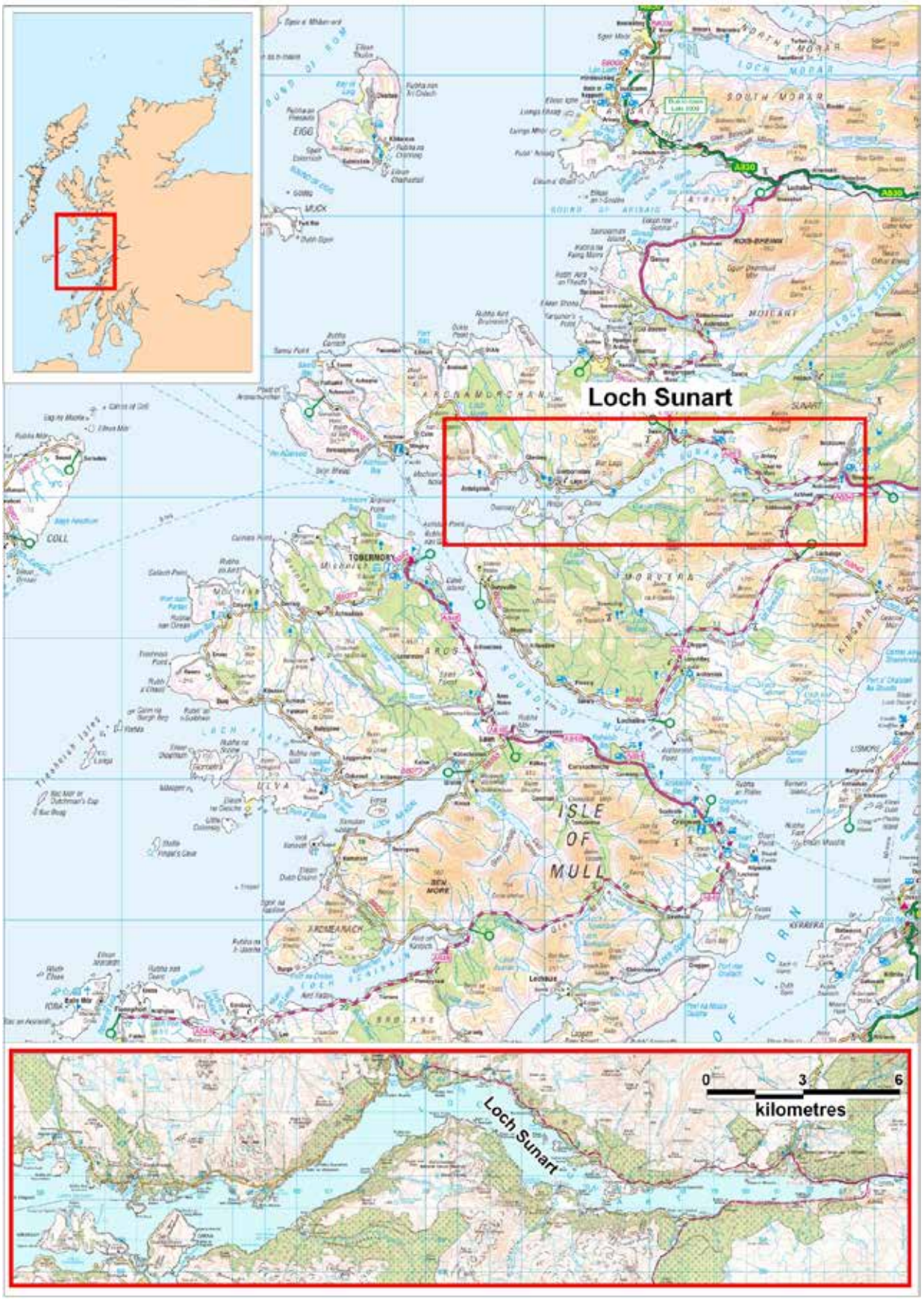

Figure 1.1 Location of Loch Sunart

2. Fishery

The present fishery at Loch Sunart is a common mussel (*Mytilus edulis*) farm which was the subject of an application for classification in early 2013. Details of the site are presented in Table 2.1.

Table 2.1 Area shellfish farms

Production area	Site	SIN	Species
Loch Sunart	Liddesdale	HL-206-1237-08	Common mussels

The area was subject to a pRMP assessment in March 2013 and this recommended the production area boundaries and pRMP as:

Production area - within lines drawn between NM 7761 6060, NM 7739 5999, NM 7808 5981, NM 7886 6112 and NM 7869 5979 extending to MHWS.

pRMP - NM 7842 6016

In the meantime, the area was awarded a Fast Track classification for a period of four months. This expired on 19th November 2013.

At the time of the shoreline survey there were six 300 m longlines. The three northern lines contained short, ladder-style droppers for the collection of spat. The three southern lines had conventional droppers of an unknown length with mature stock present, although stock density diminished greatly after 2-3 meters.

The fishery location recorded during the shoreline survey is plotted in Figure 2.1, together with the seabed lease areas and the production area and pRMP location recommended as a result of the pRMP assessment. There are two current seabed leases in the area as seen in the data provided by Scottish Government, with one totally enclosed within the other (the former appears as an outline area in Figure 2.1). The smaller area is that identified to FSA and Cefas at the time of the initial application for classification.

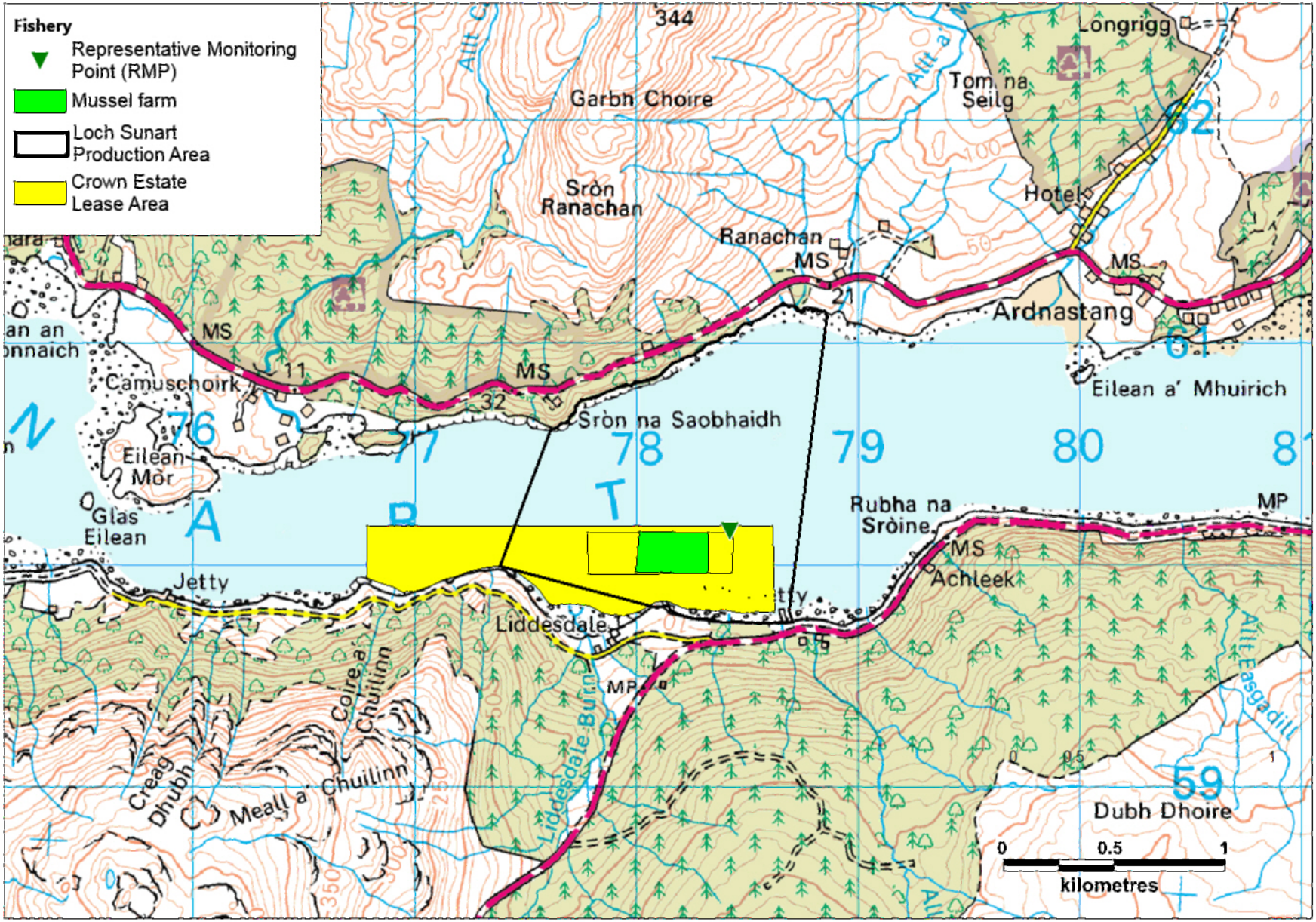

Figure 2.1 Loch Sunart fishery area

3. Human Population

Information was obtained from the General Register Office for Scotland on the population within the census output areas in the vicinity of Loch Sunart. The last census was undertaken in 2011. The census output areas surrounding Loch Sunart are shown in Figure 3.1, thematically mapped by the 2011 population densities. The figure shows that the overall population density for the census output areas surrounding Loch Sunart is low.

The small settlement of Strontian is located on the northeastern coastline of the loch. The census output area S0081703 central to Strontian has a population count of 61. However, as the village extends beyond this area, this is not a representative total population count of the settlement. An estimate of approximately 350 has been given for the village (http://www.ardnamurchan.highland.sch.uk/prospectus/catchment.htm; accessed 27/11/13) although the Highland Council population estimate for 2007 was 246 (http://www.highland.gov.uk/NR/rdonlyres/BE0F6BF4-8A8F-4ECC-8F3C-ED4B84022498/0/Strontian.pdf; accessed 27/11/13). The majority of the Strontian dwellings are located on the A road heading north with some located on the coastline. The village has both a primary school (42 pupils) and a high school (115 pupils). A slipway, moorings and boat facility were observed west of Strontian during the shoreline survey. There is a significant amount of tourist accommodation in and around Strontian, including 3 hotels and at least 14 self catering units. A small campsite at Strontian has toilet facilities, both caravan and tent pitches, and an additional self catering unit for six people. West of Strontian there is a further jetty and moorings.

To the west of Strontian lie the very small settlements of Ardnastang and Ranachan. The latter lies just over 1 km to the north-northeast of the mussel farm.

On the southern shoreline, a jetty, slipway and moorings/anchorage lie close to the fishery. Another slipway lies farther west of the fishery. A road runs parallel along the coastline of the loch. There are no settlements on the south shoreline however a few dwellings were observed near to the fishery during the shoreline survey. The Keepers Cottage is holiday accommodation at Liddesdale. One of the Loch Sunart Aquaculture Framework Plan (2004) objectives is to safeguard key tourism and recreation access to the loch. This indicates tourism is important in the area and this is reflected by the amount of tourist accommodation near Strontian. Visitor numbers to the area are expected to peak during the summer months.

The Clyde Cruising Club publication for Kintyre to Ardmurchan (2007) identifies an anchorage east of the shoal at the entrance to River Strontian.

Overall, dependant on the direction of flow in the loch, impacts from human sources to the water quality of the shellfish bed are likely to be low due to the low population density of the area and the distance between the village of Strontian and the fishery.

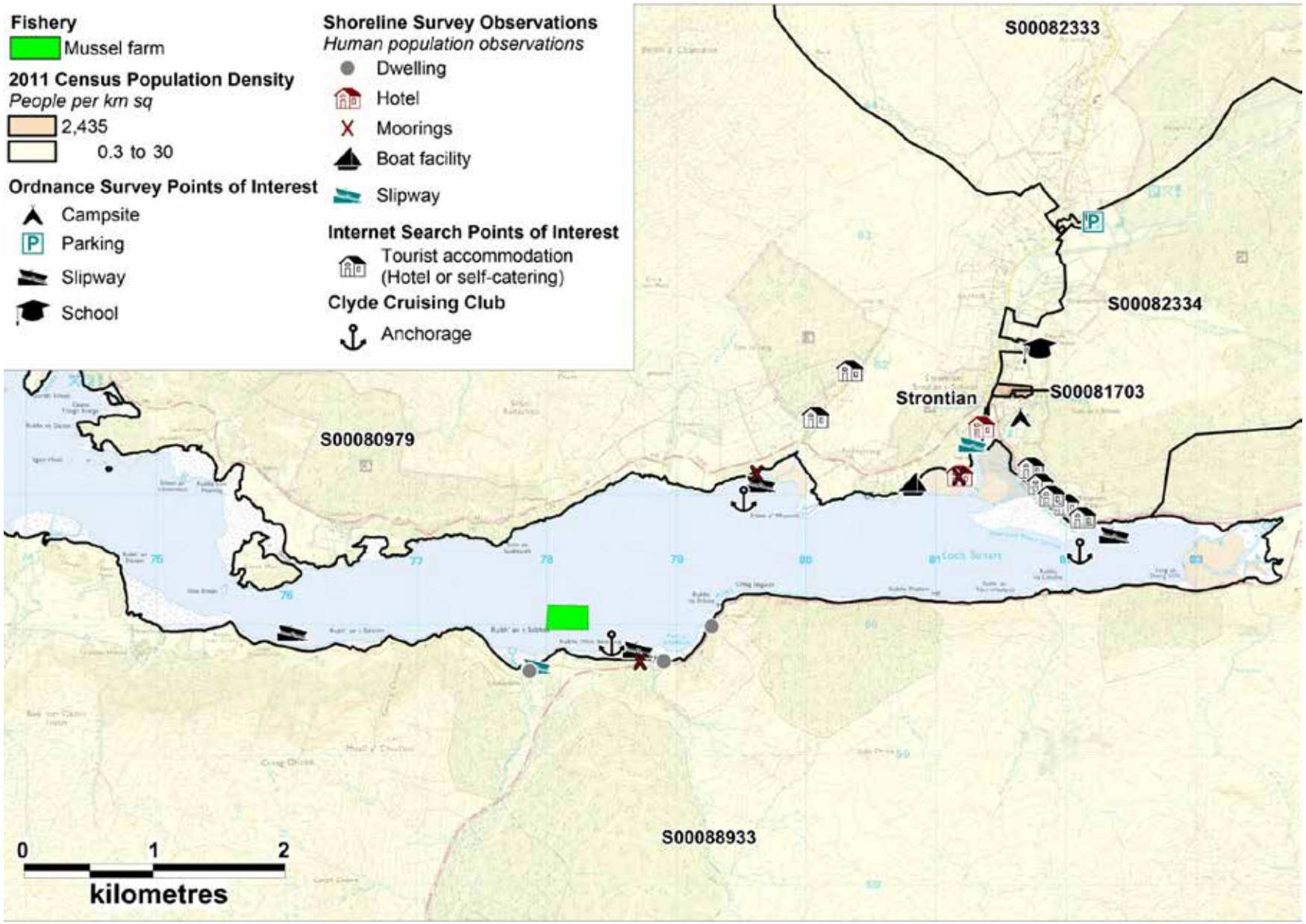

Figure 3.1 Population map for the area in the vicinity of Loch Sunart

4. Sewage Discharges

Information on sewage discharges for an area of radius 10 km around point NM 7810 6000 was sought from Scottish Water and the Scottish Environment Protection Agency (SEPA). Data requested included the name, location, type, size (in either flow or population equivalent), level of treatment, sanitary or bacteriological data, spill frequency, discharge destination (to land, to waterbody or to sea), any available dispersion or dilution modelling studies, and whether improvements were in work or planned.

4.1 Scottish Water Discharges

Scottish Water provided information of five discharges within the area requested. These are shown in Table 4.1 below:

Table 4.1 Scottish Water discharges

Licence Number	Site Name	NGR	Discharge Type	Treatment Level	DWF (m^3/d)	DPE
CAR/L/1002906	Strontian Main SEP	NM 8130 6092	FE	Septic Tank	228.7	945
WPC/N/60503	Strontian SPS 2010	NM 8130 6092	EO	6mm screen	-	-
WPC/N/60502	Strontian CSO 2010	NM 8130 6092	CSO	6mm screen	228.7	945
-	Strontian WWPS 1 CSO	NM 816 612	CSO	-	-	-
WPC/N/51739	Strontian WWPS	NM 816 612	EO	-	-	-

FE = Final Effluent, EO = Emergency Overflow, CSO = Combined Sewer Overflow - No Data Given DWF = Dry Weather Flow, DPE = Design Population Equivalent; NGR = National Grid Reference

The discharges comprised: one community septic tank outfall CAR/L/1002906, two combined sewer overflows and two emergency overflows. No spill information was provided.

4.2 SEPA Discharge Consents

SEPA provided information on a large number of consents within the requested area. The full data set is given in Appendix 6. A subset of the data was selected on the basis of discharges located on or near the shore of Loch Sunart or on or near the watercourses that enter Loch Sunart. These are listed in Table 4.2, together with consented discharge locations for marine fish farms. Site information is not given for private premises.

Table 4.2 SEPA discharge consents in the Loch Sunart catchment

Licence No.	NGR	Discharge Type	Site Description	Receiving Body	PE DWF (m^3/d)
CAR/L/1002906	NM 81300 60920	Sewage (Public) Primary	Strontian STW, FE to Loch Sunart	Loch Sunart	945 228.29
CAR/L/1002907	NM 81263 60785	Sewage (Public) CSO	Strontian STW, CSO to Loch Sunart	Loch Sunart	-
WPC/N/62503	NM 813 609	Sewage (Public) (EO)	Strontian WWPS	Loch Sunart	-
WPC/N/51739	NM 816 612	Sewage (Public) EO	Strontian WWPS	Loch Sunart	-
CAR/R/1032261	NM 81900 63830	Sewage (Private) Primary	*	Land	25
CAR/R/1109960	NM 79240 60020	Sewage (Private) Primary	*	Soakaway	20
CAR/R/1109961	NM 83306 60294	Sewage (Private) Primary	*	Soakaway	20
CAR/R/1109959	NM 78128 59447	Sewage (Private) Primary	*	Soakaway	20
CAR/R/1109956	NM 74835 59794	Sewage (Private) Primary	*	Soakaway	20
CAR/R/1109955	NM 74829 59789	Sewage (Private) Primary	*	Soakaway	20
CAR/R/1109954	NM 74919 59874	Sewage (Private) Primary	*	Soakaway	20
CAR/R/1114455	NM 81430 61870	Sewage (Private) Primary	*	Strontian River	5
CAR/R/1109958	NM 78770 59690	Sewage (Private) Primary	*	Soakaway	20
CAR/R/1039893	NM 75428 61391	Sewage (Private) Primary	*	Allt Arg Airgh	15
CAR/R/1027229	NM 84730 60700	Sewage (Private) Primary	*	Soakaway	15
CAR/R/1026506	NM 83080 65240	Sewage (Private) Primary	*	Soakaway	15
CAR/R/1037130	NM 83080 65250	Sewage (Private) Primary	*	Soakaway	12
CAR/R/1107817	NM 81430 61870	Sewage (Private) Primary	*	River Strontian	10
CAR/R/1106112	NM 72430 63870	Sewage (Private) Primary	*	Soakaway	10
CAR/R/1101773	NM 81440 61980	Sewage (Private) Primary	*	River Strontian	10
CAR/R/1037546	NM 82081 64011	Sewage (Private) Primary	*	Soakaway	10
CAR/R/1019030	NM 79980 61505	Sewage (Private) Secondary	*	Soakaway	10
CAR/R/1097628	NM 80450 61200	Sewage (Private) Secondary	*	Soakaway	8
CAR/R/1077214	NM 71800 64040	Sewage (Private) Primary	*	Soakaway	8
CAR/R/1039462	NM 75400 61390	Sewage (Private) Primary	*	Allt Ard Airigh	8
CAR/R/1010431	NM 82119 64218	Sewage (Private) Secondary	*	U/T of Allt na Meinne	8
CAR/R/1064972	NM 71630 64060	Sewage (Private) Primary	*	Soakaway	7
CAR/R/1105319	NM 82130 63280	Sewage (Private) Primary	*	Soakaway	6
CAR/R/1095473	NM 79970 61340	Sewage (Private) Primary	*	Soakaway	6
CAR/R/1086098	NM 71770 64080	Sewage (Private) Primary	*	Soakaway	6
CAR/R/1040042	NM 77670 60690	Sewage (Private) Primary	*	Soakaway	6
CAR/R/1036241	NM 81650 61200	Sewage (Private) Primary	*	U/N W/C	6
CAR/R/1022832	NM 72517 63853	Sewage (Private) Primary	*	Soakaway	6
CAR/R/1020944	NM 82086 61021	Sewage (Private) Primary	*	Soakaway	6

Licence No.	NGR	Discharge Type	Site Description	Receiving Body	PE DWF (m^3/d)
CAR/R/1011402	NM 81241 61460	Sewage (Private) Secondary	*	River Strontian	6
CAR/R/1114115	NM 81950 63970	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1094687	NM 73530 62990	Sewage (Private) Primary	*	Allt Eachain	5
CAR/R/1092397	NM 81961 62535	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1087622	NM 79590 61270	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1087459	NM 71590 64062	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1083264	NM 80022 61488	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1064979	NM 72070 63940	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1048198	NM 81770 62349	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1045836	NM 81420 62200	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1042469	NM 81983 63433	Sewage (Private) Primary	*	Allt na Meinne	5
CAR/R/1041484	NM 82002 63110	Sewage (Private) Primary	*	Allt na Meinne	5
CAR/R/1041170	NM 72614 63808	Sewage (Private) Primary	*	Loch Sunart	5
CAR/R/1040102	NM 82080 64173	Sewage (Private) Primary	*	U/N W/C	5
CAR/R/1040101	NM 81973 63197	Sewage (Private) Primary	*	Allt na Meinne	5
CAR/R/1039748	NM 82190 63960	Sewage (Private) Primary	*	Allt na Meinne	5
CAR/R/1039744	NM 81428 62156	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1039722	NM 80870 61337	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1039573	NM 81450 62250	Sewage (Private) Primary	*	River Strontian	5
CAR/R/1039541	NM 81763 62882	Sewage (Private) Primary	*	U/T of Strontian River	5
CAR/R/1039485	NM 81407 62433	Sewage (Private) Primary	*	U/T of Strontian River	5
CAR/R/1039476	NM 81378 62327	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1039469	NM 80118 61200	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1039422	NM 76263 60774	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1039333	NM 81428 62446	Sewage (Private) Primary	*	U/T of Strontian River	5
CAR/R/1039283	NM 82106 64159	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1038519	NM 80260 61200	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1038295	NM 82130 63625	Sewage (Private) Primary	*	Allt na Meinne	5
CAR/R/1038292	NM 82011 63663	Sewage (Private) Primary	*	Allt na Meinne	5
CAR/R/1038148	NM 82292 64400	Sewage (Private) Primary	*	Allt na Meinne	5
CAR/R/1037591	NM 81906 63407	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1037461	NM 81440 62110	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1037434	NM 81510 62720	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1037215	NM 82107 63818	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1037154	NM 81926 63273	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1037060	NM 72433 63871	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1030526	NM 76376 60747	Sewage (Private) Primary	*	Allt Camas a Choirce	5

Licence No.	NGR	Discharge Type	Site Description	Receiving Body	PE DWF (m^3/d)
CAR/R/1028694	NM 85290 60430	Sewage (Private) Primary	*	Soakaway	5
CAR/R/1027305	NM 75650 61229	Sewage (Private) Primary	*	Loch Sunart	5
CAR/R/1026500	NM 83087 65225	Sewage (Private) Primary	*	Allt na Meinne	5
CAR/R/1016462	NM 81906 63009	Sewage (Private) Primary	*	Allt Nan Cailleach	5
CAR/R/1014971	NM 82155 63740	Sewage (Private) Primary	*	Allt na Meinne	5
CAR/R/1009156	NM 72528 63839	Sewage (Private) Secondary	*	U/N W/C	5
CAR/R/1106786	NM 81320 61790	Sewage (Private) Primary	*	River Strontian	5
CAR/R/1015871	NM 80009 61401	Fish Farm Hatchery	*	Bun an Uillt	-
CAR/L/1009162	NM 73221 60896	Marine Cage Fish Farm	Camas na h-Airbhe MCFF, Loch Sunart	-	-

- No data provided; * Site information not included; PE= Population Equivalent; DWF=Dry Weather Flow; MCFF=Marine Cage Fish Farm; NGR = National Grid Reference

SEPA provided information on four public sewage discharges: CAR/L/1002906, WPC/N/62503, WPC/N/51739 which all corroborate with the information provided by Scottish Water and CAR/L/1002907 which describes a CSO plotting about 150 m south of CAR/L/1002906.

