Scottish Sanitary Survey Report

Sanitary Survey Report
Loch Stockinish
LH-249-129-04
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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 Stockinish 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 selected for survey at this time based on a risk-based ranking of the area amongst those in Scotland that have yet to receive sanitary surveys.

Loch Stockinish is located on the southeastern side of the Isle of Harris. The area is sparsely populated and little has been identified in the way of farm or wild animals.

The fishery at Loch Stockinish is comprised of a single, long-line mussel farm with a single longline with 12 m droppers.

The principal potential sources of faecal contamination to the fishery are:

- Private septic tanks mainly located towards the mouth of the loch, although a number lie on the eastern shore (including in the vicinity of the mussel farm) and at the head of the loch.
- Watercourses located around the loch which may carry diffuse pollution from the low animal populations in the area.

Summary of recommendations

It is recommended that the production area be defined as: The area bounded by lines drawn between NG 1277 9128 and NG 1305 9134 and between NG 1227 9200 and NG 1290 9200 extending to mean high water springs. This excludes the cluster of septic tanks located near the mouth of the loch.

It is further recommended that the RMP be moved to NG 1274 9166, at the southeastern end of the mussel lines, to represent the principal identified sources to the mussel fishery and to reflect any future changes in sources that may have a differential impact along the loch.

II. Sampling Plan

Production Area	Loch Stockinish
Site Name	Loch Stockinish
SIN	LH-203-127-08
Species	Common mussel
Type of Fishery	Long-line aquaculture
NGR of RMP	NG 1274 9166
East	112740
North	891660
Tolerance (m)	40
Depth (m)	1-3
Method of Sampling	Hand
Frequency of Sampling	Monthly
Local Authority	CnES
Authorised Sampler(s)	Paul Tyler
Local Authority Liaison Officer	Colm Fraser
Recommended Production Area	The area bounded by lines drawn between NG 1277 9128 and NG 1305 9134 and between NG 1227 9200 and NG 1290 9200 extending to mean high water springs.

III. Report

1. General Description

Loch Stockinish (also spelt Stockinis) is a south facing inlet on the south eastern side of the Isle of Harris, opening to the Minch. Harris is part of the Outer Hebrides and lies within the jurisdiction of the Comhair nan Eillean Siar local authority.

The loch is about 3 km in length and is split into two sections. The inner section is roughly consistent in width (approximately 500 m). The outer section expands, getting wider further to sea. Stockinish Island (Eilean Stocanais), is located off the eastern shore of the outer section of the loch. The general location of Loch Stockinish is shown in Figure 1.1.

The area around the loch is sparsely populated. Housing is centred along the roads which follow the east, north and upper west sides of the inner loch. There are a number of small named settlements in the area around the loch: these are Stokinish, Geocrab, Leac a' Li, Lickisto and Aird Mhighe.

A sanitary survey was undertaken on the classified fishery at Loch Stockinish 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 selected for survey at this time based on a risk-based ranking of the area amongst those in Scotland that have yet to receive sanitary surveys.