CAR/L/1002906, WPC/N/60502 and WPC/N/60503 all share the same outfall location at the mouth of Strontain River. CAR/L/1002906 has a PE of 945 and a dry weather flow of 228.7 m^3/d.

SEPA also provided information on 76 consents for private discharges to Loch Sunart and adjacent watercourses. These included one marine cage fish farm and one fish farm hatchery. Of the 74 private sewage discharge consents, 68 were for septic tanks and six for secondary treated sewage treatment works.

Of the private discharges, 27 are reported as discharging to watercourses. Two are reported as discharging to Loch Sunart and 45 recorded as discharging to soakaway. However it has been noted previously by SEPA that many consents originally registered as discharging to land may actually discharge to watercourses or sea.

The majority of private discharge consents are located on the northern side of the loch, mainly along Strontian River and Allt na Meinne. Comparatively few discharges are located along the southern shore of the loch or the head of the loch.

Shoreline Survey Discharge Observations

One observation of sewage infrastructure was noted during the shoreline survey. This is listed in Table 4.3.

Table 4.3 Discharge-associated observations made during the shoreline survey

No.	Date	Associated Photograph (Appendix 5)	Description
1	03/09/2013	Fig 18	Septic tank outfall possibly directly into Allt Ard nan Staing, noted while walking along main A861 road back to start point.

Observation 1 reported a domestic septic tank with a pipe running into a watercourse. There appear to be electrical cables going to the unit suggesting that this may be a package sewage treatment works. The watercourse receiving the effluent was identified as Allt Ard na Staing by local signage, but is named as Bun an Uillt on Ordnance Survey maps. This watercourse enters the loch at Ardnastang on the northern shore.

The shoreline survey also identified a public toilet in the village of Strontian. No further information on discharge arrangements for these toilets was available.

A map showing reported discharge locations and shoreline survey observations are presented in Figure 4.1.

Summary

The majority of sewage discharge consents are to the Strontian River valley and the north shore of Loch Sunart. The largest input of sewage to the Loch comes from the community septic tank, CAR/L/1002906, which discharges at the mouth of the Strontian River. The presence of combined sewer overflows means that on occasions of significant rainfall these will activate discharging untreated sewage mixed with surface water.

There are a small number of consented discharges in the near vicinity of the fishery: two of these were noted to be consented to discharge to soakaway while the receiving body of the other was not given. General information from SEPA indicates that discharges originally identified as going to soakaway may subsequently be modified and then discharge direct to watercourses or the marine environment. If so, they would comprise a source of contamination at the mussel farm.

List of Acronyms

MDF	Mean daily flow
DPE	Population Equivalent
WWTW	Wastewater Treatment Work
DWF	Dry weather flow
ST	Septic Tank
CSO	Combined Sewer Overflow

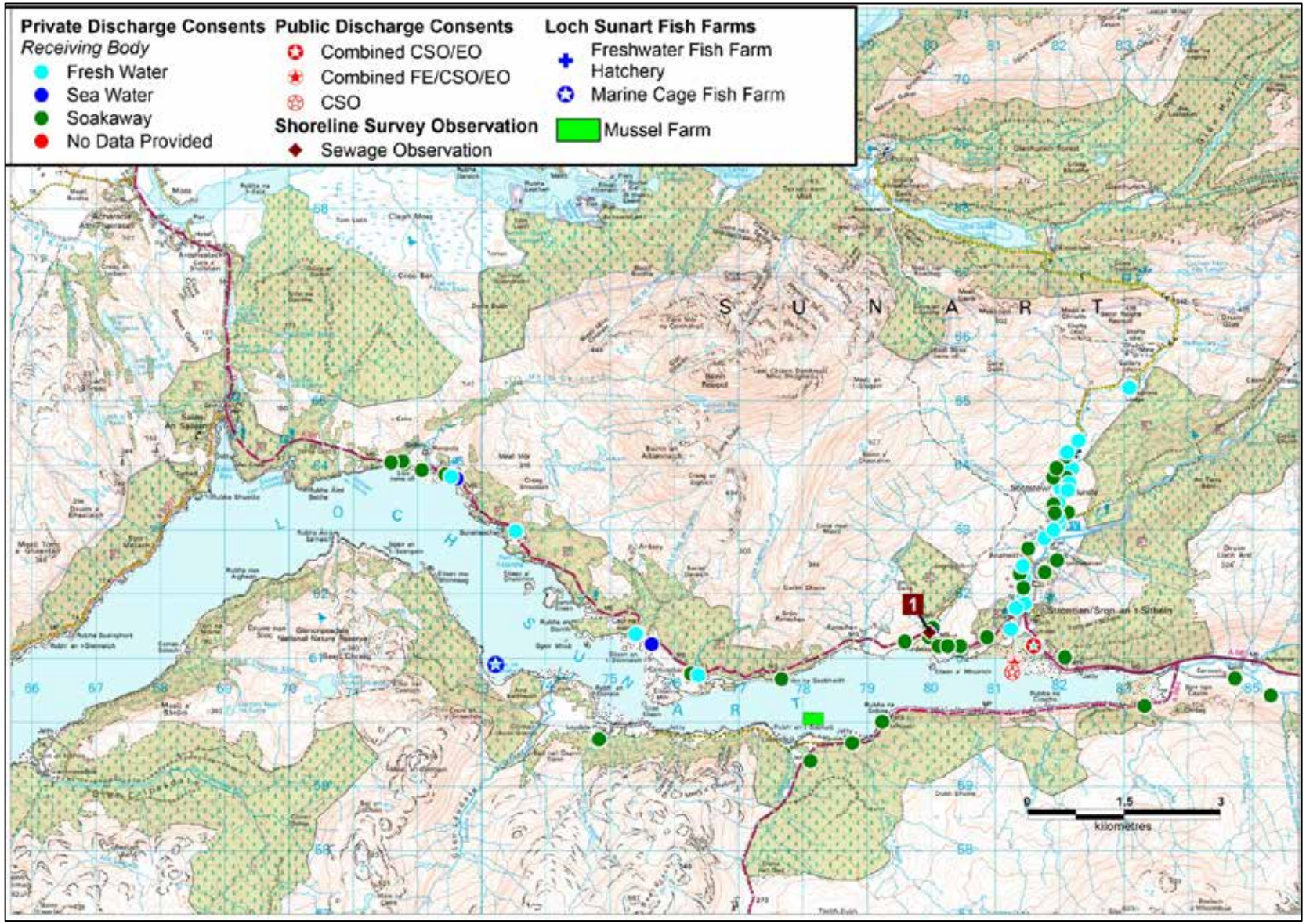

Figure 4.1 Map of discharges for Loch Sunart

5. Agriculture

Information on the spatial distribution of animals on land adjacent to or near the fishery can provide an indication of the potential amount of organic pollution from livestock entering the shellfish production area. Agricultural census data to parish level was requested from the Scottish Government Rural Environment, Research and Analysis Directorate (RERAD) for the Ardnamurchan and Morvern parishes. Reported livestock populations for the parishes in 2012 are listed in Table 5.1. RERAD withheld data for reasons of confidentiality where the small number of holdings reporting would have made it possible to discern individual farm data. Any entries which relate to less than five holdings, or where two or fewer holdings account for 85% or more of the information, are replaced with an asterisk.

Table 5.1 Livestock numbers in the Ardnamurchan and Morvern agricultural parishes 2012

	Ardnamurchan		**Morvern**	
	457 km^2		370 km^2	
	Holdings	Numbers	Holdings	Numbers
Pigs	10	39	*	*
Poultry	29	483	*	*
Cattle	33	786	8	726
Sheep	49	8623	12	7383
Other horses and ponies	12	21	*	*

The livestock census numbers relate to very large parish areas, therefore it is not possible to determine the spatial distribution of the livestock in relation to the Loch Sunart area or identify how many animals are likely to impact the catchment around the fishery. Therefore the figures are of little use in assessing the potential impact of livestock contamination to the fishery; however they do give an idea of the total numbers of livestock over the broader area. Sheep are the dominant livestock in both parishes with cattle also present in smaller numbers. In the southern parish (Morvern) the number of pigs, poultry and horses were not reported due to the small number of holdings. In the northern parish (Ardnamurchan) pigs, poultry and other horses and ponies are present in small numbers.

A source of spatially relevant information on livestock population in the area was the shoreline survey (see Appendix 5) which only relates to the time of the site visit on the 2nd September 2013. Observations made during the survey are dependent upon the viewpoint of the observer some animals may have been obscured by the terrain. The spatial distribution of animals observed and noted during the shoreline survey is illustrated in Figure 5.1.

During the shoreline survey only 2 sheep were observed grazing on the southern shoreline east of the fishery. Sheep droppings were observed on shoreline almost directly south of the fishery, indicating that sheep do roam in this area and have access

to the shoreline. The Ordnance Survey map identifies a sheepfold on either side of the loch approximately 4 km west of the fishery: it is not known whether these are still in use.

Numbers of sheep will be approximately double during late spring following the birth of lambs, and decrease again in the autumn when they are sent to market.

Any contributions of faecal contamination from livestock grazing in the area would be most likely to affect the areas of shellfish bed closest to the shoreline. Although few livestock were present during the survey, the sheep observed were in close range of the fishery and any impact would be greatest on the southern side of the farm: however, the distribution of animals around the area may change with time.

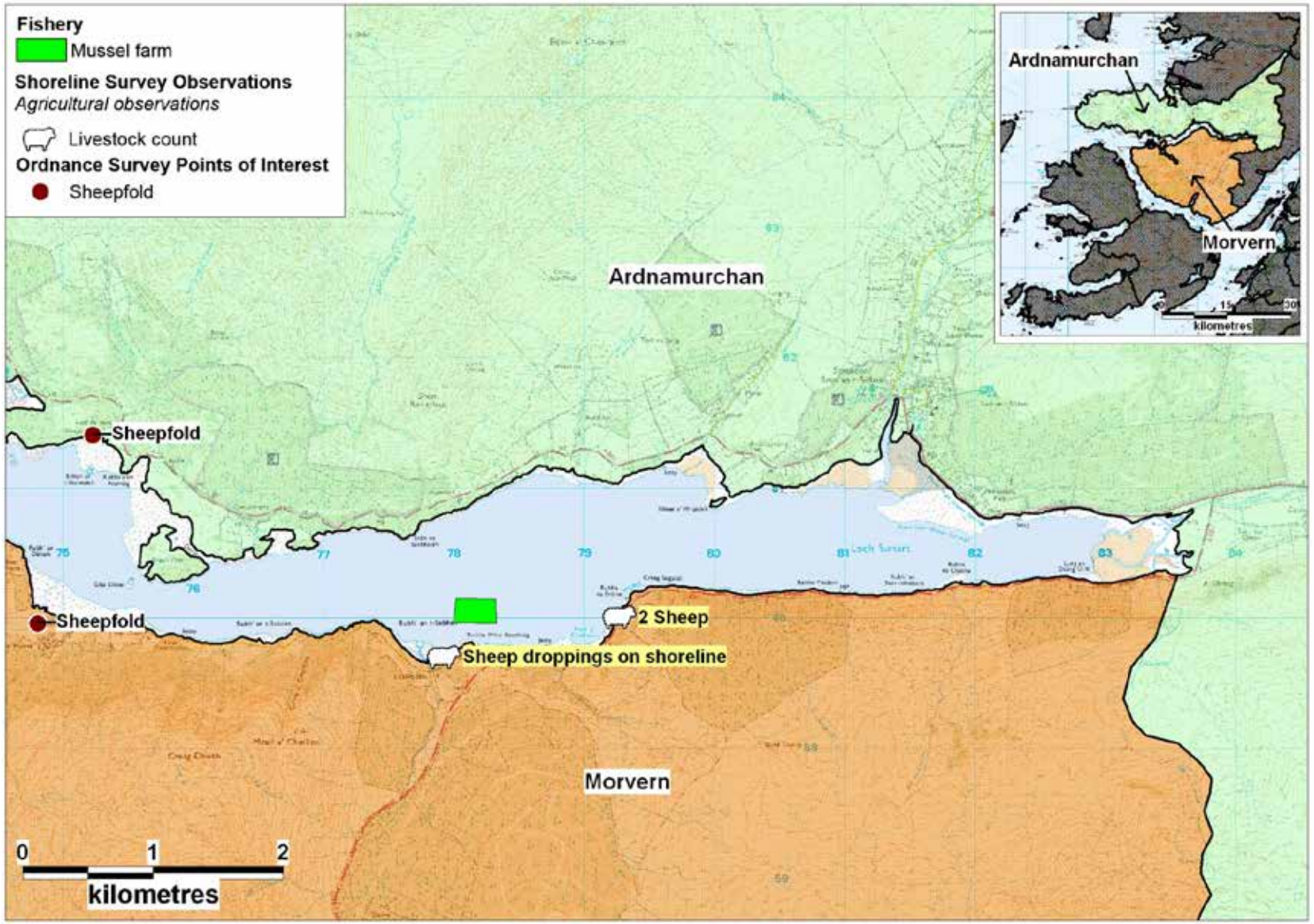

Figure 5.1 Livestock observations at Loch Sunart

6. Wildlife

Wildlife species present in and around the production area will contribute to background levels of faecal contamination at the fishery, and large concentrations of animals may constitute significant sources when they are present. Seals, cetaceans and some seabirds may deposit faeces directly into the sea, while birds and mammals present on land will contribute a proportion of any faecal indicator loading carried in diffuse run-off or watercourses.

The species most likely to contribute to faecal indicator levels at the Loch Sunart common mussel fishery are considered below.

Seals

In a report by Special Committee on Seals (2012), it was noted that through aerial studies, 10-100 harbour seals and 10-20 grey seals were frequently observed within Loch Sunart. It also highlighted that larger numbers of both species of seals were also often observed in the immediate waters surrounding the loch. Anecdotal accounts from a wildlife viewing hut approximately 4.5 km northwest of the fishery report a common seal haul out site on the small island of Garbh Eilean and also highlights seals are frequently observed on the nearby island of Eilean a'Chuilinn (Sunart Oakwoods, 2013).

No seals were observed during the shoreline survey.

Cetaceans

The west coast of Scotland is recognised as being an important area for cetaceans (whales and dolphins). There are reports of small cetaceans using Loch Sunart; eight pilot whales were observed in 2010, whilst in 2013 there have already been four separate sightings of harbour porpoises, totalling 11 animals (Hebridean Whale and Dophin Trust, 2013). It is likely that smaller whales and dolphins will be present in the loch and at times may pose a potential contamination risk to the fishery. No cetaceans were observed during the shoreline survey.

Birds

Seabird 2000 census data (Mitchell, et al., 2004) for the area within a 5 km radius of Loch Sunart was obtained and is summarised in Table 6.1. This census, undertaken between 1998 and 2002 covered twenty five species of seabird that breed regularly in Britain and Ireland.

Table 6.1 Seabird counts within 5 km of the Loch Sunart

Common name	Species	Count*	Method
European herring gull	*Larus argentatus*	2	Occupied nests

*The count has been adjusted where the method used was occupied nests to reflect the probable number of individual birds (i.e. counts of nests were doubled).

Only one count was available from the Seabird 2000 data; a single European herring gull nest, 4.5 km NW of the fishery at Garbh Eilean. There is also a report of a heronry (heron breeding/roosting area) on the small island Eilean a'Chuilinn nearby (Resipole Farm, 2010). In a report by Scottish Natural Heritage, there were reports of populations of Arctic terns and other gull species on these islands and land within Loch Sunart (Scottish Natural Heritage, 2006).

Deer

Three deer species are found around Loch Sunart: Red, Roe and Sika deer (Ardnamurchan Chalet, 2013). Red deer are likely to be found on high ground during summer months, but will come down to land around sea level during the cold winter months. Comparatively, Roe deer are most commonly found around woodland areas. One red stag was observed grazing along the southern shoreline during the survey, approximately <300 m from the southern extent of the fishery.

Otters

Loch Sunart is recognised as a special conservation area (SAC) for the Eurasian otter (*Lutra lutra*). A JNCC report identified 1400 otter holts in the area suggesting a significant number of otters around the loch (Joint Nature Conservation Committee, 2013). Holts are mostly found in dense vegetation areas, with otters also likely to use the kelp/wrack forests to forage for food (Joint Nature Conservation Committee, 2013). Coastal otters will also use the large number of watercourses discharging to Loch Sunart for washing and latrines. During the shoreline survey one otter was observed to the northeast of the loch.

Overall

Species potentially impacting on Loch Sunart include seals, birds, deer, and otters. There may also be a small contribution from smaller whales and dolphins. Any contamination arising from the identified animals is likely to be intermittent and sporadic across the fishery.

The locations of any significant observations of wildlife around the fishery area are shown in Figure 6.1.

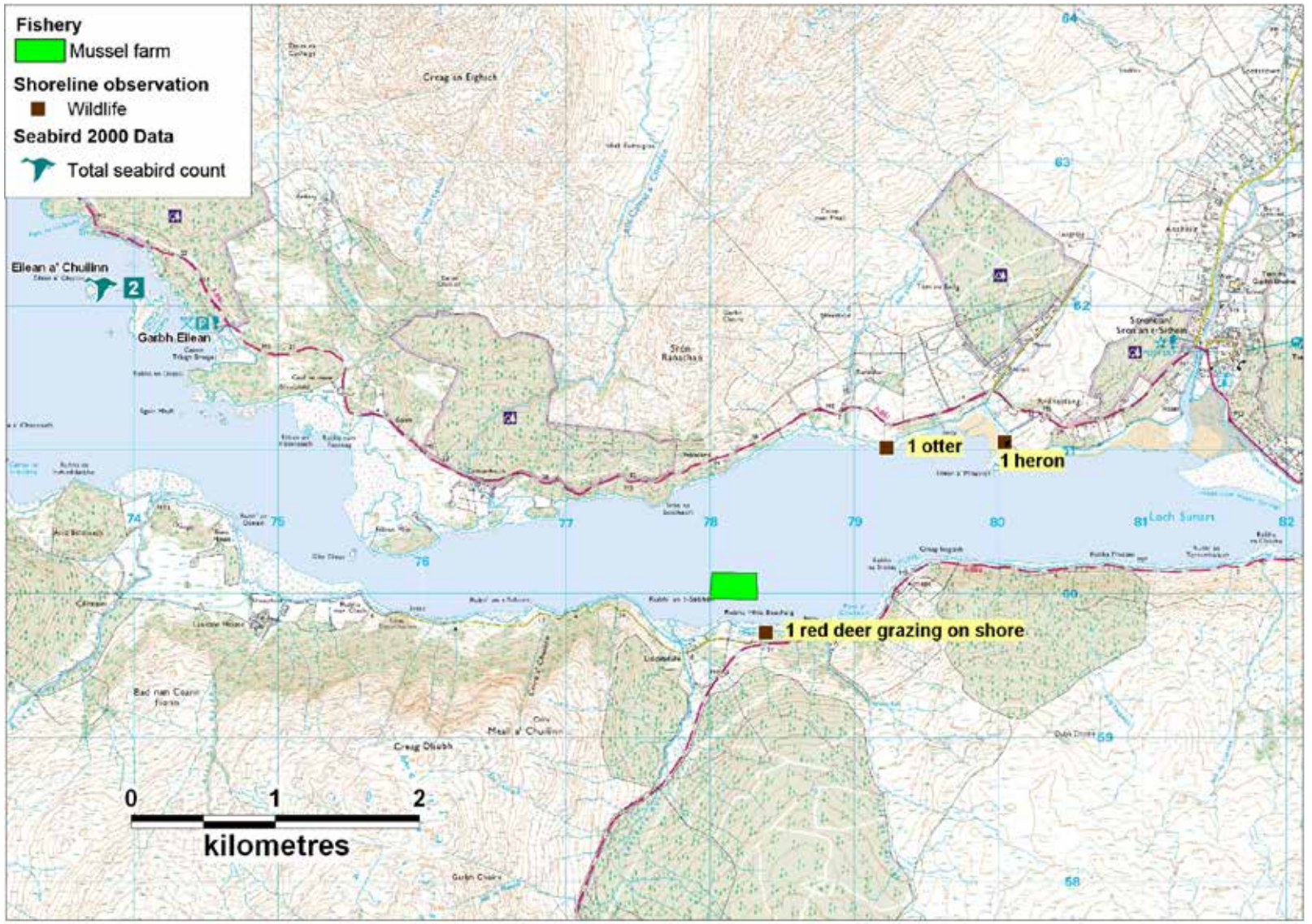

Figure 6.1 Map of wildlife around Loch Sunart

7. Land Cover

The Land Cover Map 2007 data for the area is shown in Figure 7.1 below:

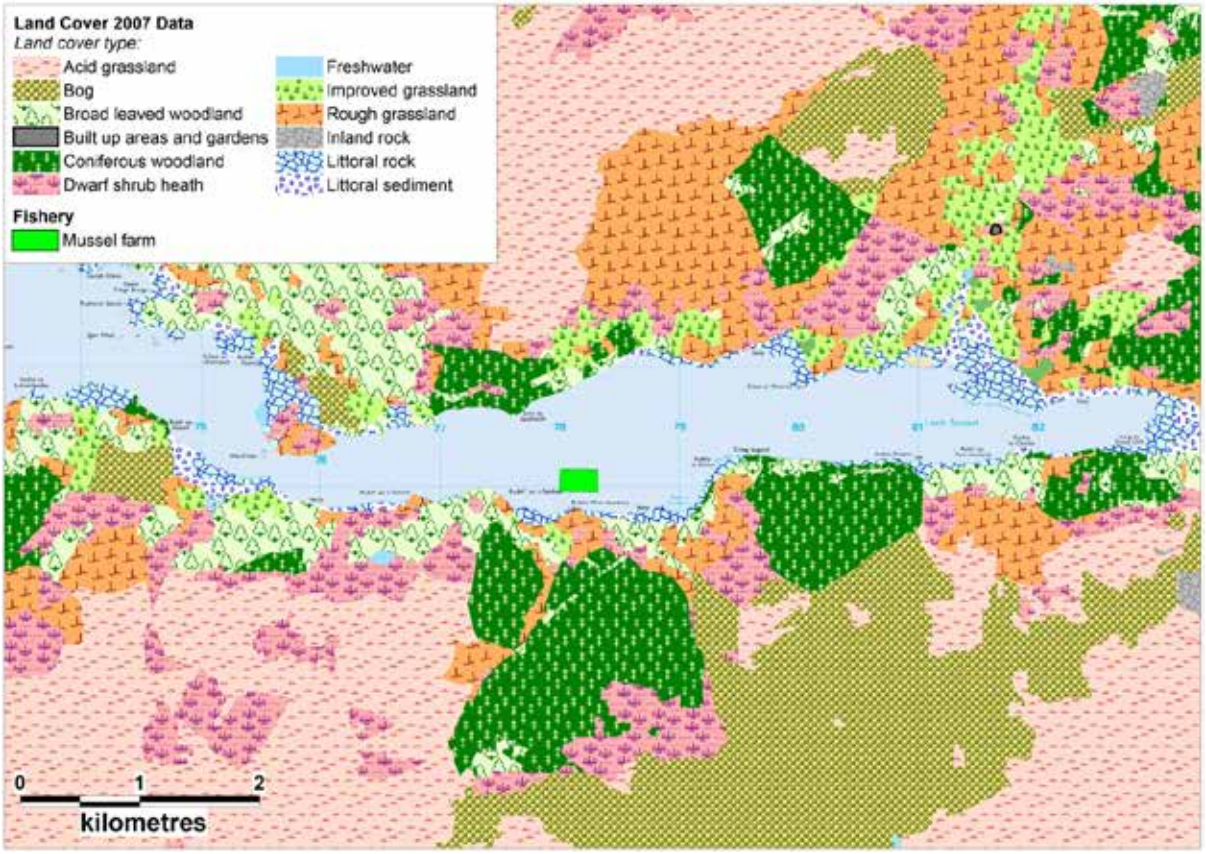

Figure 7.1 LCM2007 land cover data for the area around Loch Sunart

Acid grassland, bog, coniferous woodland, and rough grassland are the predominant land cover types on the shoreline surrounding the Loch Sunart fishery. There are small areas of improved grassland on the south west and north shorelines, and along the Strontian River. The settlement of Strontian is represented by two very small zones identified as built up areas and gardens. This is not representative of the entire village as it covers a much larger area stretching down to the shoreline as discussed in the Human Population section of this report.

Faecal indicator organism export coefficients for faecal coliform bacteria have been found to be approximately 1.2 – 2.8×10^9 cfu/km^2/hr for urban catchment areas, 8.3×10^8 cfu/km^2/hr for areas of improved grassland and approximately 2.5×10^8 cfu/km^2/hr for rough grazing (Kay, et al., 2008). The contributions from all land cover types would be expected to increase significantly after rainfall events, however this effect would be particularly marked from improved grassland areas (roughly 1000-fold) (Kay, et al., 2008).

The highest potential contribution of contaminated run-off to upper Loch Sunart is from the built-up area around Strontian followed by the areas of improved grassland

located along the south western and northern shorelines. However, the improved grassland is closer to the fishery than is Strontian.

8. Watercourses

There are no gauging stations on watercourses entering into Loch Sunart. A number of small hydro-electric schemes are in-place on watercourses entering into Loch Sunart:

- Ranachan Croft hydro power. The reported location of the intake weir is NM 793 623, just north of Allt a Mhuilinn. The reported mean flow is 0.14 m^3/s (12100 m3/day).
- RWE Scheme on the River Carnoch.
- Allt Eachain hydro (which lies to the west of the area considered in this report)

Spot measurements of flow and microbial content were obtained during the shoreline survey conducted on the 2rd and 3rd September 2013. Light rain fell on both survey days, with heavy rainfall also recorded in the 24 hrs prior to the survey. The watercourses listed in Table 8.1 are noted to be the most significant freshwater inputs to the area around the fishery in upper Loch Sunart.

There were an additional 10 sites of land drainage observed during the survey, but flow was no sufficient to measure. The majority (8) were noted along the northern shoreline, with two on the south shoreline. No flow information was obtained from Carnoch River to the east of the survey area at the time of the survey, though it is expected to contribute significantly to freshwater input and may also represent a contamination source to Loch Sunart.

Table 8.1 Watercourses entering Loch Sunart

No.	NGR	Description	Width (m)	Depth (m)	Flow (m^3/d)	Loading (*E. coli* per day)
1	NM 7883 5972	Allt na h'Airigh	5.00	0.62	42000	$3.7x10^{10}$
2	NM 7787 5966	Unnamed watercourse	0.90	0.13	430	$1.74x10^{8}$
3	NM 7782 5959	Liddesdale Burn	5.00	0.18	49000	$2.5x10^{10}$
4	NM 8135 6153	Unnamed watercourse	0.60	0.21	1400	$2.8x10^{8}$
5	NM 8129 6140	Strontian River	15.00*	0.80	84000	$2.9x10^{11}$
6	NM 7991 6131	Bun an Uillt	2.10	0.18	33200	$1.6x10^{11}$
7	NM 7899 6108	Unnamed watercourse	0.90	0.04	1350	$3.5x10^{9}$
8	NM 7891 6113	Allt a'Mhuilinn	7.00	0.27	35000	$1.0x10^{10}$

*This is a visual estimate of the width as the watercourse was deemed unsafe to get an accurate measurement of width. Verification via satellite maps and OS maps were not possible.

There are a number of watercourses with significant flows entering into Loch Sunart; Strontian River, Liddesdale Burn and Allt na h'Airigh. The majority of freshwater inputs enter from the northern shoreline, where the majority of land drainage areas

were also seen between Strontian and Ardnastang. The highest calculated loadings were from the Strontian River and Bun an Uillt (north).

Five watercourses enter Loch Sunart within <1 km of the mussel farm. Loadings from these watercourses varied between low levels ($1.7x10^8$ *E. coli* per day) to moderate levels ($3.7x10^{10}$ *E. coli* per day) of contamination. It is expected that contamination from Liddesdale Burn and the unnamed watercourse (number 2) will have a significant impact on the southwestern extent of the fishery. Contamination from Allt na h'Airigh may also be a significant source to the southeast extent of the farm. Two areas of land drainage were also noted on land adjacent to the fishery and may represent significant contamination sources during/following periods of heavier rainfall than was experienced over the survey period. The locations and loadings of measured watercourses as well as noted areas of drainage are shown in Figure 8.1.

Overall freshwater contamination is expected to be a significant contributor to contamination levels experienced at the fishery in Loch Sunart. This assessment does not take into account contributions from the River Carnoch, which is expected to similarly represent as a large source of contamination.

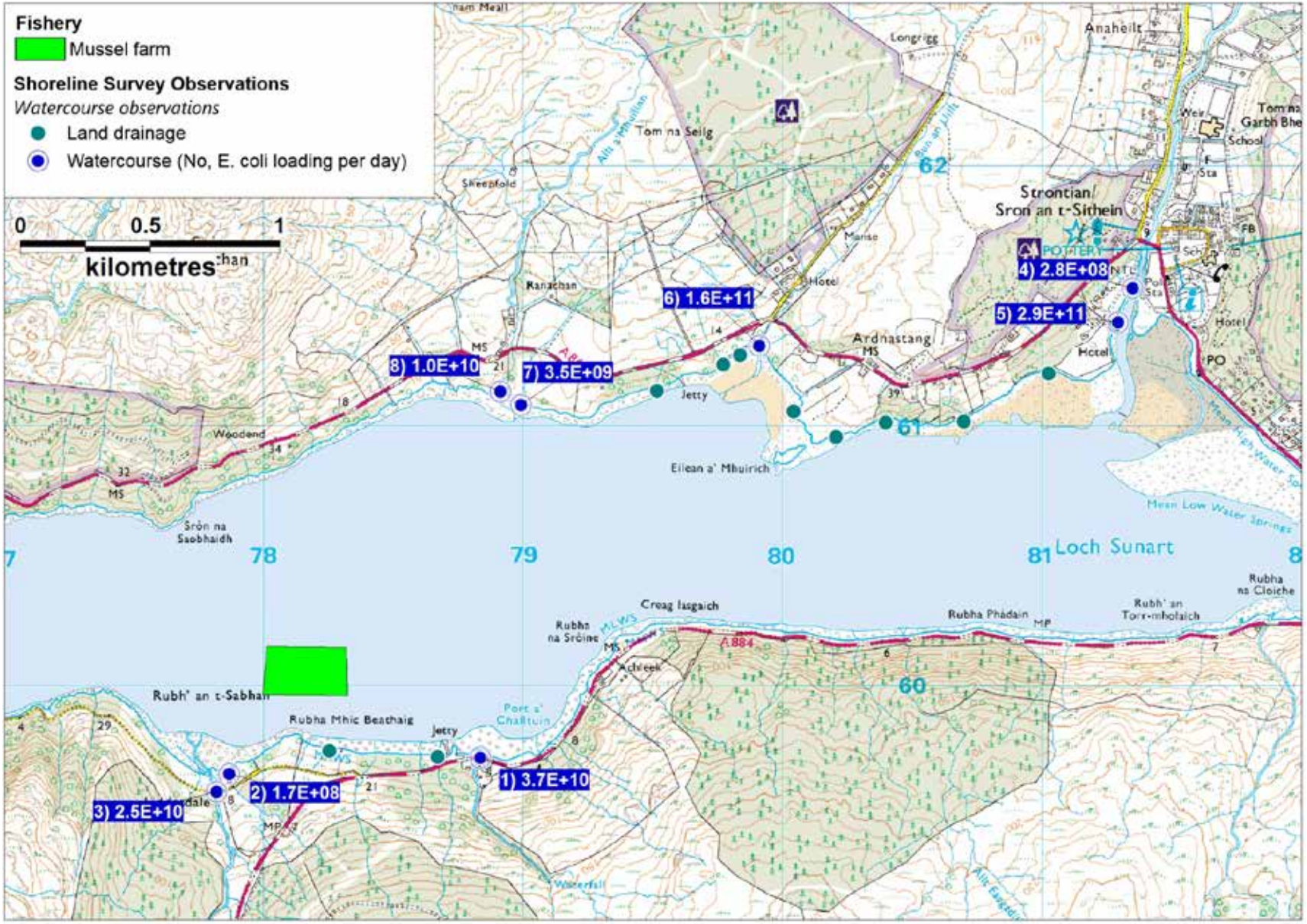

Figure 8.1 Map of watercourse loadings at Loch Sunart

9. Meteorological Data

The nearest weather station for which a complete rainfall data set was available is located at Lismore: Frackersaig Farm, situated approximately 19 km to the south of Loch Sunart mussel farm. Rainfall data was available for January 2007 – December 2012: this data set had no missing observations. The nearest wind station is situated in Tiree located 80 km west of the fishery. Data for these stations was purchased from the Meteorological Office. Unless otherwise identified, the content of this section (e.g. graphs) is based on further analysis of this data undertaken by Cefas. This section aims to describe the local rain and wind patterns in the context of the bacterial quality of shellfish at Loch Sunart.

9.1 Rainfall

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

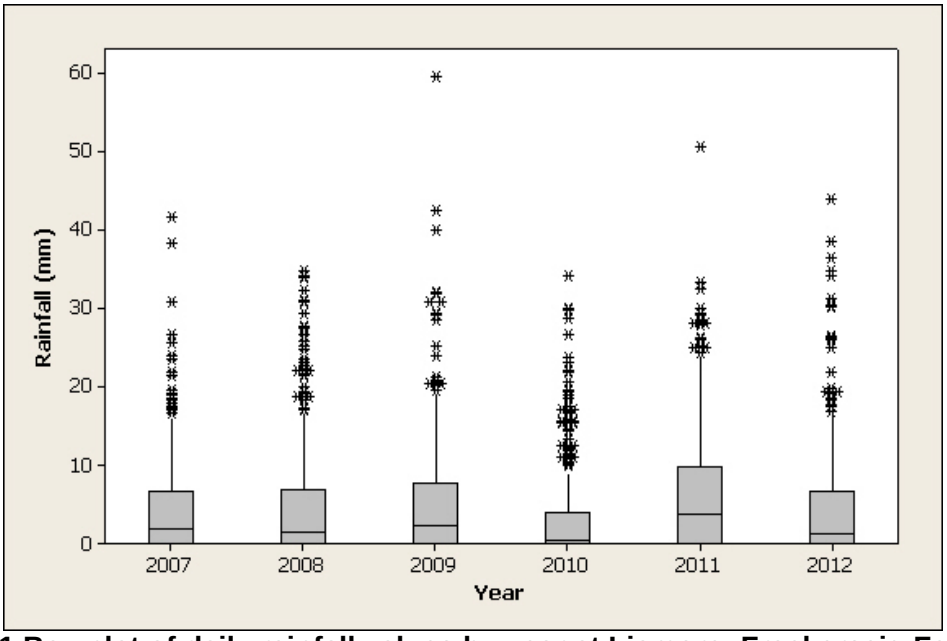

Figure 9.1 Box plot of daily rainfall values by year at Lismore: Frackersaig Farm (2007 – 2012)

Daily rainfall values varied from year to year, with 2010 being the driest year (a total of 1199 mm). The wettest year was 2011 (a total of 2354 mm). High daily rainfall

values of more than 30 mm/d occurred in all years but an extreme rainfall event of nearly 60 mm/d was seen in 2009.

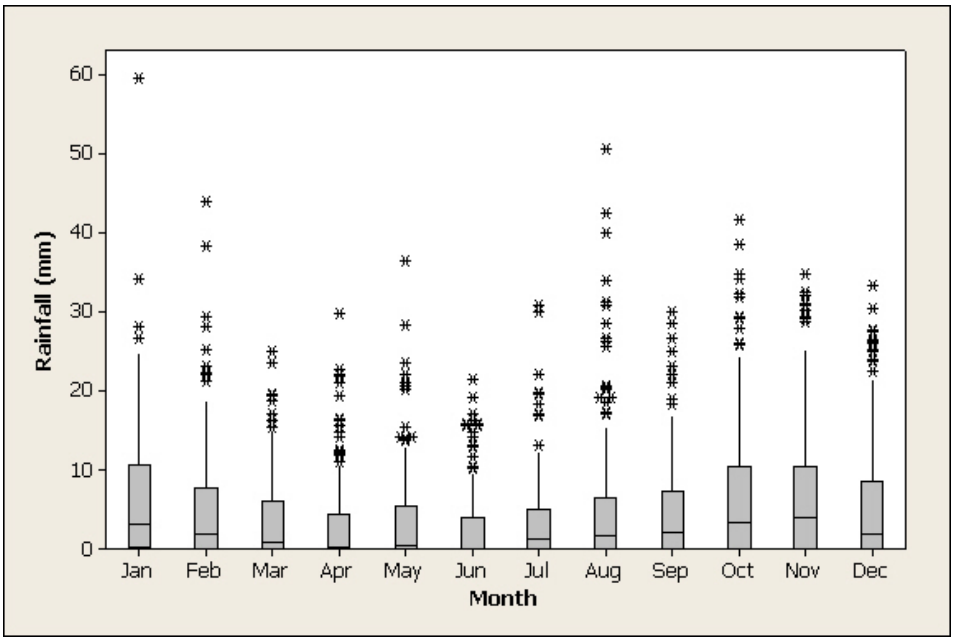

Figure 9.2 Box plot of daily rainfall values by month at Lismore: Frackersaig Farm (2007 – 2012)

Rainfall was lower between March and August and higher from September to February. Rainfall values exceeding 30 mm/d were seen in all months except March and June. The 2009 extreme event occurred in January.

For the period considered here (2007 – 2012) 46% of days received daily rainfall of less than 1 mm and 17% of days received rainfall of over 10 mm.

Run-off due to rainfall is expected to be higher during the autumn and winter months. However, extreme rainfall events leading to episodes of high runoff can occur in most months and when these occur during generally drier periods in summer and early autumn, they are likely to carry higher loadings of faecal material that will have accumulated on pastures when greater numbers of livestock were present.

9.2 Wind

Wind data was collected from Tiree and summarised in seasonal wind roses in Figure 9.3 and annually in Figure 9.4.

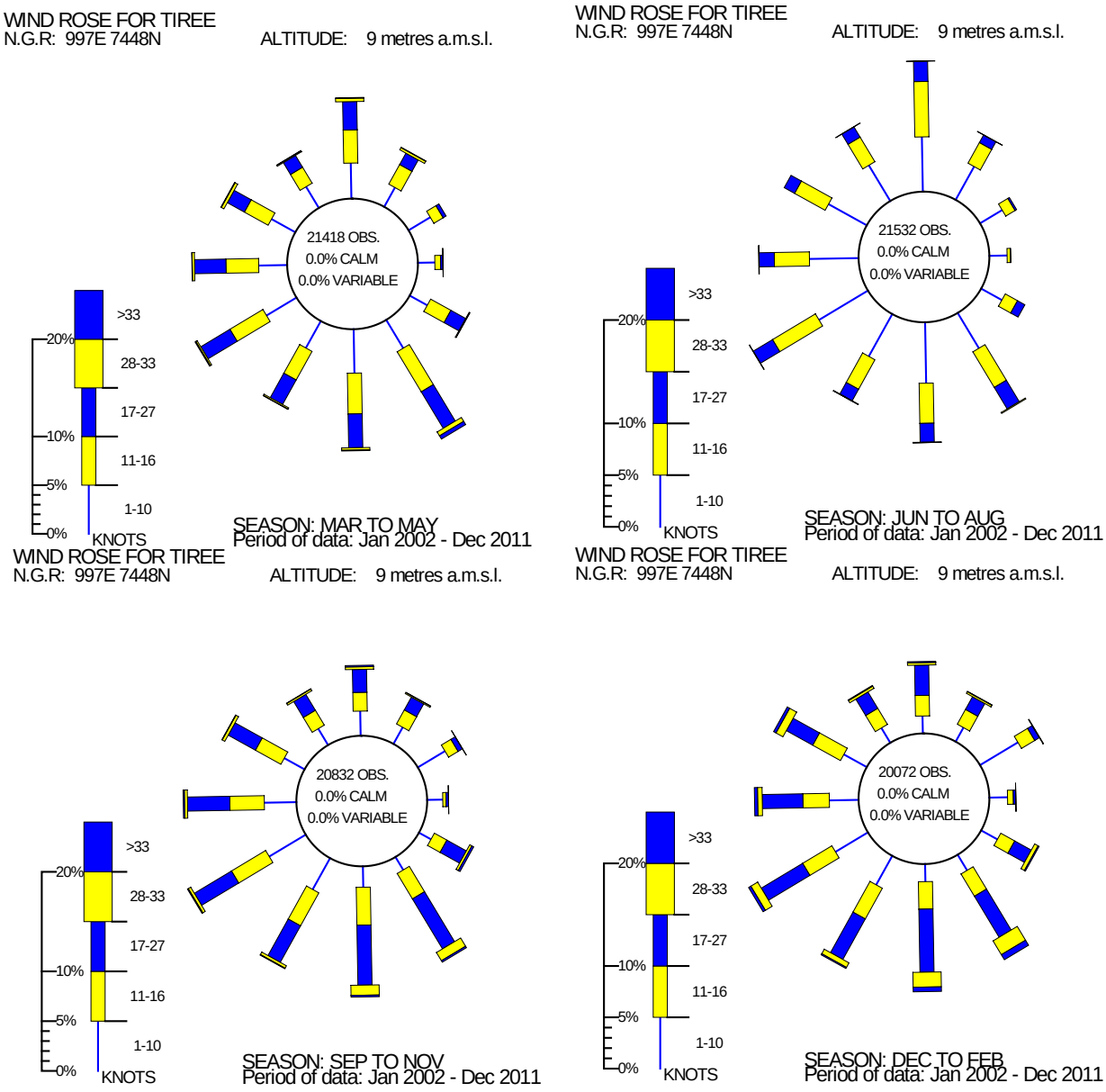

Figure 9.3 Seasonal wind roses for Tiree

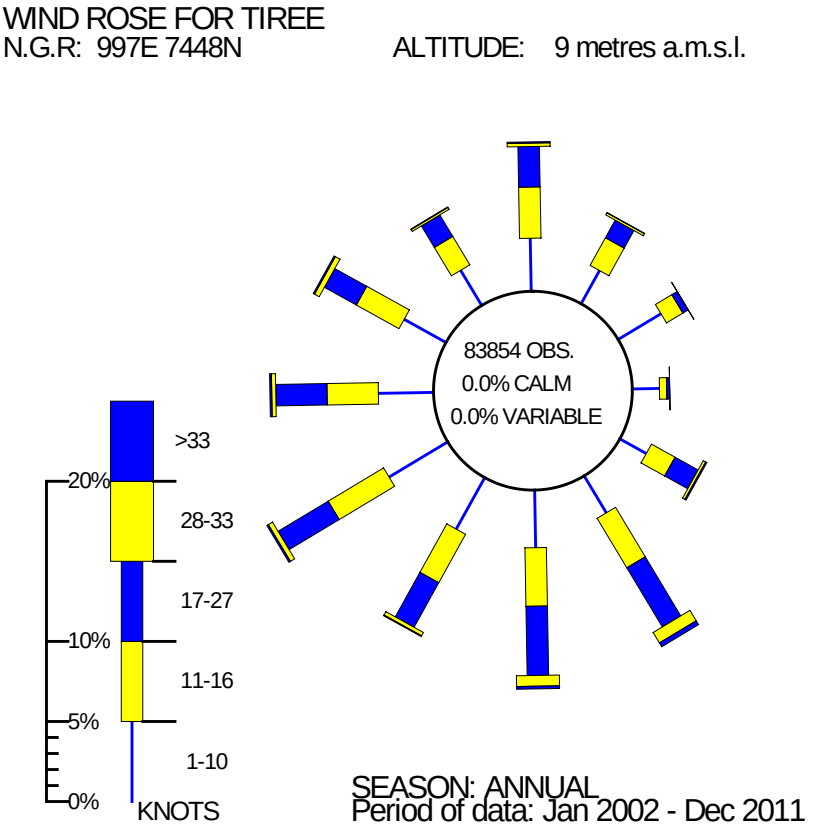

Figure 9.4 Annual wind rose for Tiree

Overall the predominant winds ranged between west southwest and south southeast. Winds were least likely to blow from the east. Northerly winds occurred relatively frequently during spring and summer.

Wind is an important factor in the spread of contamination as it has the ability to drive surface water at about (3%) of the wind speed (Brown, 1991) so a gale force wind (34 knots or 17.2 m/s) would drive a surface water current of about 1 knot or 0.5 m/s. Therefore strong winds can significantly alter the pattern of surface currents. Strong winds also have the potential to affect tide height depending on wind direction and local hydrodynamics of the site. A strong wind combined with a spring tide may result in higher than usual tides, which will carry any accumulated faecal matter at and above the normal high water mark into the fishery area.

10. Classification Information

Loch Sunart is a new production area. The area was subject to a new application in early 2013 and was previously classified under a four month fast track classification which expired on 19/11/2013.

11. Historical *E. coli* Data

11.1 Validation of historical data

Results for all samples assigned against the Loch Sunart production area, for the period 01/01/2008 to the 24/10/2013 were extracted from the FSAS database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. The data was extracted from the database on 24/10/2013. All *E. coli* results were reported as most probable number (MPN) per 100 g of shellfish flesh and intravalvular fluid.

All sample results reported as <20 were reassigned a value of 10 *E. coli* MPN / 100 g for the purposes of statistical evaluation and geographical representation.

All 13 sample results were reported as valid and were received within the permitted 48 hr time window. All samples plotted within the production area.

11.1 Summary of microbiological results

A summary of the historical monitoring results is presented in Table 11.1.

Table 11.1 Summary of historical sampling and results

Sampling Summary		
Production area	Loch Sunart	
Site	Liddesdale	Liddesdale Fast-Track
Species	Common mussels	
SIN	HL-206-1237-08	HL-206-1279-08
Location	Various	
Total no of samples	5	8
No. 2013	5	8
Minimum	<20	
Maximum	490	
Median	50	
Geometric mean	44	
90 percentile	398	
95 percentile	490	
No. exceeding 230/100g	2 (15%)	
No. exceeding 1000/100g	0	
No. exceeding 4600/100g	0	
No. exceeding 18000/100g	0	

The majority of samples taken to date returned results <230 *E. coli* MPN/100 g.

11.2 Overall geographical pattern of results

The geographical locations of Loch Sunart sample results are displayed below in Figure 11.1. Two areas have been sampled: the northeast and the west extents of the farm. Of the six samples taken from the northeast location, three were associated with the full classification (taken August to October) and three with the fast track classification, which were taken in the latter half of June and July. The seven samples taken from western location were taken between February and early June. The current provisional RMP is located approximately 100 m northeast of the northeast corner of the farm and from the most recent sampling points.

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Figure 11.1 Map of reported sampling locations at Loch Sunart

The highest results have been given by samples taken at the northeast corner of the Loch Sunart fishery. A summary of results at both locations is given in Table 11.2. A statistical analysis was not undertaken due to the small number of results to date.

Table 11.2 Summary of historical *E. coli* results at two sampling locations

	E. coli MPN/100 g		
Site	**Minimum**	**Maximum**	**Geometric mean**
Mid-west	<20	70	25
Northeast	<20	490	83

11.3 Overall temporal pattern of results

A scatterplot of *E. coli* results against date for Loch Sunart is presented in Figure 11.2.

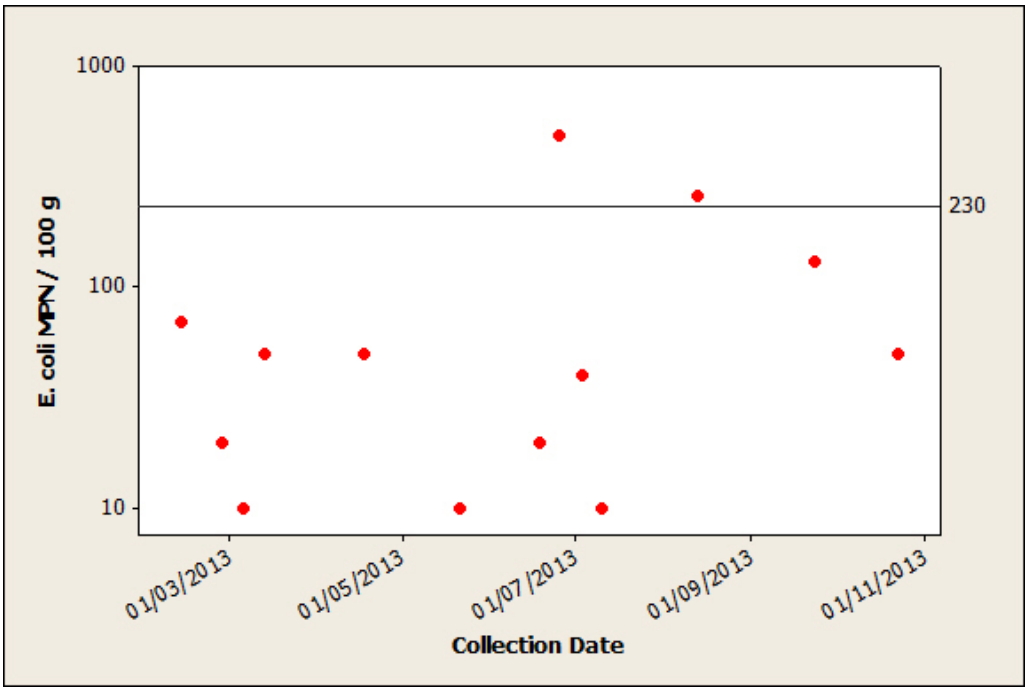


Figure 11.2 Scatterplot of *E. coli* results by collection date at Loch Sunart

Contamination levels are shown to have been predominantly low, with the majority of results <100 *E. coli* MPN / 100 g. The highest results were taken in June and August.

11.4 Summary and conclusions

Sample results taken during Fast Track and monthly classification sampling in Loch Sunart have returned predominantly low results, with only two >230 *E. coli* MPN / 100 g. The highest results were taken in June and August. Two distinct areas of sampling have been used at Loch Sunart; northeast and west of the mussel farm. These sample locations do not clearly correspond to the fast track and monthly classification RMP locations, with samples assigned to both taken at both locations. The results from the northeast side of the farm have tended to be higher, though there was insufficient data to determine whether this was a geographical rather than temporal effect.

12. Designated Waters Data

The Loch Sunart fishery does not currently lie within a designated shellfish growing water and there are no designated bathing waters in the vicinity. Historically, the western end of Loch Sunart was a designated shellfish water, however this area is located approximately 5 km from the present mussel farm and therefore is not considered further here.

13. Bathymetry and Hydrodynamics

13.1 Introduction

13.1.1 The Study Area

Loch Sunart is situated on the west coast of Scotland approximately 30 km southwest of Fort William. The mouth of Loch Sunart is bordered to the north by Ardnamurchan and to the south by the Morvern peninsula. Loch Sunart is one of the longest sea lochs in Scotland at almost 31 km and has a maximum depth of 124 m. This report focussed on the inner reaches, from Garbh Eilean eastward to the head of the loch, and is referred to as the 'upper basin'. The main town in this area is Strontian on the north-eastern shore of the upper basin which has a population of approximately 350. Other minor villages, all on the northern shore, include Ardnastang and Ranachan. There are only sparse dwellings on the southern shore. There are two islands within the hydrographic boundary, Garbh Eilean at the extreme northwest and Eilean Mór. The latter island is situated to the west and is surrounded by an intertidal sandy area. The general study area is shown in Figure 13.1

Coordinates for the middle of Loch Sunart study area:

56° 41.08' N 005° 36.27' W

NM 79336 60570

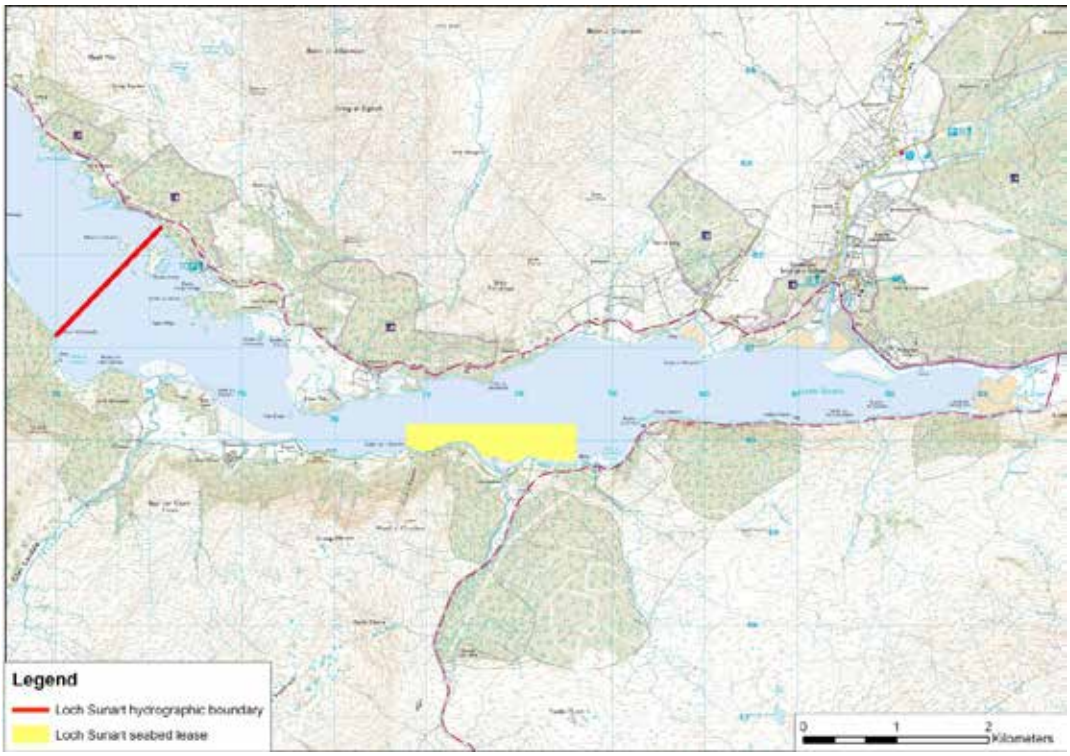


Figure 13.1 Extent of hydrographic study area

13.2 Bathymetry and Hydrodynamics

13.2.1 Bathymetry

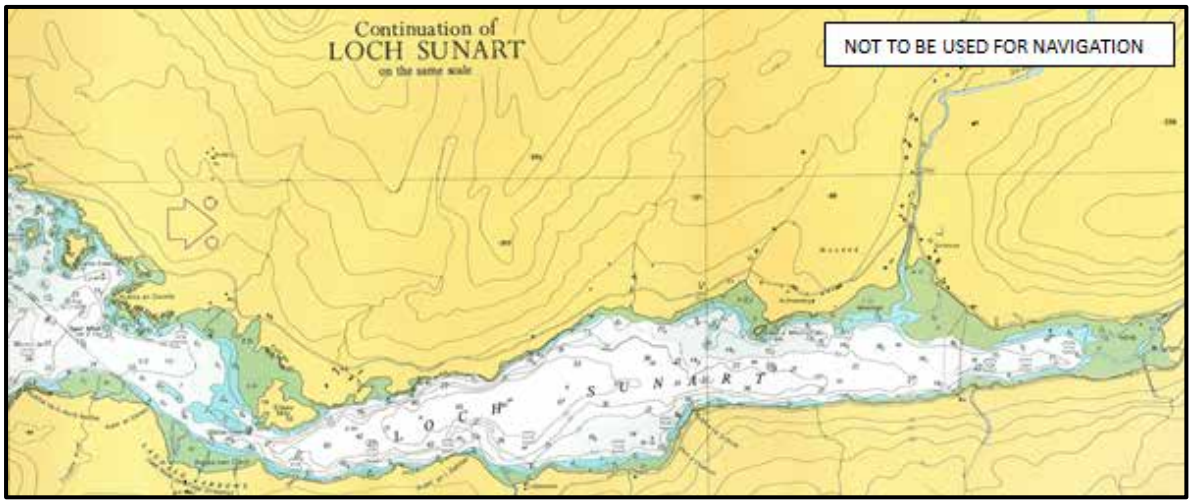


Figure 13.2 Admiralty chart (2394) extract for Loch Sunart.

Figure 13.2 shows the bathymetry of Loch Sunart. In its entirety, Loch Sunart is 30.7 km in length and has an average width of approximately 1.5 km and a maximum depth of 124 m and an estimated mean low water volume of approximately 1.8 x 109 m^3 (Edwards & Sharples, 1986). The catchment for the entire area of Loch Sunart is 299 km^2. It is rather complex in form, having six discrete sills and basins, with sill depths at low water ranging from 70 m to 6 m. The most easterly of these basins contains the study area of interest here. The large length of Loch Sunart combined with the narrow width and surrounding high topography contributes to a wide range of exposure levels to wave and wind action. This is most pronounced when comparing the sheltered inner reaches at the head of the loch to the moderately exposed outer reaches (Bates, et al., 2004).

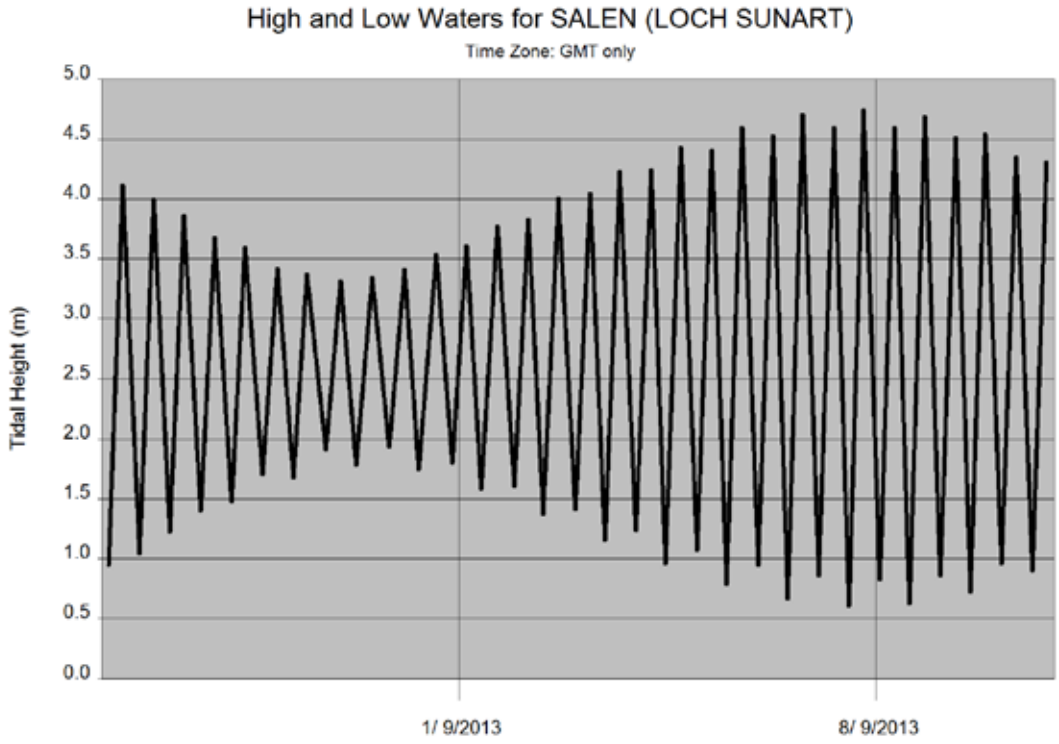
The upper basin is approximately 7 km in length with a maximum water depth of 91 m. The catchment area is 136 km^2 (Gillibrand, et al., 1995). There is a sill near the limit of the seaward boundary stretching from Eilean Mór on the northern shore to the opposite point of Rubh' an Dùnain on the southern shore, an area referred to as the Laudale Narrows. This sill is 600 m in length with a maximum depth at low water of 6 m. In the upper basin, there are several intertidal zones most notably at the head of the loch, at Strontian and around Eilean Mór. With the exception of the intertidal areas, the upper basin of Loch Sunart is typically steep sloping with significant bathymetric gradients within < 50 m from the shore.

13.2.2 Tides

Loch Sunart has a typical semi-diurnal tidal characteristic (Gillibrand, et al., 1995). Data on tidal information is given from charted information. The nearest location for

tidal predictions is Salen, Loch Sunart, situated approximately 8 km from the seaward boundary of the study area in Loch Sunart [http://easytide.ukho.gov.uk].

Standard tidal data for Salen are given below (from Admiralty Surveys) and the spring/neap cycle of tidal height around the time of the planned survey (2 - 3 September 2013) is shown in Figure 13.3.



Reproduced from Poltips3 [www.pol.ac.uk/appl/poltips3]

Figure 13.3 Two week tidal curve for Salen, Loch Sunart.

Tidal Heights at Salen, Loch Sunart:

- Mean High Water Springs = 4.6 m
- Mean Low Water Springs = 0.6 m
- Mean High Water Neaps = 3.4 m
- Mean Low Water Neaps = 1.7 m

Tidal Ranges:

- Mean Spring Range = 4.0 m
- Mean Neap Range = 1.7 m

This gives a tidal volume of water for the entire sea loch during each tidal cycle of approximately:

Springs: 1.8×10^8 m^3

Neaps: 7.8×10^7 m^3

The volume of water for the upper basin during each tidal cycle is approximately one order of magnitude less at:

Springs: 2.2×10^7 m^3

Neaps: 9.4×10^6 m^3

13.2.3 Tidal Streams and currents

There are no published tidal diamonds for this area. Enhancement of tidal streams caused by straights and shallow channels will be important near the western boundary of the study area at the Laudale Narrows. Here the spring rate of the ingoing stream is reported to run up to 1.5 ms^{-1} and the rate of the outgoing stream is 1.8 ms^{-1} (Admiralty Chart 2394). The mean speed over the sill during spring tides is given as 0.23 ms^{-1} (Edwards & Sharples, 1986).

Data from ten current meter deployments in the area were available from previous surveys and were provided by SEPA. Of these, we have selected six, based on their geographic spread across the loch and adequacy of the associated metadata (ERT (Scotland) Ltd, 2000; Marine Harvest (Scotland) Ltd, 2003; Marine Harvest (Scotland) Ltd, 2004a; Marine Harvest (Scotland) Ltd, 2004b; Marine Harvest (Scotland) Ltd, 2004c). In the case of the remaining four sites, the locations were not adequately known. The selected locations are shown in Figure 13.4. The Hydrographic surveys typically span 15 days; being the half-lunar period to capture a spring-neap cycle. Only one of these sites is within the assessment area.

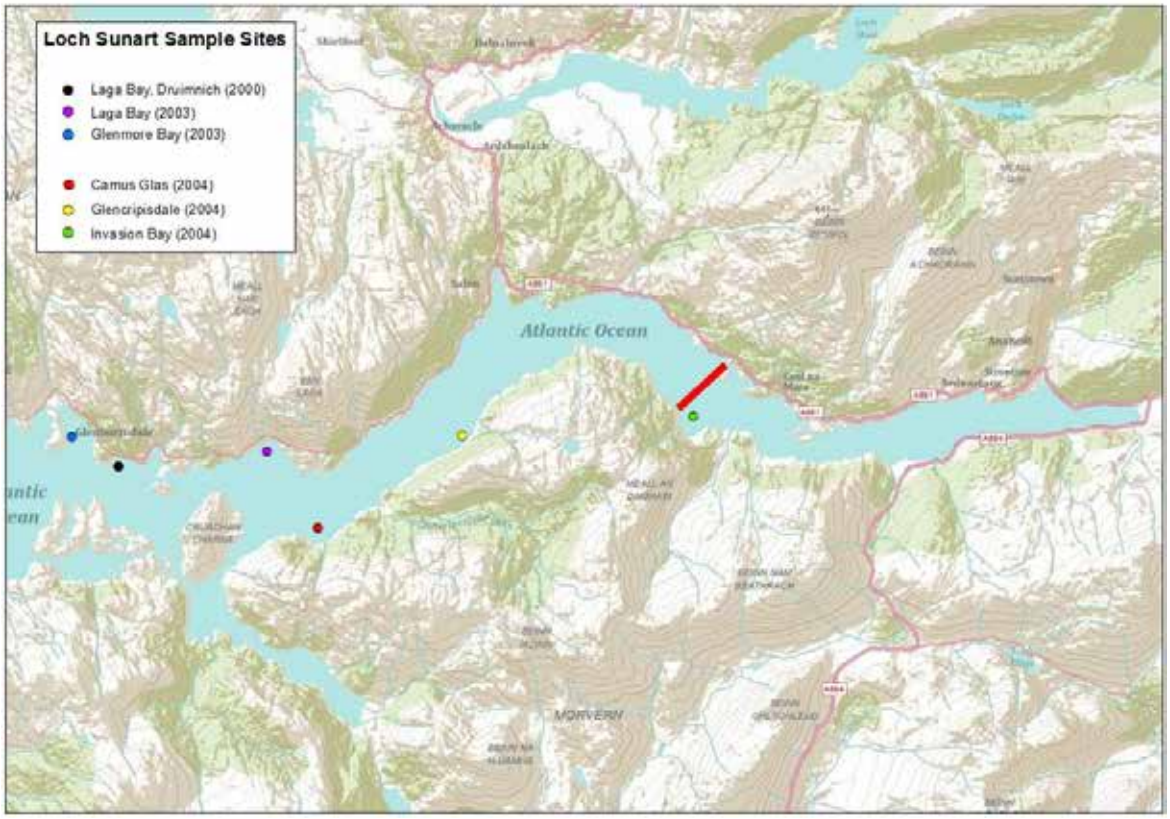


Figure 13.4 Map showing Loch Sunart sample sites.

Note that they are mostly outwith the assessment area. The assessment area is demarcated by the red line as per Figure 13.1.

Data from the southern shore of Loch Sunart were collected from Camus Glas, Glencripisdale and Invasion Bay (Marine Harvest (Scotland) Ltd, 2004a; Marine Harvest (Scotland) Ltd, 2004b; Marine Harvest (Scotland) Ltd, 2004c) and are summarised in Table 13.1. Semi-diurnal periodicity along with some spring-neap variation was displayed throughout the velocity readings. In general, the currents were of a moderate velocity. Invasion Bay has a greater mean velocity than Camus Glas and Glencripisdale which both show similar rates to one another.

Table 13.1 Current data measured in Camus Glas, Glencripisdale and Invasion Bay

Site Height above seabed	Camus Glas (2004) Near-bed Mid Surface (3.5 m) (30.7 m) (37.0 m)			Glencripisdale (2004) Near-bed Mid Surface (3.5 m) (27.5 m) (33.5 m)			Invasion Bay (2004) Near-bed Mid Surface (4.0 m) (22.3 m) (33.8 m)		
Mean Speed (ms-1)	0.049	0.059	0.070	0.04	0.036	0.078	0.071	0.061	0.108
Principal Axis Amp & Dir(ms-1)&(oM)	Not given	Not given	0.08 (210)	Not given	Not given	0.10 (350)	0.11 (155)	0.08 (170)	0.16 (065)
Residual speed (ms-1)& Dir (^{o}M)	0.020 (087)	0.024 (185)	0.032 (222)	0.019 (068)	0.018 (038)	0.05 (356)	0.059 (163)	0.028 (161)	0.081 (080)

Data from the northern shore of Loch Sunart were collected from Glenmore Bay (no technical report), Druimnich and Laga Bay (ERT (Scotland) Ltd, 2000; Marine Harvest (Scotland) Ltd, 2003) and are summarised in Table 13.2. Semi-diurnal periodicity along with some spring-neap variation was displayed throughout the velocity readings. In general, the currents were of a moderate to high velocity. The tabulated mean velocity was greatest in the surface.

Table 13.2 Current data measured inGlenmore Bay, Druimnich and Laga Bay

Site Height above seabed	Glenmore Bay (2003) Near-bed Mid Surface (3.2 m (6.8 m) (17.8 m)			Druimnich (2000) Near-bed Mid Surface (6.4 m) (10.7 m) (23.8 m)			Laga Bay (2003) Near-bed Mid Surface (2.0 m) (17.7 m) (28.2 m)		
Mean Speed (ms^{-1})	0.031	0.040	0.045	0.03	0.03	0.03	0.048	0.042	0.1

The most complete record of tidal flow in the upper basin comes from current meter deployments for a scientific project during the summers of 1987, 1989 and 1990 (Gillibrand, et al., 1995). In each year, there were measurement from the surface (~5 m depth) and the near bottom. The observations show maximum seaward and landward currents typically around 0.03 ms^{-1} but peaking at 0.04 ms^{-1}. Whilst these speeds varied over a 2-3 day duration, there is generally a well-developed estuarine circulation with residual surface flow to seaward. However, the shallow nature of the sill means that this seaward flow can be transported downwards into the basin. In contrast, bottom currents were comparatively weak, < 0.01 ms^{-1} were recorded for the subtidal near-bottom currents.

It is rather difficult to summarise this wide geographical spread of measurements into a single estimate that will relate to particle transport. Although the data from SEPA indicate maximum tidal currents in the surface would be around 0.1 m/s with residual current speed in the surface of 0.5 m/s the data measured in the upper basin of Sunart indicates rather smaller values with surface flows peaking at 0.04 m/s and residual flows being weaker. This is probably due to the limited volume exchanged over the shallow sill. Based on these the surface transports would be just a few hundred meters.

Additional work was done by Willis et al (2005) using surface drifters within the upper basin to measure the horizontal dispersion coefficients. They measure values of 0.056 m^2 s^{-1} along the axis of the loch and 0.028 m^2s^{-1} across the loch. These are lower than the default value of 0.1 m^2 s^{-1} recommended by SEPA for sea lice medicine consent modelling. However, there is a clear caveat that the values are highly dependent upon tidal and wind conditions at the time of any dispersion survey. Such data is therefore only a general indicator of dispersion potential.

13.2.4 River/Freshwater Inflow

There are several rivers surrounding Loch Sunart with variable flow rates depending on the season. The main watercourses are at and around the head of the loch. Carnoch River is a significant amalgamation of several watercourses and flows into

Loch Sunart through a considerable intertidal sandy area. Approximately 1.7 km to the west at the township of Strontian, another considerable watercourse, Strontian River, flows into Loch Sunart. Several other minor rivers on both the northern and southern shore around the head of the loch include Lurg an Dearg Uillt, Allt Easgadill and Allt a' Mhuilinn. Towards the mouth of the study area, the watercourses include Allt Camas a' Choirce, Allt Ard Airigh and Laudale River. There are numerous unnamed watercourses on the OS map around the whole coastline of the study area which may or may not flow depending on weather and season.

The annual precipitation in the area is approximately 2000 mm and the annual freshwater runoff is estimated as 523 Mm^3yr^{-1} (Edwards & Sharples, 1986). The ratio of freshwater flow to tidal flow in Loch Sunart is low at 1:200, in fact it has one of the smallest freshwater discharges of all the Scottish loch complexes (Austin & Inall, 2002) and therefore the input of freshwater near the surface has rather little influence on the overall salinity of the loch. This will also contribute to the comparatively frequent renewal of its bottom waters (Austin & Inall, 2002).

However, the upper basin receives around half of the total freshwater input into the whole of Loch Sunart mainly through the Carnoch and Strontian Rivers (Gillibrand, et al., 1995). Consequently, the upper basin has a lower salinity (reported 32.8 ppt) compared to the mouth of the loch (reported 33.6 ppt) (Bates, et al., 2004).

13.2.5 Meteorology

Rainfall data were taken from Lismore: Frackersaig Farm which is situated roughly 19 km to the south of the Loch Sunart fishery. These records spanned the time frame from January 2007 to August 2012.

The year with the highest rainfall was 2011 and the least rain fell in 2010. In 2009, extreme rainfall levels of > 60 mm/d were recorded but generally high rainfall values (>30 mm/d) were seen in all years. The highest daily rainfall values occurred throughout autumn and winter where rainfall increased from August onwards and peaked in October, November and January. There was rainfall of >30 mm/d in all months with the exception of March and June. For the duration of the data set, daily rainfall of below 1 mm occurred 46% of the time and daily rainfall of above 10 mm occurred 17% of the time.

It can be surmised from these data that run-off due to rainfall is expected to be higher in the autumn and winter months but it must also be noted that high rainfall and consequently high run-off can occur in most months.

Data about wind conditions were collected from Tiree which is located approximately 80 km west of the production area. Due to the distance between the two areas, the wind rose statistics may not be directly transferrable to the specific production area in Loch Sunart but they can be used to give a general picture of the seasonal wind

conditions in the this west coast area. The data from Tiree shows that overall westerly winds and southerly winds were stronger than northerly or easterly winds. There is a predominant south-westerly airflow year round for the western isles. It is highly likely that the wind direction will be strongly influenced in Loch Sunart by the morphology of the surrounding high ground. From the data gathered, it can be surmised that Inner Loch Sunart may be relatively sheltered from prevailing winds.

The topography of the surrounding steep hillsides around the loch unquestionably drives the winds along the axis of the loch but this is not necessarily reflected by the data from the wind station in Tiree (Gillibrand, et al., 1995).

In terms of stratification, during periods of low run off (July 1989), salinity gradients (horizontal and vertical) can be weak with relatively high >32.0 salinity readings near the head of the loch. This can change markedly during periods of high run off (August 1989) with a well-defined 10m deep surface layer forming, demarcated by strong vertical salinity gradients, and the surface salinity can reduce to <10.0 (Gillibrand, et al., 1995). It can be surmised from this that freshwater runoff and wind stress has a large influence on the amount of stratification seen in Loch Sunart. The overall characteristics of Loch Sunart can be described as being highly stratified for only short periods of time immediately following episodes of high runoff (Gillibrand, et al., 1995).

Salinity data collected during the Survey work on 2nd September 2013, also found very fresh surface waters with salinity between 10-15, strongly stratified in the upper 3 m. This was recorded after a period of heavy rain.

During aforementioned hydrographic surveys, meteorological surveys were also completed in the six sites in Loch Sunart (see Figure 13.4) and the data have been presented in Table 13.3 for the purpose of this report (ERT (Scotland) Ltd, 2000; Marine Harvest (Scotland) Ltd, 2003; Marine Harvest (Scotland) Ltd, 2004a; Marine Harvest (Scotland) Ltd, 2004b; Marine Harvest (Scotland) Ltd, 2004c). They show that in general, during the period of these surveys the mean wind speed is typically less than 3 ms^{-1}, therefore the dynamic response to winds is due to short periods of stronger winds.

Table 13.3 Loch Sunart wind speed data

Site & Measurement date (15 day period)	Druimnich July – Aug 2000	Laga Bay Feb 2003	Glenmore Bay Mar – Apr 2003	Camus Glas Feb – Mar 2004	Glen-cripisdale Nov – Dec 2004	Invasion Bay Oct – Nov 2004
Mean Speed (ms-1)	1.56	4.1	2.6	2.6	2.7	2.1
Maximum Speed (ms-1)	7.3	11.0	8.9	6.5	7.5	4.9
Minimum Speed (ms-1)	0.0	0.2	0.1	0.0	0.2	0.6
Modal wind directions	SW	Not reliable	SE & NW	N & S	SSW	NW

Based on a simple analysis of the modal wind directions for each site, there is some evidence for the topographically steered winds described in 2.5.5. For example, Invasion Bay experienced predominantly NW winds (where the loch is angled NW/SE) whilst Glencripisdale experienced a dominant wind direction of SSW (where the loch is angled SW/NE).

13.2.6 Model Assessment

The exchange characteristics of Loch Sunart have been broadly assessed using a layered box model approach. The model represents the Loch as a box made up of three layers and was formulated according to the method of Gillibrand et al (2013). The box layers are forced with surface wind stress, estimates of fresh water discharge, surface heat flux parameters and, at the open coastal boundary, profiles of temperature and salinity are prescribed from climatology compiled by the UK Hydrographic Office. This sets the model with climatological boundary conditions to represent an ‘average’ year. The model was tuned and validated for Lochs Creran and Etive though a full validation for Loch Sunart has not been done due to lack of seasonal data.

The box model quantifies the primary exchange mechanisms. The key outputs from the model with respect to this hydrographic assessment are a series of annual mean values that describe the relative importance of the estuarine (gravity) exchange, tidal exchange, exchange between the layers and the flushing time (inverse of the exchange rate) of the surface and intermediate layers. These values are given in Table 1.4

Table 13.4 Summary of annual mean parameter values from the box modelling exercise.

Parameter	Value
Tidal Volume Flux (m3 s-1)	3179.8
Estuarine Circulation Volume Flux (m3 s-1)	31.4
Median Flushing Time (days)	4.7
95%-ile Flushing Time (days)	7.6

The ratio of tidal volume flux to estuarine circulation volume flux is 93.2. Values greater than 2 indicate a system that is strongly tidal in its exchange characteristics (Gillibrand, et al., 2013).

Using a simple tidal prism model, the flushing time for the entire volume of Loch Sunart is estimated at around 6.5-7 days (Edwards & Sharples, 1986; Marine Scotland, 2012). The three layer box model gives a value less than 5 days, probably related to the contribution by any estuarine exchange. Nevertheless, this suggests that the exchange environment is relatively efficient and similar to that calculated by simple tidal exchanges models.

Other publications have stated that the estimated flushing time for the surface layer (comprising the upper 10 m) is 3 days (Willis, et al., 2005).

13.3 Hydrographic Assessment

13.3.1 Surface flow

Surface current data from the SEPA records do not show a conclusive picture due to the sporadic timing of data collection and the local effects of in each measurement location. Further, only one of these sites was within the assessment area. However, observations in the upper basin (Gillibrand, et al., 1995) show both seaward and landward residual flows, although at times of high run-off and favourable winds, and estuarine circulation would be expected to form.

Surface flow in the inner basin was seen from observations to be rather weak with particle transport estimated to be a few hundred meters. This would be enhanced close to the faster flow in the narrows.

Surface flows are modified by the wind (Gillibrand, et al., 1995) and this is particularly the case with flow over the sill at the Laudale Narrows. Enhanced estuarine circulation on the sill can lead to deep water renewal of the deep basin waters.

The site and the meteorological data indicate that there is likely to be a rather small freshwater discharge into the surface waters of the loch compared to the tidal volumes. However, in the upper basin a significant brackish layer can form during times of high run-off as half the catchment for Sunart discharges into this area.

Surface flows would be enhanced/retarded by winds blowing out of/into the loch. The winds would be generally funnelled by the surrounding hills creating winds blowing along the axis of the loch which would further enhance the mixing of the waters through the full depth.

In summary the surface circulation in Loch Sunart is primarily driven by tides but under appropriate stratification and wind conditions an estuarine type circulation can develop.

13.3.2 Exchange Properties

The flushing time for the whole loch complex using a simple tidal prism approach is around 7 days with the tidal exchange being considerably greater than the estuarine exchange. Published estimates give a flushing time of 3 day for the surface waters in the upper basin (Willis, et al., 2005).

Model output for Sunart show a typically fjordic circulation with faster seaward flow in the surface and slower landward flow in the deep water. In the upper basin where the sill is particularly shallow, this can cause surface water to be transported deeper through vertical circulation. Therefore, residence times of the surface waters in the upper basin may be somewhat larger than the suggested 3 days.

Rapid deep water renewal is known to occur periodically in Loch Sunart, usually at least monthly (Gillibrand, et al., 1995) and in response to forcing by southeast winds.

The key aspect of the model output in terms of the exchange is that the tidal volume flux dominates the estuarine (or gravitational) volume flux by a factor of 93. This means that exchange of waters in Loch Sunart is principally a tidally driven process. Hence there is likely to be rather little seasonal variation in the flushing time of the Loch except during period of very high run off. The model predicts that 95% of the time the flushing time will be 7.6 days or less which is rather rapid.

There is a relatively good data series available for the upper basin of Loch Sunart and there is some numerical modelling effort in this region. Consequently, we are able to determine some of the broad features of the loch circulation, though the details of seasonality are not easily inferred. Therefore the confidence level of this assessment is MEDIUM.

14. Shoreline Survey Overview

The shoreline survey at Loch Sunart was carried out on the 2nd and 3rd September 2013. Light rainfall fell on both survey days, with heavy rainfall recorded in the 24 hrs prior to the survey. Wind varied from F2-3 WSW to F1-2 SSW on the second day.

The fishery consisted of a single common mussel farm, made up of 6x300 m long-lines. At the time of the survey, stock consisted of two mussel age classes; older mussels located on the three lines to the south (conventional droppers), with mussels severely depleted at 2-3 m depth. Newly settled spat were distributed on the three northern lines (short, ladder style droppers). Mussel samples were taken at the southwest and mid-eastern extents of the mussel farm from the surface and 4 m depth. Results were 2400 *E. coli* MPN/100 g for both samples taken to the southwest (<1 and 4 m depth) and 5400 (<1m depth) and 230 (4 m depth) *E. coli* MPN/100 g respectively for samples taken to the east. Seawater samples were taken at the southwest and northeast extents of the farm and returned results of 100 and 700 *E. coli* cfu/100 ml respectively.

The harvester (Mr Byrne) indicated the site is used as backup when his other farms are closed due to bio-toxin outbreaks.

The human population is concentrated on the northern shore in the villages of Strontian and Ardnastang where there are also hotels and B&B's. One septic tank was observed on the north shore, discharging into Allt Ard nan Staing. A freshwater sample taken further downstream returned a result of 490 *E. coli* cfu/ 100 ml. Several private dwellings were observed on the south shore, thought to be associated with the Laudale Estate. No outfalls were observed on the south shore.

Several mooring sites (private and public jetties/piers) were present around Loch Sunart, with a number of pleasure craft anchored around Strontian and Ardnastang (north shore). A private jetty/slipway with several anchored boats was also noted adjacent to the Laudale estate houses (south shore).

Two sheep were observed on the south shore, with land close to the shoreline mostly un-grazed. Land along both shorelines (outside the villages) was mostly forestry. Only a very small number of wildlife animals were seen (1 deer, 1 otter, 3 birds).

Several large watercourses enter into Loch Sunart: Strontian River (north shore), Allt na h-Airigh and Liddesdale Burn (south shore). Contamination levels varied between 20 and 490 *E. coli* cfu/100 ml.

The most significant observations from the shoreline survey are shown in Figure 14.1.

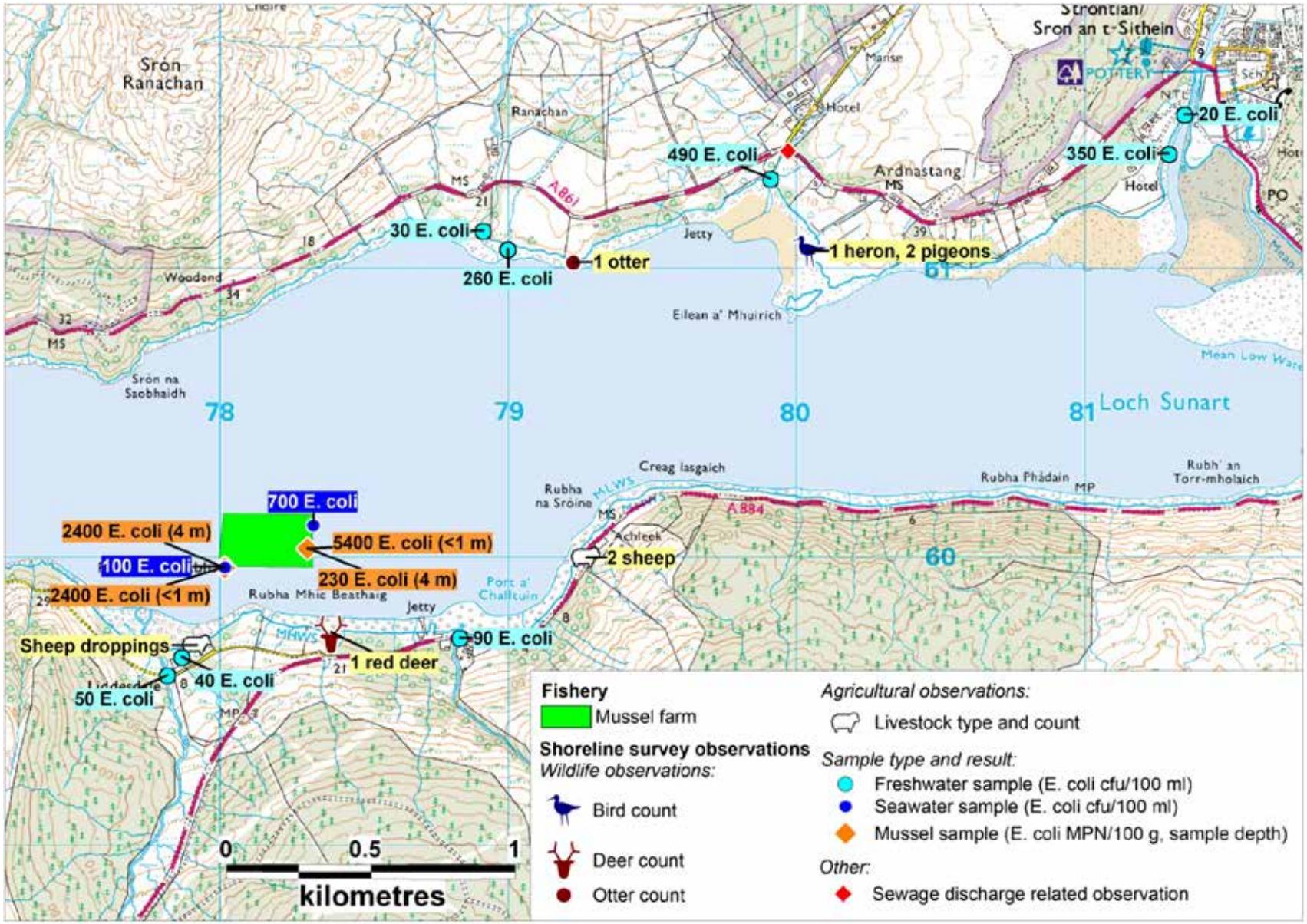


Figure 14.1 Principal shoreline survey observations at Loch Sunart

15. Overall Assessment

Human sewage impacts

The human population is concentrated around the village of Strontian on the northern shore as well as at Ardnastang and Ranachan. The southern shoreline is sparsely populated. Sewage inputs are concentrated around Strontian, although there are private discharges associated with the other villages and a small number immediately to the east and south of the mussel farm.

Agricultural impacts

Available information suggests that the risk of contamination from farm animal sources will be low. The main concentration of improved grassland was associated with what appeared to be crofted land along the Strontian River. There will be separate impacts from this source and also those near the southern and eastern extents of the fishery (i.e. those parts closest to the shore).

Wildlife impacts

Species identified as potentially impacting on Loch Sunart included cetaceans, seals, birds, deer, otters, mink. Where information on numbers was available, it indicated that the risk form these sources would generally be low although this would vary with time. Any impact would tend to be sporadic in both time and geographical location.

Seasonal variation

There is a large amount of tourist accommodation in the area relative to the small population and thus it would be expected that contamination from human sources would be greatest during spring, summer and early autumn. Variations would be expected to occur in inputs from farm and wild animal sources but the timing of these would vary between the species and the overall outcome would be to accentuate the sporadic nature of the risk from these sources.

Too few *E. coli* monitoring results for the mussels were available to undertake a statistical assessment with respect to season but the highest results to date occurred in samples taken in June and August.

Rivers and streams

The two major potential sources of contamination from watercourses are the Carnoch and Strontian Rivers as the largest watercourses in the area. No information was available on loadings from the Carnoch River but those estimated for the Strontian River were the highest of those determinate on the basis of the shoreline survey measurements. The loading estimated for Bun an Uillt, a smaller watercourse, was almost as great. Both of these are located to the northeast of the fishery. Loadings were

estimated for three watercourses along the southern shore in the immediate vicinity of the fishery. The two on the adjacent shore were low but one to the southeast of the fishery gave a medium estimated loading. As heavy rainfall was recorded prior to the shoreline survey, it would be anticipated that the estimated loadings reflected the worst case.

Salinity measurements taken during the shoreline survey indicated much lower values in the top 1 m of the loch, with the effect being even greater in the upper 0.5 m. The near surface values were lower at the northeast corner of the mussel lines than at the southwest corner, indicating a strong influence from the watercourses located at and near the head of the loch.

Movement of contaminants

Particle transport in the loch was estimated to be in the order of a few hundred metres, with modification of currents by wind (which tend to flow along the loch) and an estuarine circulation during periods of significant freshwater input. The latter would increase the flow away from the head of the loch. This would coincide with periods of increased stratification and contamination constrained in the upper layers would travel a greater distance towards the mussel lines.

Temporal and geographical patterns of sampling results

Only a limited number of *E. coli* results available from the classification monitoring of mussels. The highest results were seen at a sampling location at the northeast side of the lines and occurred during June and August. The highest *E. coli* results from mussels taken during the shoreline survey also occurred in samples taken at the northeast part of the mussel farm, as did the highest seawater result. At that location, the *E. coli* result from mussels taken near the surface was markedly higher than the result from mussels taken at depth.

Conclusions

The principal sources of contamination in the area lie to the northeast of the mussel farm and available microbiological data indicates that this is the part of the farm that is subject to the greatest impact. However, there are some sources on southern shore of the loch that may also affect the microbiological quality of the mussels.

16. Recommendations

The more extensive assessment undertaken in this report supports the outcome of the pRMP assessment and thus the production area boundaries and sampling location given in that assessment. However, the mussel farm lies within the seabed lease area and the RMP has been moved from the location recommended in the pRMP assessment to reflect that fact. The definition for the production area boundaries has been amended slightly to clarify the exclusion of the mouth of Liddesdale Burn. The recommendations are shown in Figure 16.1.

Production area

The recommended boundaries are the area bounded by lines drawn from NM 7761 6060 to NM 7739 5999 to NM 7808 5981 and from NM 7886 6112 to NM 7869 5979 and extending to MHWS between NM 7761 6060 and NM 7886 6112 and between NM 7808 5981 and NM 7869 5979. These exclude the sources nearer to the head of the loch as well as the mouth of Liddesdale Burn to the south.

RMP

It is recommended that this be located at NM 7830 6012 to reflect the principal sources of contamination to the northeast of the mussel farm.

Tolerance

It is recommended that this be 40 m to allow for some movement of the mussel lines.

Depth of sampling

It is recommended that this be at one metre or less to reflect the significant stratification that occurs within the loch after heavy rainfall.

Frequency

It is recommended that sampling is undertaken monthly given the very limited data set that is currently available together with the anticipated seasonal variation in contamination within the area.

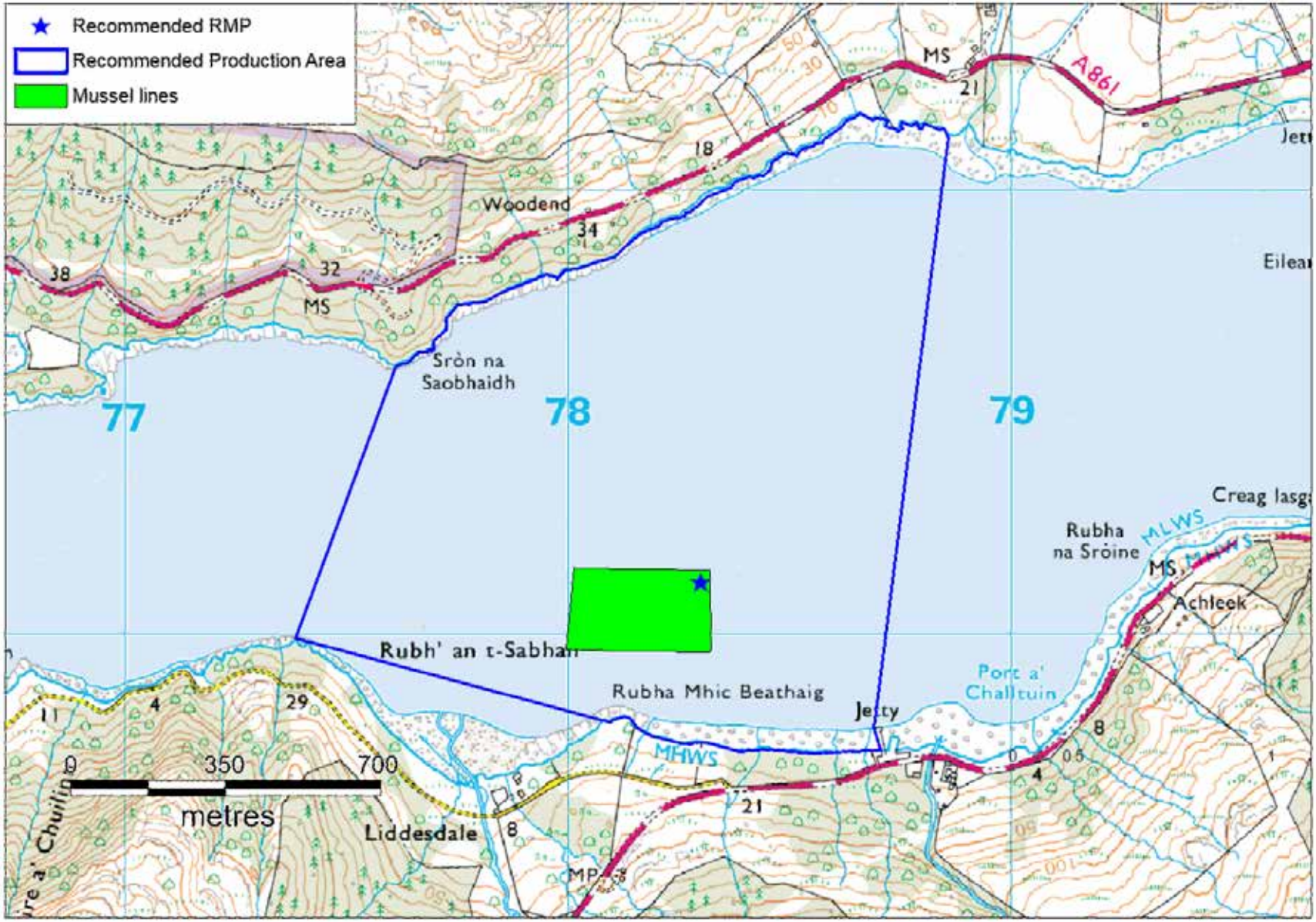


Figure 16.1 Map of recommendations at Loch Sunart

17. References

Ardnamurchan Chalet, 2013. *Hillside Chalet.* [Online] [Accessed 21 11 2013].

Austin, W. E. N. & Inall, M. E., 2002. *Polar Research,* 21(2), pp. 251-258.

Bates, C. R. et al., 2004. *Broakd scale mapping of sublittoral habitats in loch Sunart, Scotland,* Edinburgh: Scottish Natural Heritage Comissioned Report No. 006 [ROAME No. F01AA401C].

Brown, J., 1991. The final Voyage of Rapaiti:A measure of surface drift velocity in relation to the surface wind. *Marine Pollution Bulletin,* 22(1), pp. 37-40.

Edwards, A. & Sharples, F., 1986. *Scottish Sea Lochs: a Catalogue,* Oban: Scottish Marine Biological Association/Nature Conservancy Council.

ERT (Scotland) Ltd, 2000. *Hydrographic survey Laga Bay, Druimnich Final Report. ERTSL R00/118/20/R025,* Aberdeen: ERT (Scotland) Ltd.

Gillibrand, P. A., Inall, M. E., Portilla, E. & Tett, P., 2013. A Box Model of Seatonal Exchange Mixing in Regions of Restricted Exchange: Application to Two Contrasting Scottish Inlets. *Environmental Moddeling and Software,* Volume 43, pp. 144-159.

Gillibrand, P. A., Turrell, W. R. & Elliott, A. J., 1995. Deep-water renewal in the upper basin of Loch Sunart, a Scottish fjord. *Journal of Physical Oceanography,* Volume 25, pp. 1488-1503.

Hebridean Whale and Dophin Trust, 2013. *Recent Sightings.* [Online] Available at: http://www.whaledolphintrust.co.uk/sightings-recent-sightings.asp [Accessed 21 11 2013].

Joint Nature Conservation Committee, 2013. *Sunart.* [Online] Available at: http://jncc.defra.gov.uk/protectedsites/sacselection/sac.asp?EUcode=UK0019803 [Accessed 21 11 2013].

Kay, D. et al., 2008. Faecal indicator organism in concentration sewage and treated effluents. *Water Research,* 42(1/2), pp. 442-454.

Lee, R. J. & Morgan, O. C., 2003. Envrionmental factors influencing the microbial contamination of commercially harvested shellfish.. *Water Science and Technology,* Issue 47, pp. 65-70.

Mallin, M. A. et al., 2001. Demographis, landscape and meterological factors controlling the microbial pollution of coastal waters. *Hydrobiologica,* Issue 460, pp. 185-193.

Marine Harvest (Scotland) Ltd, 2003. *Hydrographic report: Laga Bay, Loch Sunart,* Rotho Station: Marine Harvest (Scotland) Ltd.

Marine Harvest (Scotland) Ltd, 2004a. *Hydrographic Survey Camus Glas, Laga Bay, Loch Sunart Febuary 2004,* Ratho Station: Marine Harvest (Scotland) Ltd.

Marine Harvest (Scotland) Ltd, 2004b. *Hydrographic Survey Invasion Bay, Loch Sunart October 2004,* Ratho Station: Marine Harvest (Scotland) Ltd.

Marine Harvest (Scotland) Ltd, 2004c. *Hydrographic survey Glencripisdale, Loch Sunart, November 2004,* Ratho Park: Marine Harvest (Scotland) Ltd.

Marine Scotland, 2012. *Locational Guidelines for the authorisation of marine fish farmes in Scottish waters.,* Edinburgh: Produced for Marine Scotland Science by the Marine Scotland Performance Graphics Group.

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

Resipole Farm, 2010. *Things to Do.* [Online] Available at: http://www.resipole.co.uk/thingstodo.html [Accessed 21 11 2013].

Scottish Government, 2012. *Consultation Analysis: Delivering Scotland's River Basin Management Plans - An integrated approach to the protection of shellfish growing waters,* Edinburgh: Scottish Government.

Scottish Natural Heritage, 2006. *News: Project Launched to Protect Birds from Foreign Marauders.* [Online] Available at: http://www.snh.org.uk/press/detail.asp?id=1347 [Accessed 21 11 2013].

Sunart Oakwoods, 2013. *Garbh Eilean Wildlife Hide.* [Online] Available at: http://www.sunartoakwoods.org.uk/getactive/aboutthehide.htm [Accessed 21 11 2013].

Willis, K. J., Gillibrand, P. A., Cromey, C. J. & Black, K. D., 2005. Sealice treatments on slamon farms have no adverse effects on zooplankton communities: a case study. *Marrine Pollution Bulletin,* Volume 50, pp. 806-816.

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1. General Information on Wildlife Impacts

Pinnipeds

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

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

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

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

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

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

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

Cetaceans

As mammals, whales and dolphins would be expected to have resident populations of *E. coli* and other faecal indicator bacteria in the gut. Little is known about the concentration of indicator bacteria in whale or dolphin faeces, in large part because the animals are widely dispersed and sample collection difficult.

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

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

Birds

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

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

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

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

Deer

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

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

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

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

Other

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

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

References

Alderisio, K. A. & DeLuca, N., 1999. Seasonal enumeration of fecal coliform bacretia from the feces of ring-billed gulls (Larus delawerensis) and Canada geese (Branta canadensis). *Applied and Environmental Microbiology,* 65(12), pp. 5628-5630.

Gauthier, G. & Bedard, J., 1986. Assessment of faecal output in geese. *Journal of Applied Ecology,* 23(1), pp. 77-90.

Lisle, J. T., Smith, J. J., Edwards, D. D. & McFeters, G. A., 2004. Occurence of microbial indicators and Clostridium perfringens in wastewater, water coloum samples, sediments, drinking water and weddel seal faeces collected at McMurdo Station, Antarctica. *Applied and Environmental Microbiology,* 70(12), pp. 7269-7276.

Poppe, C. et al., 1998. Salmonella typhimurium DT104: a virulent and drug-resistant pathogen. *The Canadian Veterinary Journal,* 39(9), pp. 559-565.

Scottish National Heritage, n.d. *Otters and Development.* [Online] Available at: http://www.snh.org.uk/publications/on-line/wildlife/otters/biology.asp [Accessed 10 10 2012].

Stoddard, R. A. et al., 2005. Salmonella and Campylobacter spp. in Northern Elephant Seals, California. *Emerging Infections Diseases,* 11(12), pp. 1967-1969.

2. Tables of Typical Faecal Bacteria Concentrations

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

Indicator organism	**Base-flow conditions**				**High-flow conditions**			
Treatment levels and specific types: Faecal coliforms	n^c	Geometric mean	Lower 95% CI	Upper 95% CI	n^c	Geometric mean	Lower 95% CI	Upper 95% CI
Untreated	252	$1.7 \times 10^{7*}$ (+)	1.4×10^{7}	2.0×10^{7}	282	$2.8 \times 10^{6*}$ (-)	2.3×10^{6}	3.2×10^{6}
Crude sewage discharges	252	$1.7 \times 10^{7*}$ (+)	1.4×10^{7}	2.0×10^{7}	79	$3.5 \times 10^{6*}$ (-)	2.6×10^{6}	4.7×10^{6}
Storm sewage overflows					203	2.5×10^{6}	2.0×10^{6}	2.9×10^{6}
Primary	127	$1.0 \times 10^{7*}$ (+)	8.4×10^{6}	1.3×10^{7}	14	4.6×10^{6} (-)	2.1×10^{6}	1.0×10^{7}
Primary settled sewage	60	1.8×10^{7}	1.4×10^{7}	2.1×10^{7}	8	5.7×10^{6}		
Stored settled sewage	25	5.6×10^{6}	3.2×10^{6}	9.7×10^{6}	1	8.0×10^{5}		
Settled septic tank	42	7.2×10^{6}	4.4×10^{6}	1.1×10^{7}	5	4.8×10^{6}		
Secondary	864	$3.3 \times 10^{5*}$ (-)	2.9×10^{5}	3.7×10^{5}	184	$5.0 \times 10^{5*}$ (+)	3.7×10^{5}	6.8×10^{5}
Trickling filter	477	4.3×10^{5}	3.6×10^{5}	5.0×10^{5}	76	5.5×10^{5}	3.8×10^{5}	8.0×10^{5}
Activated sludge	261	$2.8 \times 10^{5*}$ (-)	2.2×10^{5}	3.5×10^{5}	93	$5.1 \times 10^{5*}$ (+)	3.1×10^{5}	8.5×10^{5}
Oxidation ditch	35	2.0×10^{5}	1.1×10^{5}	3.7×10^{5}	5	5.6×10^{5}		
Trickling/sand filter	11	2.1×10^{5}	9.0×10^{4}	6.0×10^{5}	8	1.3×10^{5}		
Rotating biological contactor	80	1.6×10^{5}	1.1×10^{5}	2.3×10^{5}	2	6.7×10^{5}		
Tertiary	179	1.3×10^{3}	7.5×10^{2}	2.2×10^{3}	8	9.1×10^{2}		
Reed bed/grass plot	71	1.3×10^{4}	5.4×10^{3}	3.4×10^{4}	2	1.5×10^{4}		
Ultraviolet disinfection	108	2.8×10^{2}	1.7×10^{2}	4.4×10^{2}	6	3.6×10^{2}		

Source: (Kay, et al., 2008b)

Table 3 – Geometric mean (GM) and 95% confidence intervals (CIs) of the GM faecal indicator organism (FIO) concentrations (cfu/100ml) under base- and high-flow conditions at the 205 sampling points and for various subsets, and results of paired t-tests to establish whether there are significant elevations at high flow compared with base flow

FIO	*n*	**Base Flow**			**High Flow**		
Subcatchment land use		Geometric mean	Lower 95% CI	Upper 95% CI	Geometric mean[a]	Lower 95% CI	Upper 95% CI
Total coliforms							
All subcatchments	205	5.8×10^{3}	4.5×10^{3}	7.4×10^{3}	7.3×10^{4}**	5.9×10^{4}	9.1×10^{4}
Degree of urbanisation							
Urban	20	3.0×10^{4}	1.4×10^{4}	6.4×10^{4}	3.2×10^{5}**	1.7×10^{5}	5.9×10^{5}
Semi-urban	60	1.6×10^{4}	1.1×10^{4}	2.2×10^{4}	1.4×10^{5}**	1.0×10^{5}	2.0×10^{5}
Rural	125	2.8×10^{3}	2.1×10^{3}	3.7×10^{3}	4.2×10^{4}**	3.2×10^{4}	5.4×10^{4}
Rural subcatchments with different dominant land uses							
≥75% Imp pasture	15	6.6×10^{3}	3.7×10^{3}	1.2×10^{4}	1.3×10^{5}**	1.0×10^{5}	1.7×10^{5}
≥75% Rough Grazing	13	1.0×10^{3}	4.8×10^{2}	2.1×10^{3}	1.8×10^{4}**	1.1×10^{4}	3.1×10^{4}
≥75% Woodland	6	5.8×10^{2}	2.2×10^{2}	1.5×10^{3}	6.3×10^{3}*	4.0×10^{3}	9.9×10^{3}
Faecal coliform							
All subcatchments	205	1.8×10^{3}	1.4×10^{3}	2.3×10^{3}	2.8×10^{4}**	2.2×10^{4}	3.4×10^{4}
Degree of urbanisation							
Urban	20	9.7×10^{3}	4.6×10^{3}	2.0×10^{4}	1.0×10^{5}**	5.3×10^{4}	2.0×10^{5}
Semi-urban	60	4.4×10^{3}	3.2×10^{3}	6.1×10^{3}	4.5×10^{4}**	3.2×10^{4}	6.3×10^{4}
Rural	125	8.7×10^{2}	6.3×10^{2}	1.2×10^{3}	1.8×10^{4}**	1.3×10^{4}	2.3×10^{4}
Rural subcatchments with different dominant land uses							
≥75% Imp pasture	15	1.9×10^{3}	1.1×10^{3}	3.2×10^{3}	5.7×10^{4}**	4.1×10^{4}	7.9×10^{4}
≥75% Rough Grazing	13	3.6×10^{2}	1.6×10^{2}	7.8×10^{2}	8.6×10^{3}**	5.0×10^{3}	1.5×10^{4}
≥75% Woodland	6	3.7×10	1.2×10	1.2×10^{2}	1.5×10^{3}**	6.3×10^{2}	3.4×10^{3}
Enterococci							
All subcatchments	205	2.7×10^{2}	2.2×10^{2}	3.3×10^{2}	5.5×10^{3}**	4.4×10^{3}	6.8×10^{3}
Degree of urbanisation							
Urban	20	1.4×10^{3}	9.1×10^{2}	2.1×10^{3}	2.1×10^{4}**	1.3×10^{4}	3.3×10^{4}
Semi-urban	60	5.5×10^{2}	4.1×10^{2}	7.3×10^{2}	1.0×10^{4}**	7.6×10^{3}	1.4×10^{4}
Rural	125	1.5×10^{2}	1.1×10^{2}	1.9×10^{2}	3.3×10^{3}**	2.4×10^{3}	4.3×10^{3}
Rural subcatchments with different dominant land uses							
≥75% Imp. pasture	15	2.2×10^{2}	1.4×10^{2}	3.5×10^{2}	1.0×10^{4}**	7.9×10^{3}	1.4×10^{4}
≥75% Rough Grazing	13	4.7×10	1.7×10	1.3×10^{2}	1.2×10^{3}**	5.8×10^{2}	2.7×10^{3}
≥75% Woodland	6	1.6×10	7.4	3.5×10	1.7×10^{2}**	5.5×10	5.2×10^{2}
[a] Significant elevations in concentrations at high flow are indicated: **po0.001, *po0.05.							
[b] Degree of urbanisation categorised according to percentage built-up land: 'Urban' (X10.0%), 'Semi-urban' (2.5–9.9%) and 'Rural' (o2.5%).							

Source: (Kay, et al., 2008a)

Table 4 - Comparison of faecal indicator concentrations (average numbers/g wet weight) excreted in the faeces of warm-blooded animals

Animal	Faecal coliforms (FC) number	Excretion (g/day)	FC Load (numbers/day)
Chicken	1,300,000	182	2.3×10^8
Cow	230,000	23,600	5.4×10^9
Duck	33,000,000	336	1.1×10^{10}
Horse	12,600	20,000	2.5×10^8
Pig	3,300,000	2,700	8.9×10^8
Sheep	16,000,000	1,130	1.8×10^{10}
Turkey	290,000	448	1.3×10^8
Human	13,000,000	150	1.9×10^9

Source: (Gauthier & Bedard, 1986)

References

Gauthier, G. & Bedard, J., 1986. Assessment of faecal output in geese. *Journal of Applied Ecology,* 23(1), pp. 77-90.

Kay, D. et al., 2008a. Faecal indicator organism concentrations and catchment export coefficients in the UK. *Water Research,* 42(10/11), pp. 2649-2661.

Kay, D. et al., 2008b. Faecal indicator organism in concentration sewage and treated effluents. *Water Research,* 42(1/2), pp. 442-454.

3. Statistical Data

```
One-way ANOVA: logec versus Season

Source  DF      SS     MS     F      P
Season   3   4.419  1.473  4.73  0.005
Error   53  16.506  0.311
Total   56  20.925

S = 0.5581   R-Sq = 21.12%   R-Sq(adj) = 16.66%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level   N    Mean   StDev   -+---------+---------+---------+--------
1      16  1.2863  0.3605   (-------*-------)
2      14  1.8223  0.6396                 (-------*--------)
3      13  1.9251  0.8163                   (--------*--------)
4      14  1.3614  0.3091    (--------*-------)
                           -+---------+---------+---------+--------
                          1.05      1.40      1.75      2.10

Pooled StDev = 0.5581

Grouping Information Using Tukey Method

Season   N    Mean  Grouping
3       13  1.9251  A
2       14  1.8223  A B
4       14  1.3614  A B
1       16  1.2863    B

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Season

Individual confidence level = 98.95%

Season = 1 subtracted from:

Season    Lower  Center   Upper  ---------+---------+---------+---------+
2       -0.0055  0.5360  1.0776                    (--------*--------)
3        0.0863  0.6388  1.1914                     (---------*--------)
4       -0.4664  0.0751  0.6166             (--------*--------)
                                 ---------+---------+---------+---------+
                                       -0.60      0.00      0.60      1.20


Season = 2 subtracted from:

Season    Lower   Center   Upper  ---------+---------+---------+---------+
3       -0.4672   0.1028  0.6727             (---------*--------)
4       -1.0202  -0.4609  0.0984    (--------*---------)
                                  ---------+---------+---------+---------+
                                        -0.60      0.00      0.60      1.20


Season = 3 subtracted from:

Season    Lower   Center   Upper  ---------+---------+---------+---------+
4       -1.1337  -0.5637  0.0062  (---------*--------)
                                  ---------+---------+---------+---------+
                                        -0.60         0.00         0.60         1.20
```

4. Hydrographic Assessment Glossary

The following technical terms may appear in the hydrographic assessment.

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

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

MHW. Mean High Water, The highest level that tides reach on average.

MHWN. Mean High Water Neap, The highest level that tides reach on average during neap tides.

MHWS. Mean High Water Spring, The highest level that tides reach on average during spring tides

MLW. Mean Low Water, The lowest level that tides reach on average.

MLWN. Mean Low Water Neap, The lowest level that tides reach on average during neap tides.

MLWS. Mean Low Water Spring, The lowest level that tides reach on average during spring tides.

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

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

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

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

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

Spring/Neap Tides. Spring tides occur during or just after new moon and full moon when the tide-generating force of the sun acts in the same direction as that of the moon, reinforcing it. The tidal range is greatest and tidal currents strongest during spring tides.

Neap tides occur during the first or last quarter of the moon when the tide-generating forces of the sun and moon oppose each other. The tidal range is smallest and tidal currents are weakest during neap tides.

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

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

Return flow. A surface flow at the surface may be accompanied by a compensating flow in the opposite direction at the bed.

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

5. Shoreline Survey Report

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

Document Number	B0067_Shoreline 0021

Revision History

Revision	Changes	Date
A	Issue for internal review	12/09/2013
01	First formal issue to Cefas	04/10/2013
02	Revision addressing comments on Issue 01	07/10/2013

	Name & Position	Date
Author	Lars Brunner, Peter Lamont	10/09/2013
Checked	Andrea Veszelovszki, John Hausrath	04/10/2013
Approved	Andrea Veszelovszki	17/10/2013

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

Shoreline Survey Report

Production area:	Loch Sunart
Site name:	Liddesdale
SIN:	HL-206-1237-08
Species:	Common Mussel
Harvester:	Mr Alan Byrne
Local Authority:	Highland Council; Lochaber
Status:	Existing area
Date Surveyed:	02nd & 03rd September 2013
Surveyed by:	Lars Brunner & Peter Lamont
Existing RMP:	NM 7842 6016
Area Surveyed:	Mussel farm site, and southern shore of Loch Sunart adjacent to farm, along with northern shore of Loch westwards from the village of Strontian.

Note: The survey plan quotes the name of the site as *Liddesdale*, but the ordnance survey quotes it as *Liddesdale* on all maps. To avoid any confusion the correct spelling, *Liddesdale, has been used throughout the report*.

Weather

There was intermittent rainfall in the week preceding the survey, with some heavy rain 24hrs immediately before the survey.

Monday, 02nd September: 100% cloud cover, wind W/SW F2-3, gusting to 4. Sea state slight with good to moderate visibility. Intermittent light showers.

Tuesday, 03rd September: 100% cloud cover, decreasing to 60% later, wind S/SW 1-2. Sea state slight. Light rain showers with good visibility.

Stakeholder engagement during the survey

It was not possible to meet the harvester in person during the survey. Contact was made by phone and e-mail in the weeks preceding the survey, but due to Mr Byrne's work commitments it was not possible for him to be present at the site in Liddesdale while the survey was being undertaken. Contact was also made by phone and e-mail with Mr Stephen Lewis, the shellfish sampling officer at Highland Council, who provided us with information as to the current state of the Liddesdale site. Unfortunately, although contact was made shortly before the survey, it was not possible to arrange a suitable time to meet on site.

Fishery

The cultivation area at Liddesdale consists of 6x300m longlines of Common Mussel (*Mytilus edulis*). The site itself sits on the southern shore of Loch Sunart, just off the village of Liddesdale, and around 3.5km to the SW of Strontian village. The stock present on site appears to be of two age classes – the three lines to the south of the site contain more conventional droppers with older mussels (Fig.3) while the three lines to the north of the site contain short, ladder style droppers (Fig. 4) with young, newly settled spat. On the longer droppers the number of mussels present decreased significantly after approximately 2-3m depth. Information on the exact lengths of the droppers was not gathered on site as there was no suitable equipment available to lift the lines. The survey team were informed by the skipper of the charter vessel, Andy Jackson from Ardnamurchan Charters, that the loch waters can become very stratified after heavy rain and this was reflected in the salinities observed at the surface (see CTD data provided separately).

Information provided by the harvester, Mr Byrne, indicated that the site was originally set up for spat collection. Later, an application was filed to move the site to another location but permission was not granted. Now the site has mature mussels and is used as a back-up site for the occasions when there are other site closures due to bio-toxins. As a result of this, harvest at this site is only undertaken during summer months. The appearance of tubeworms on shells in greater numbers in the autumn months also restricts harvest to the summer months. The method of harvest is simple line stripping.

Sewage Sources

Excepting the village of Strontian, the survey area is countryside and sparsely inhabited, especially on the southern side of the loch. The village of Strontian has a collection of small shops and a set of public toilets, and outside the village to the west along the northern shore there are a series of detached houses, with a small agglomeration of houses plus the Ben View Hotel at Ardnastang. One septic tank was observed on the northern shore, with an outfall possibly directly into Allt Ard nan Staing (waypoint 58 and Fig. 18). No other discharges were observed on the northern shore. On the southern shore of the loch there are isolated detached houses – no discharges were noted on the shoreline.

Seasonal Population

Two hotels (Kilcamb Lodge and Strontian) were noted in the village of Strontian as well as one (Ben View) in the village of Ardnastang. There were several B&Bs present on the northern side of Loch Sunart and in Strontian itself. No campsites were noted on the survey. It was not possible to determine how many buildings on the northern loch survey route are holiday homes. The properties passed on the

survey route on the southern shore of the loch appear to be holiday rental properties associated with the Laudale estate, although this could not be confirmed during the survey.

Boats/Shipping

There is a public jetty to the east of Strontian village at NM 82339 60756, as well as a private jetty/pier at the mouth of the Strontian River (NM 81291 61389). There is also a disused jetty at NM 79626 61156 on the northern shore (Fig.17). On the southern side of the loch at NM 78733 59729 there is a private jetty/slipway adjacent to some of the Laudale estate houses.

Little was seen in the way of vessels on the loch, although some pleasure craft were noted at anchor near to the public jetty to the east of the village, and also just off the mouth of the Strontian River (Fig.14). A few small pleasure craft were also present near to the village of Ardnastang, and on the southern shore of the loch off the private pier/jetty.

Farming and Livestock

Only two sheep were observed during the survey, on the southern shore at the location of waypoint 17 (see notes for waypoint 31). No other livestock were observed during the survey. On the southern shore the land appears ungrazed along the survey route. Along the northern survey route the land above the shore is mostly native forest west of the Kilcamb Lodge Hotel grounds (Fig.15) at the mouth of the Strontian River.

Land Use

The land use in the area of the survey is predominantly rural in nature. On the southern shore of Loch Sunart the immediate shoreline is not grazed, and the area above the roadside is a mixture of native and plantation forestry. On the northern side of Loch Sunart the village of Strontian is the main population centre for the area, although, west of the village along the survey route, unused land has developing native woodland e.g. Fig.16. From road level (A861) it is possible to see smaller areas of farmed land, which appear to conform to a crofting system. No industry, heavy or otherwise, was observed.

Land Cover

On the southern shores of the loch, there is a mixture of wild grassland, heath and plantation/native forestry. On the northern shore of the loch, a mixture of native woodland, wild grassland & heath was observed, along with smaller areas of farmed grazing alongside the A861 main road.

Watercourses

The largest watercourse in the area is the Strontian River (Fig.11), which discharges into Loch Sunart on its north shore at NM 81355 61067. On the southern shore of the loch, the Allt na h-Airigh enters the loch at NM 78834 59746, and the Liddesdale Burn (Fig.10) enters at NM 77801 59666. On the northern shore numerous smaller watercourses enter the loch, the largest of which (after the Strontian River) are the Burn an Uillt at NM 79901 61298 and the Allt a Mhuilinn at NM 78922 61139.

Wildlife/Birds

Very few birds were seen during the survey, with only one grey heron and two pigeons noted on the second day of survey. On the first day of the survey a red deer stag was seen grazing on the southern foreshore (Fig.8) and on the second day an otter was observed in the sea near the north shore (Waypoint 52).

Shoreline Survey Maps

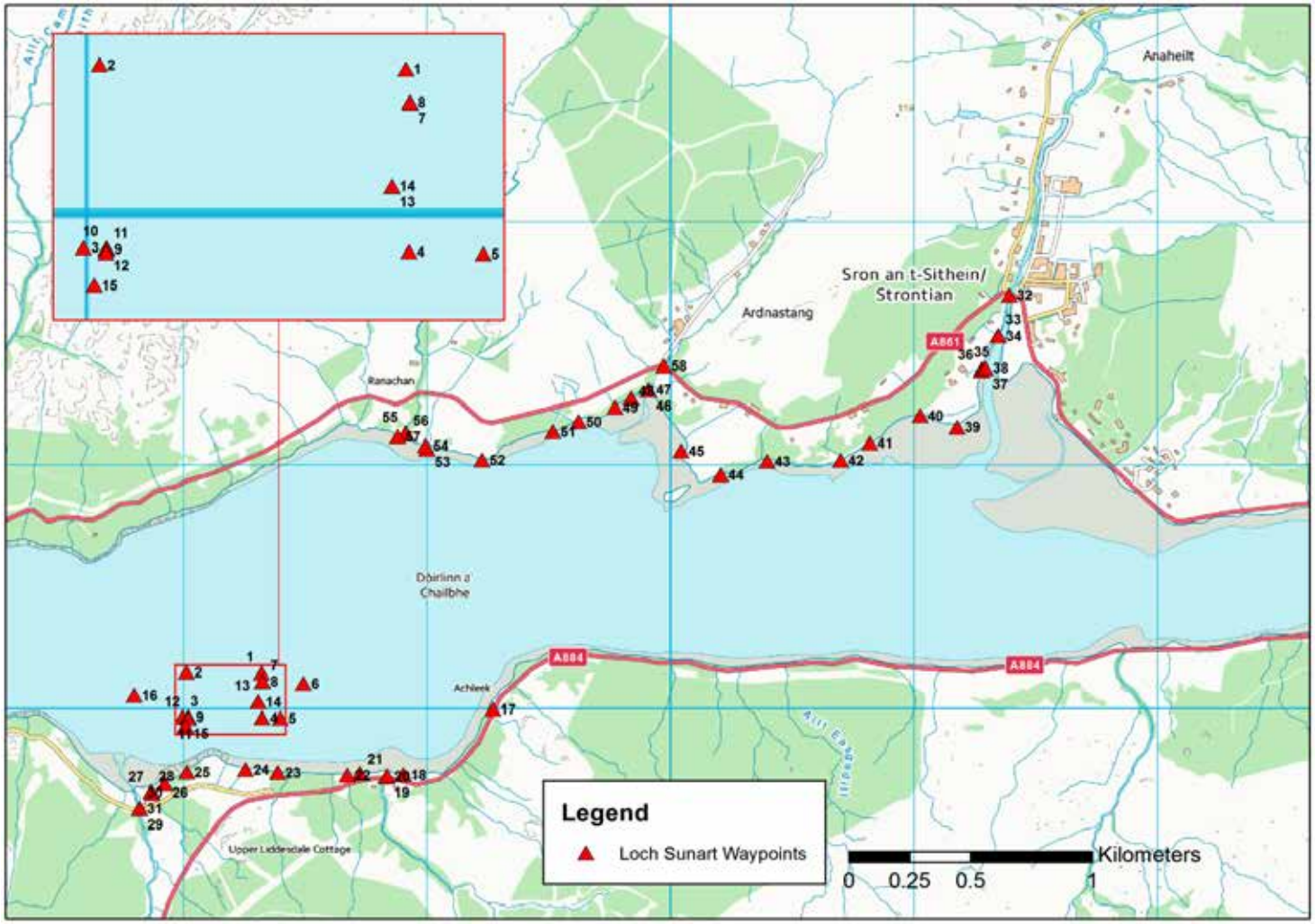

Figure 1. Waypoints

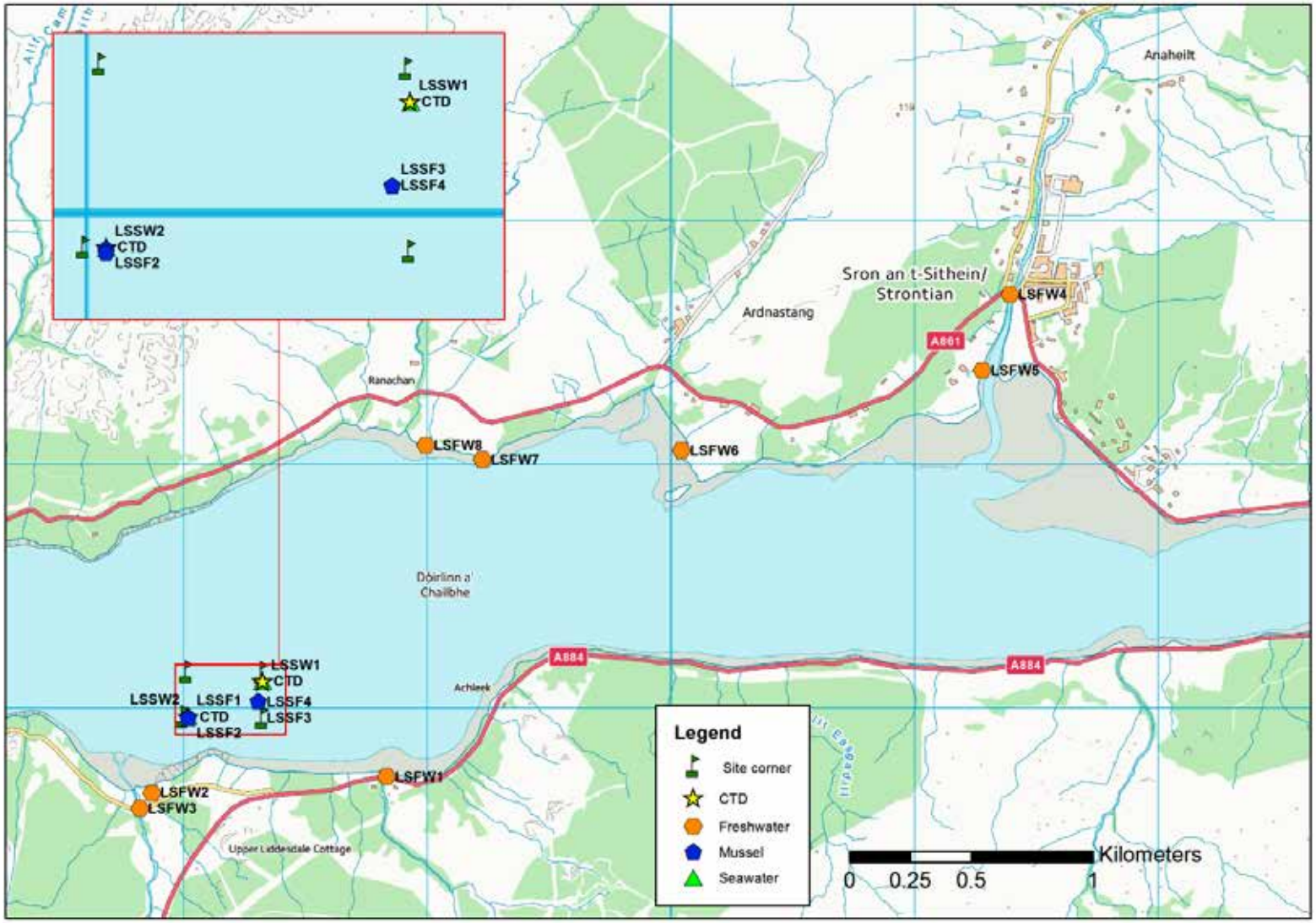

Figure 2. Samples

Table 1 Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	02/09/2013	11:16	NM 78319 60144	178320	760145			Corner of mussel line array, NE.
2	02/09/2013	11:18	NM 78012 60148	178012	760149			Corner of mussel line array, NW.
3	02/09/2013	11:18	NM 77996 59965	177996	759965			Corner of mussel line array, SW.
4	02/09/2013	11:19	NM 78323 59961	178323	759961			Corner of mussel line array, SE.
5	02/09/2013	11:20	NM 78397 59959	178398	759959			E side of grid system (anchor mooring system for longlines), S extremity.
6	02/09/2013	11:21	NM 78492 60102	178492	760102			E side of grid system (anchor mooring system for longlines), N extremity.
7	02/09/2013	11:27	NM 78324 60110	178325	760110	Fig 3	LSSW1	NE end of 2nd line from N, line only had small spat mussels present. Seawater sample taken.
8	02/09/2013	11:28	NM 78324 60111	178324	760112	Fig 4	CTD	N end of 2nd line from N. Small mussels on very shallow ladder style droppers (<0.5 m). CTD cast taken.
9	02/09/2013	11:44	NM 78019 59964	178019	759964		LSSW2	Moved to SW end of site as no mussels present at NE end. Seawater sample taken.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
10	02/09/2013	11:45	NM 78019 59965	178019	759966		CTD	CTD cast taken.
11	02/09/2013	11:48	NM 78018 59963	178019	759964		LSSF1	Mussel sample taken from top of line.
12	02/09/2013	11:59	NM 78018 59960	178019	759960	Fig 5	LSSF2	Mussel sample taken from 4m depth. Total line depth about 10 m. Only sea squirts below 4 m.
13	02/09/2013	12:09	NM 78306 60027	178306	760027		LSSF3	Mussel sample taken from surface.
14	02/09/2013	12:09	NM 78306 60027	178306	760028		LSSF4	Mussel sample taken from 4m depth. Total line depth around 10m. Only sea squirts below 4m.
15	02/09/2013	12:20	NM 78007 59927	178007	759928			W side of grid system (anchor mooring system for longlines), S extremity.
16	02/09/2013	12:22	NM 77797 60054	177797	760054			W side of grid system (anchor mooring system for longlines), N extremity.
17	02/09/2013	12:58	NM 79271 59997	179271	759997			Start of shore survey track S shore of upper Loch Sunart. No discharge visible from house above shore (i.e. no pipes present on shore).
18	02/09/2013	13:15	NM 78902 59727	178903	759728			Site of former fish farm base, now a private house - no pipes or material on shore

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
19	02/09/2013	13:17	NM 78833 59718	178833	759718	Fig 6	LSFW1	Freshwater sample LSFW1. Sample associated with observations made in waypoint 20.
20	02/09/2013	13:20	NM 78834 59722	178835	759722			Observations: width 5 m, flows (**1**) depth 50 cm, 0.0380 m/s SD 0.042 (**2**) depth 74 cm, 0.272 m/s SD 0.071.
21	02/09/2013	13:31	NM 78723 59733	178724	759733	Fig 7		Old yard - appears disused and no signs of recent activity. No discharges visible on shoreline. Two moorings present with 1 yacht moored and 1 mussel harvesting raft.
22	02/09/2013	13:33	NM 78672 59725	178673	759726			Small stream not sampled because flowing from uninhabited woodland above.
23	02/09/2013	13:40	NM 78385 59736	178386	759737	Fig 8		Red deer stag grazing on shore.
24	02/09/2013	13:43	NM 78255 59748	178255	759749			Small stream not sampled because flowing from uninhabited woodland above.
25	02/09/2013	13:49	NM 78012 59737	178013	759738			Liddesdale Bay and abandoned building.
26	02/09/2013	13:53	NM 77922 59692	177922	759692			Photos taken of buildings, rock slipway plus mussel farm. Some sheep droppings present on shore.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
27	02/09/2013	13:56	NM 77870 59651	177870	759652	Fig 9	LSFW2	Small stream by dwelling (estate letting property) has section of what looks like old, broken, unused sewage pipe. Extra freshwater sample taken in case of contamination. Sample associated with observations in waypoint 28.
28	02/09/2013	14:01	NM 77867 59659	177867	759660			Observations: width 90 cm, depth 13 cm, flow 0.043 m/s SD 0.012
29	02/09/2013	14:06	NM 77820 59589	177820	759589	Fig 10	LSFW3	Freshwater sample LSFW3. Sample associated with observations in waypoint 30.
30	02/09/2013	14:08	NM 77818 59589	177818	759590			Observations : width 5 m, flows (**1**) depth 20 cm 0.613 m/s SD 0.061 (**2**) depth 24 cm, 0.825 m/s SD 0.079 (**3**) depth 14 cm, 0.711 m/s SD 0.031 (**4**) depth 15 cm 0.378 m/s SD 0.034. Stream bed under the bridge is smooth bedrock facilitating measurement.
31	02/09/2013	14:14	NM 77818 59589	177819	759590			End of survey S shoreline Day 1. On return to van two sheep seen on the shore at site of WP17.
32	03/09/2013	9:12	NM 81391 61698	181392	761698	Fig 11		Star of survey Day 2. No freshwater sample at bridge because of steep banks and fast flow - not safe to access.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
33	03/09/2013	9:19	NM 81346 61531	181346	761532	Fig 12	LSFW4	Extra freshwater sample taken at small stream running from hotel grounds. Sample taken because of houses immediately above (including one under construction). Sample associated with observations in waypoint 34.
34	03/09/2013	9:23	NM 81348 61531	181348	761531			Observations: width 60 cm, depth 21 cm, flow 0.130 m/s SD 0.017.
35	03/09/2013	9:28	NM 81280 61396	181281	761396			Pontoon plus slipway for hotel.
36	03/09/2013	9:29	NM 81278 61386	181278	761387			Small stream running into main river - not sampled - no houses adjacent.
37	03/09/2013	9:33	NM 81291 61396	181292	761396		LSFW5	Returned to slipway to sample main river as it was the best place to sample before the river entered Loch Sunart. The river was still very deep and fast flowing at this point (in spate), so it was not possible to take flow measurements properly. Freshwater sample (LSFW5) taken. Sample associated with observations in waypoint 38.
38	03/09/2013	9:37	NM 81293 61398	181293	761399			Observations: width 15 m (visual estimate); flow 0.0806 m/s SD 0.081. Depth at side of slipway approx. 80cm. No further measurements possible due to depth of river.
39	03/09/2013	9:45	NM 81178 61155	181179	761155	Figs 13, 14 and 15		Photo of Kilcamb Lodge Hotel, L. Sunart W and E. Total of 5 moorings off bay, 3 unoccupied and 2 with pleasure craft moored.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
40	03/09/2013	9:49	NM 81025 61203	181026	761203			Running stream, not sampled, issuing from woods with no sign of housing.
41	03/09/2013	9:54	NM 80819 61089	180820	761090			Small boat launching facility for recreational use.
42	03/09/2013	9:58	NM 80699 61018	180700	761018			Small stream similar to waypoint 40.
43	03/09/2013	10:05	NM 80397 61014	180398	761015			Small stream similar to waypoint 40.
44	03/09/2013	10:14	NM 80207 60959	180207	760959			Small stream similar to waypoint 40.
45	03/09/2013	10:22	NM 80044 61058	180044	761058			Small stream similar to waypoint 40. Birds - 1 heron, 2 pigeons.
46	03/09/2013	10:29	NM 79910 61310	179911	761310	Fig 16	LSFW6	Freshwater sample. Sample associated with observations in waypoint 47.
47	03/09/2013	10:31	NM 79909 61309	179910	761309			Observations: width 2.1 m, depth 18 cm, flow 1.015 m/s SD 0.072.
48	03/09/2013	10:36	NM 79838 61274	179838	761274			Small stream similar to waypoint 40.
49	03/09/2013	10:38	NM 79772 61236	179773	761237			Small stream similar to waypoint 40.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
50	03/09/2013	10:43	NM 79622 61177	179623	761178	Fig 17		Old stone jetty with some boats above shoreline. 4 moorings present with 2 occupied, one with a small pleasure craft, and one with a commercial raft.
51	03/09/2013	10:47	NM 79517 61136	179518	761137			Small stream similar to waypoint 40.
52	03/09/2013	10:56	NM 79226 61021	179227	761021			Wildlife: otter seen in sea by shoreline.
53	03/09/2013	11:03	NM 79000 61064	179000	761065		LSFW7	Freshwater sample. Sample associated with observations in waypoint 54.
54	03/09/2013	11:07	NM 78993 61079	178993	761080			Observation: width 90 cm, depth 4 cm, flow 0.433 m/s SD 0.009
55	03/09/2013	11:14	NM 78914 61128	178914	761129		LSFW8	Freshwater sample. Sample associated with observations in waypoint 56.
56	03/09/2013	11:16	NM 78911 61131	178912	761132			Observations: width 7 m (**1**) depth 20 cm, flow 0.110 m/s SD0.008; (**2**) depth 32 cm, flow 0.226 SD0.021; (**3**) depth 24 cm, flow 0.228 m/s SD 0.012: (**4**) depth 31 cm, flow 0.284 SD0.017.
57	03/09/2013	11:24	NM 78880 61117	178880	761117			End of survey day 2.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
58	03/09/2013	11:51	NM 79972 61407	179972	761407	Fig 18		Septic tank outfall possibly directly into Allt Ard nan Staing (NM799614), noted while walking along main A861 road back to start point. Photo taken.

Photographs referenced in the table can be found attached as Figures 3-18.

Sampling

Sampling proceeded according to plan on the 2nd and 3rd September.

Water samples were collected at the sites marked on the Loch Sunart samples map shown in Figures 1 & 2.

All the samples were transferred to a Biotherm 30 box (2nd September) and a Biotherm 10 box (3rd September) (with ice packs) and posted to the Glasgow Scientific Services (GSS) for *E.coli* analysis. All the samples were posted on the day of collection and all the samples were received the following day. The sample temperatures on arrival at the laboratory were recorded as 4.0°C (2nd) and 4.2 °C (3rd).

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

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

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (cfu/100ml)	Salinity (ppt)
1	02/09/2013	LSSW1	NM 78324 60110	Seawater	700	8.11
2	02/09/2013	LSSW2	NM 78019 59964	Seawater	100	1.59
3	02/09/2013	LSFW1	NM 78833 59718	Freshwater	90	
4	02/09/2013	LSFW2	NM 77870 59651	Freshwater	40	
5	02/09/2013	LSFW3	NM 77820 59589	Freshwater	50	
6	03/09/2013	LSFW4	NM 81391 61698	Freshwater	20	
7	03/09/2013	LSFW5	NM 81278 61386	Freshwater	350	
8	03/09/2013	LSFW6	NM 80044 61058	Freshwater	490	
9	03/09/2013	LSFW7	NM 79226 61021	Freshwater	260	
10	03/09/2013	LSFW8	NM 78993 61079	Freshwater	30	

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	Sample depths	E. coli (MPN/100g)
1	02/09/2013	LSSF1	NM 78018 59963	Mussel	surface	2400
2	02/09/2013	LSSF2	NM 78018 59960	Mussel	4m	2400
3	02/09/2013	LSSF3	NM 78306 60027	Mussel	surface	5400
4	02/09/2013	LSSF4	NM 78306 60027	Mussel	4m	230

Salinity Profiles

Two CTD profiles were taken, one at the NE end of the second line where the mussels were very small and the second at the SW side of the site.

The gathered data will be sent to customer as agreed previously on a separate Excel sheet.

Photographs

Fig 3: NE end of second line looking S. Waypoint 7, sample LSSW1.

Fig 4: Ladder style dropper present on the three northernmost longlines on the site with a covering of juvenile mussel spat (animals too small to sample).

Fig 5: General overview of the longlines at the Liddesdale Mussel farm, looking directly down Loch Sunart to the W. (Waypoint 12, location of LSSF2)

Fig 6: Allt na h-Airigh river running under A884 road – the site of freshwater sample LSFW1, Waypoint 19.

Fig 7: Commercial Harvest raft moored off S shore. Waypoint 21.

Fig 8: Typical shoreline along S shore of Loch Sunart, with rough ground above shore. Red deer stag grazing on the shoreline. Waypoint 23.

Fig 9: Section of broken pipe present in unnamed stream at waypoint 27. No evidence of discharge into bay, or inflow into stream above or below presence of pipe. Site of extra freshwater sample (LSFW2).

Fig 10: Liddesdale Burn running under unnamed, dead-end minor road – the site of freshwater sample LSFW3. Waypoint 29.

Fig 11: Strontian River taken from the road bridge in the village. Access to the banks and into the river to sample was not possible at this location. Waypoint 32.

Fig 12: Houses present near the mouth of the Strontian River. A small burn runs through the centre of the photo, and there was building work underway on the house (hidden by trees left of centre of photo). Waypoint 33, location of extra freshwater sample LSFW4.

Fig 13: View of the eastern portion of the village of Strontian, photo looking east, taken from waypoint 39.

Fig 14: View west along the loch from the Sunart river estuary with two moored pleasure craft right of centre, taken from waypoint 39.

Fig 15: View of Kilcamb Lodge Hotel, west of the Strontian river mouth, photo looking north, taken from waypoint 39.

Fig 16: Allt-ard-nan-Staing River, with housing adjacent. Waypoint 46. Location of sample LSFW6.

Fig 17: Jetty on northern shore of Loch Sunart, with boats on mooring offshore. Waypoint 50.

Fig 18: Tank observed on roadside while walking along main road back to start point. Drain at front of tank exits into river (Allt ard nan Staing) out of shot to the right. Waypoint for this photo is 58, and the river was sampled earlier in the survey at waypoint 46 (see also Fig. 16).

6. Consented discharges (source: SEPA)

Licence No.	NGR	Site Name	Discharge Type	Site Description	MDF (m^3/d)	DWF (m^3/d)	PE
CAR/L/1002906	NM 81300 60920	Strontian WwTP	Sewage (Public) Primary	Strontian STW, FE to Loch Sunart	1	228.69	945
CAR/L/1002907	NM 81263 60785	Strontian WwTP	Sewage (Public) Combined Sewer Overflow (CSO)	Strontian STW, CSO to Loch Sunart, Strontian, Ardnamurchan			
CAR/L/1009162	NM 73221 60896	Invasion Bay MCFF, Loch Sunart		Camas na h-Airbhe MCFF, Loch Sunart			
CAR/R/1009156	NM 72528 63839		Sewage (Private) Secondary	STW FE to u/n w/c			5
CAR/R/1010431	NM 82119 64218			FE to U/T of Allt na Meinne			8
CAR/R/1011402	NM 81241 61460						6
CAR/R/1014020	NM 83504 68296						6
CAR/R/1014971	NM 82155 63740						5
CAR/R/1015871	NM 80009 61401	Strontian Hatchery, Ardnastaing	Fish Farm Freshwater Tank or Hatchery	TE to Bun an Uillt			
CAR/R/1016462	NM 81906 63009		Sewage (Private) Primary	STE to Allt Nan Cailleach			5
CAR/R/1019030	NM 79980 61505						10
CAR/R/1020944	NM 82086 61021						6
CAR/R/1022832	NM 72517 63853						6
CAR/R/1023847	NM 81829 67516		Sewage (Private) Primary	STE to soakaway			5
CAR/R/1026500	NM 83087 65225		Sewage (Private) Primary	STE to Allt na Meinne			5
CAR/R/1026506	NM 83080 65240		Sewage (Private) Primary	STE to land			15
CAR/R/1027229	NM 84730 60700	Carnoch Hydro welfare facilites	Sewage (Private) Primary	STE to soakaway			15
CAR/R/1027305	NM 75650 61229		Sewage (Private) Primary	STE to Loch Sunart			5
CAR/R/1028694	NM 85290 60430	Carnoch Hydro, Carnoch Powerhouse, Ardgour	Sewage (Private) Primary	STE to soakaway			5

Licence No.	NGR	Site Name	Discharge Type	Site Description	MDF (m^3/d)	DWF (m^3/d)	PE
CAR/R/1030526	NM 76376 60747		Sewage (Private) Primary	STE to Allt Camas a Choirce			5
CAR/R/1032261	NM 81900 63830		Sewage (Private) Primary	STE to land			25
CAR/R/1036241	NM 81650 61200		Sewage (Private) Primary	STE to u/w			6
CAR/R/1037060	NM 72433 63871		Sewage (Private) Primary	STE to soakaway			5
CAR/R/1037130	NM 83080 65250		Sewage (Private) Primary	STE to soakaway			12
CAR/R/1037154	NM 81926 63273						5
CAR/R/1037215	NM 82107 63818		Sewage (Private) Primary	STE to soakaway			5
CAR/R/1037434	NM 81510 62720		Sewage (Private) Primary	STE to soakaway			5
CAR/R/1037461	NM 81440 62110		Sewage (Private) Primary	STE to land			5
CAR/R/1037546	NM 82081 64011						10
CAR/R/1037591	NM 81906 63407		Sewage (Private) Primary	STE to soakaway			5
CAR/R/1038148	NM 82292 64400						5
CAR/R/1038292	NM 82011 63663						5
CAR/R/1038295	NM 82130 63625		Sewage (Private) Primary	STE to Allt na Meinne			5
CAR/R/1038519	NM 80260 61200		Sewage (Private) Primary	STE to soakaway			5
CAR/R/1039194	NM 81890 67353						15
CAR/R/1039283	NM 82106 64159						5
CAR/R/1039333	NM 81428 62446		Sewage (Private) Primary	STE to U/T of Strontian River			5
CAR/R/1039422	NM 76263 60774						5
CAR/R/1039462	NM 75400 61390		Sewage (Private) Primary	STE to Allt Ard Airigh			8

Licence No.	NGR	Site Name	Discharge Type	Site Description	MDF (m^3/d)	DWF (m^3/d)	PE
CAR/R/1039469	NM 80118 61200		Sewage (Private) Primary	STE to soakaway			5
CAR/R/1039476	NM 81378 62327		Sewage (Private) Primary	STE to soakaway			5
CAR/R/1039485	NM 81407 62433		Sewage (Private) Primary	STE to U/T of Strontian River			5
CAR/R/1039541	NM 81763 62882		Sewage (Private) Primary	STE to U/T of Strontian River			5
CAR/R/1039573	NM 81450 62250						5
CAR/R/1039722	NM 80870 61337						5
CAR/R/1039744	NM 81428 62156						5
CAR/R/1039748	NM 82190 63960		Sewage (Private) Primary	STE to Allt na Meinne			5
CAR/R/1039893	NM 75428 61391		Sewage (Private) Primary	STE to Allt Arg Airigh			15
CAR/R/1040042	NM 77670 60690		Sewage (Private) Primary	STE to soakaway			6
CAR/R/1040101	NM 81973 63197						5
CAR/R/1040102	NM 82080 64173						5
CAR/R/1041170	NM 72614 63808						5
CAR/R/1041484	NM 82002 63110						5
CAR/R/1041952	NM 83504 68296						5
CAR/R/1042469	NM 81983 63433						5
CAR/R/1045836	NM 81420 62200		Sewage (Private) Primary	STE to soakaway			5
CAR/R/1048198	NM 81770 62349		Sewage (Private) Primary	STE to soakaway			5
CAR/R/1064972	NM 71630 64060						7
CAR/R/1064979	NM 72070 63940						5
CAR/R/1077214	NM 71800 64040						8
CAR/R/1077593	NM 84931 52779		Sewage (Private) Primary	STE to Soakaway			5
CAR/R/1077597	NM 83933 52960						5

Licence No.	NGR	Site Name	Discharge Type	Site Description	MDF (m^3/d)	DWF (m^3/d)	PE
CAR/R/1077616	NM 84404 52913						5
CAR/R/1077619	NM 84267 52792						5
CAR/R/1077621	NM 83880 52953						5
CAR/R/1077625	NM 83650 53200		Sewage (Private) Primary	STE to Soakaway			10
CAR/R/1077631	NM 83585 53116		Sewage (Private) Primary	STE to River Connich			13
CAR/R/1077636	NM 83354 53004						5
CAR/R/1077641	NM 82985 54064						5
CAR/R/1077651	NM 79210 55603						5
CAR/R/1083264	NM 80022 61488						5
CAR/R/1086098	NM 71770 64080		Sewage (Private) Primary	STE to soakaway			6
CAR/R/1086368	NM 79374 68816						50
CAR/R/1087459	NM 71590 64062						5
CAR/R/1087622	NM 79590 61270						5
CAR/R/1092397	NM 81961 62535						5
CAR/R/1094687	NM 73530 62990						5
CAR/R/1095473	NM 79970 61340		Sewage (Private) Primary	STE to soakaway			6
CAR/R/1097628	NM 80450 61200		Sewage (Private) Secondary	STW FE to soakaway			8
CAR/R/1099738	NM 79214 68687		Sewage (Private) Primary	STE to School Burn			5
CAR/R/1101773	NM 81440 61980						10
CAR/R/1105319	NM 82130 63280		Sewage (Private) Primary	STE to land			6
CAR/R/1106112	NM 72430 63870		Sewage (Private) Untreated	STE to soakaway			10

Licence No.	NGR	Site Name	Discharge Type	Site Description	MDF (m^3/d)	DWF (m^3/d)	PE
CAR/R/1106786	NM 81330 61800						5
CAR/R/1107817	NM 81430 61870						
CAR/R/1109601	NM 75020 52300		Sewage (Private) Primary	STE to soakaway			5
CAR/R/1109954	NM 74919 59874						20
CAR/R/1109955	NM 74829 59789						20
CAR/R/1109956	NM 74835 59794						20
CAR/R/1109957	NM 76358 56030						20
CAR/R/1109958	NM 78770 59690		Sewage (Private) Primary	STE to soakaway			20
CAR/R/1109959	NM 78128 59447						20
CAR/R/1109960	NM 79240 60020		Sewage (Private) Primary	STE to soakaway			20
CAR/R/1109961	NM 83306 60294						20
CAR/R/1114115	NM 81950 63970		Sewage (Private) Primary	STE to land			5
CAR/R/1114455	NM 81430 61870						5
CAR/R/1114457	NM 79180 68800		Sewage (Private) Primary	STE to land			5
WMX/N/0036100	NM 81961 62535			Drimnatorran Farm, Strontian, Acharacle, PH36 4JA			

Appendix 7. Loch Sunart CTD data

Data obtained during the shoreline survey. The locations of the casts are shown in Figure A7.1.

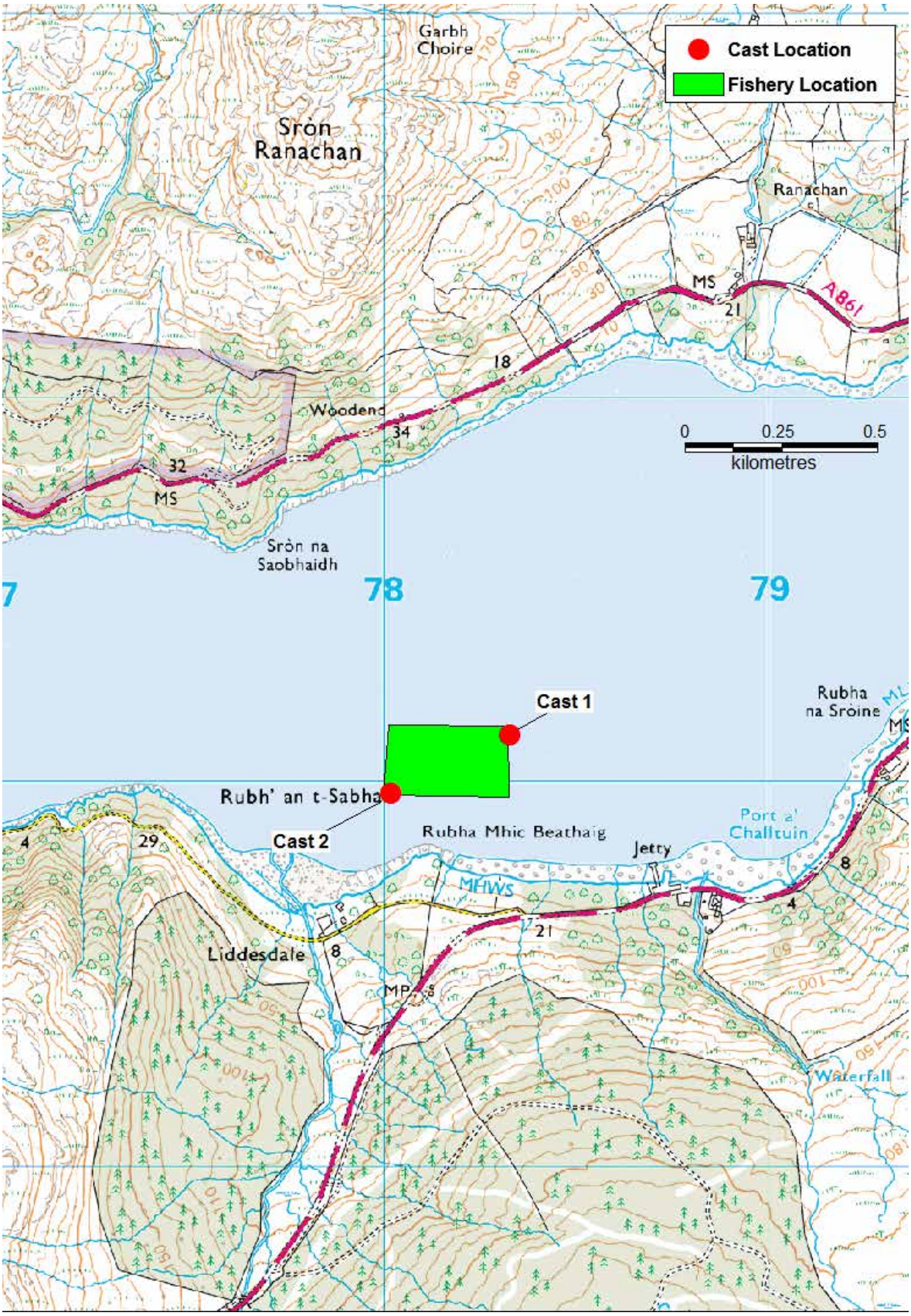

Figure A7.1 CTD cast locations

Cast 1 Data Header

% Device	10G100653
% File name	10G100653_20130902_103239
% Cast time (local)	10:32
% Sample type	Cast
% Cast data	Processed
% Location source	GPS
% Start latitude	56.6800587
% Start longitude	-5.620506
% Start GPS horizontal error(Meter)	5.400000095
% Start GPS vertical error(Meter)	6.880000114
% Start GPS number of satellites	6
% Cast duration (Seconds)	105.6
% Samples per second	5
Calibration Date	Mar-13
Calibration offset for Temperature	-0.08
Calibration offset for Salinity	0.18

Cast 1 CTD data (calibration offsets applied)

Depth (Meter)	Temperature (Celsius)	Salinity (Practical Salinity Scale)
0.151941341	13.66484853	8.334744473
0.455624217	13.77511736	9.913690272
0.75771711	14.00960709	22.30591003
1.057862739	14.0642253	27.00566435
1.357374235	14.02317996	27.90024242
1.656701117	13.98199177	28.61522793
1.955821988	13.97819953	29.71052785
2.254746503	13.9608819	30.34730341
2.553568053	13.95167255	30.61398252
2.852319854	13.95138489	30.96087364
3.151006376	13.95037838	31.19017344
3.449645916	13.9552922	31.37612324
3.748248277	13.95923934	31.51975926
4.04682792	13.95625881	31.57520218
4.3453907	13.95347428	31.66508218
4.643934772	13.94148519	31.73452716
4.942467604	13.92481413	31.75441113
5.240990521	13.90515904	31.81005483
5.539501118	13.87952631	31.84894572
5.83799849	13.85828755	31.91222974
6.136481008	13.84747873	31.9695048
6.434952361	13.84161772	32.00407129
6.73341723	13.83779809	32.02159233
7.031876224	13.83872558	32.05254896
7.330328926	13.83084606	32.07269964
7.628776013	13.82990097	32.09714549
7.927216969	13.82534127	32.12276075

Depth (Meter)	Temperature (Celsius)	Salinity (Practical Salinity Scale)
8.225653751	13.83023613	32.13136344
8.524088264	13.82212281	32.13910426
8.822520813	13.82032229	32.14322868
9.12095251	13.82227183	32.14373646
9.419383184	13.81983663	32.14922536
9.71781281	13.82494695	32.15078408
10.01624179	13.82641299	32.15375557
10.31466943	13.82236139	32.15900976
10.61309502	13.82198975	32.1678314
10.91151715	13.82622736	32.18776914
11.20993477	13.8229723	32.20531447
11.50834874	13.82607505	32.21712532
11.80676105	13.82781049	32.21840262
12.10517188	13.83402971	32.2293537
12.40357652	13.83070034	32.27127225
12.80382287	13.83614167	32.26682533

Cast 2 Data Header

Device	10G100653
File name	10G100653_20130902_104639
Cast time (local)	11:46
Sample type	Cast
Cast data	Processed
Location source	GPS
Default latitude	32
Default altitude	0
Start latitude	56.6785665
Start longitude	-5.6254194
Start GPS horizontal error(Meter)	20.75
Start GPS vertical error(Meter)	29.57999992
Start GPS number of satellites	6
Cast duration (Seconds)	86.2
Samples per second	5
Calibration Date	Mar-13
Calibration offset for Temperature	-0.08
Calibration offset for Salinity	0.18

Cast 2 CTD data (calibration offsets applied)

Depth (Meter)	Temperature (Celsius)	Salinity (Practical Salinity Scale)
0.151147091	14.17600686	15.32286161
0.453233436	14.15107572	16.98002351
0.754469076	14.06984779	22.79524896
1.054707588	14.04333414	25.70886238
1.354396009	14.07393621	27.64712494
1.653759761	14.06723459	28.58294425

Depth (Meter)	Temperature (Celsius)	Salinity (Practical Salinity Scale)
1.952958079	14.04324082	29.10114659
2.252010521	14.0031274	29.85619083
2.5508802	13.98229125	30.70318102
2.849590114	13.93882127	31.25421094
3.14820981	13.93422491	31.48863354
3.446779797	13.94436752	31.69425502
3.745317444	13.94833846	31.77669614
4.043840611	13.94839734	31.82101047
4.342352182	13.94496701	31.87588404
4.640853957	13.94088814	31.9030863
4.939348846	13.92423317	31.92862817
5.237829365	13.89815751	32.01651231
5.536292896	13.86446422	32.06082474
5.834745119	13.84842903	32.10089628
6.133190518	13.8411521	32.11234614
6.431633623	13.84319004	32.11692902
6.730074159	13.84930953	32.13435755
7.028508354	13.84575859	32.17099013
7.326935498	13.84768555	32.19361877
7.625357796	13.84785652	32.21165867
7.9237753	13.84617948	32.23285057
8.222187526	13.84432588	32.25466949
8.52059469	13.84052223	32.27338502
8.81899864	13.83543646	32.27791257
9.117400917	13.8356265	32.28398747
9.415801153	13.83699439	32.29349707
9.714198542	13.83385355	32.30585913
10.0125925	13.83499476	32.32053323
10.3109777	13.83226372	32.3802599
10.60935116	13.82627795	32.41963543
10.90771655	13.82492323	32.44707486
11.20607596	13.81956356	32.46811272
11.50443077	13.81783879	32.4830869
11.80278309	13.81596147	32.48639966
12.10113434	13.81796929	32.48954979
12.39948455	13.817258	32.49311276
12.69783188	13.81300593	32.51084475
12.99617368	13.81394206	32.5384081
13.22389063	13.81414243	32.54731762