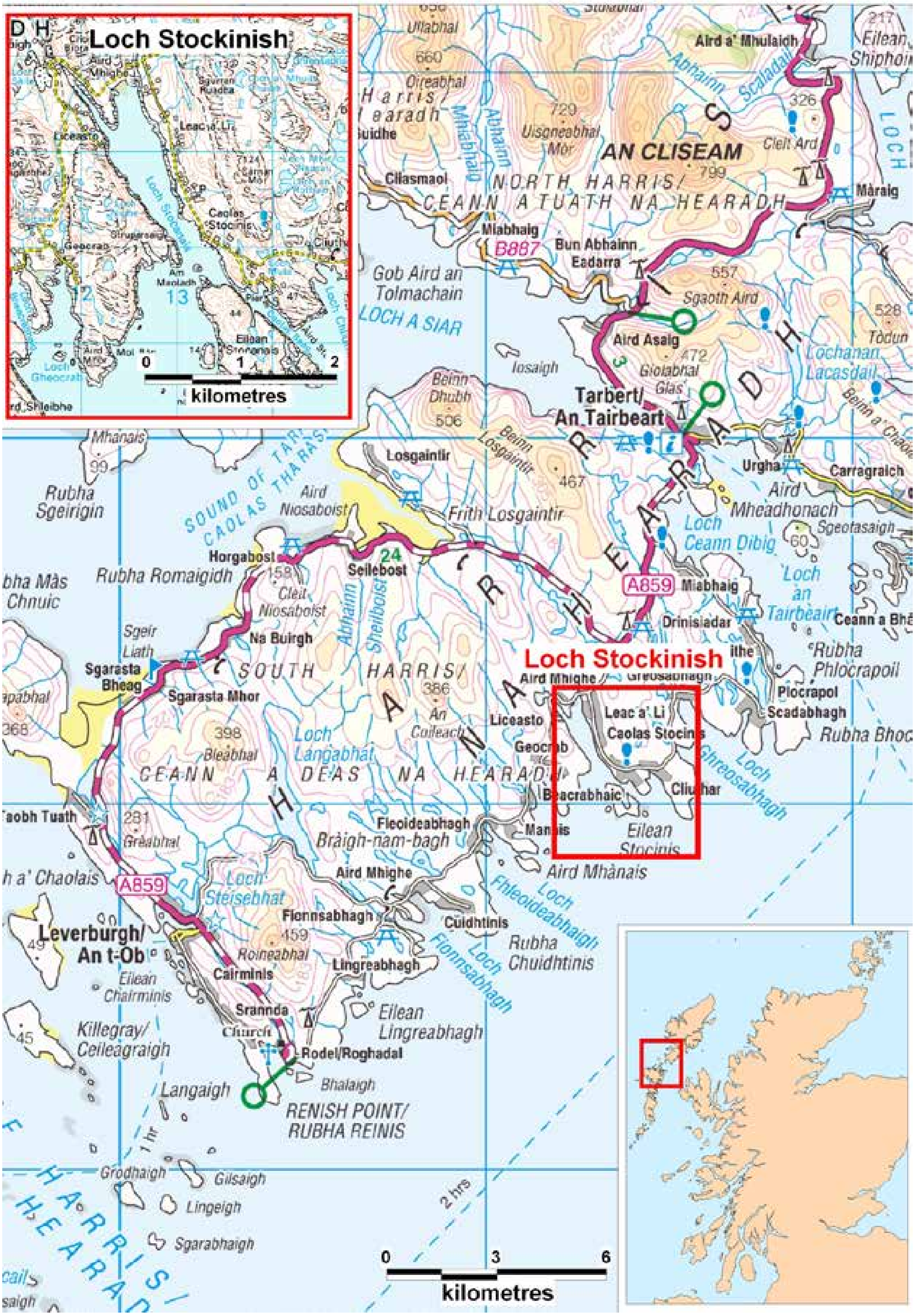


Figure 1.1 Location of Loch Stockinish

2. Fishery

Loch Stockinish fishery is a common mussel (*Mytilus edulis*) fishery. The site details are shown in Table 2.1.

Table 2.1 Loch Stockinish Area shellfish farms

Production area	Site	SIN	Species
Loch Stockinish	Loch Stockinish	LH-203-127-08	Common Mussels *(Mytilus edulis)*

At the time of the shoreline survey the site consisted of a single longline with 12 m droppers.

The current production area boundaries are defined by lines drawn between NG 1222 8956 to NG 1352 8971 and between NG 1331 9058 to NG 1346 9087 and from points NG 1227 9200 to NG 1290 9200. The area is presumed to extend to mean high water springs, though this is not specified in the FSA Scotland classification report for 2013/14. The current Representative Monitoring Point is located at NG 1331 9076.

The fish farm locations, as reported in the shoreline survey, are plotted in Figure 2.1 along with the current area boundaries and RMP location.

The current RMP, and all but one of the reported locations of samples taken from March 2011 on, lie approximately 1 km to the southeast of the location of the mussel farm as recorded during the shoreline survey. The sampling officer identified that there is a raft in the vicinity to which a bag of mussels is tied for sampling purposes.

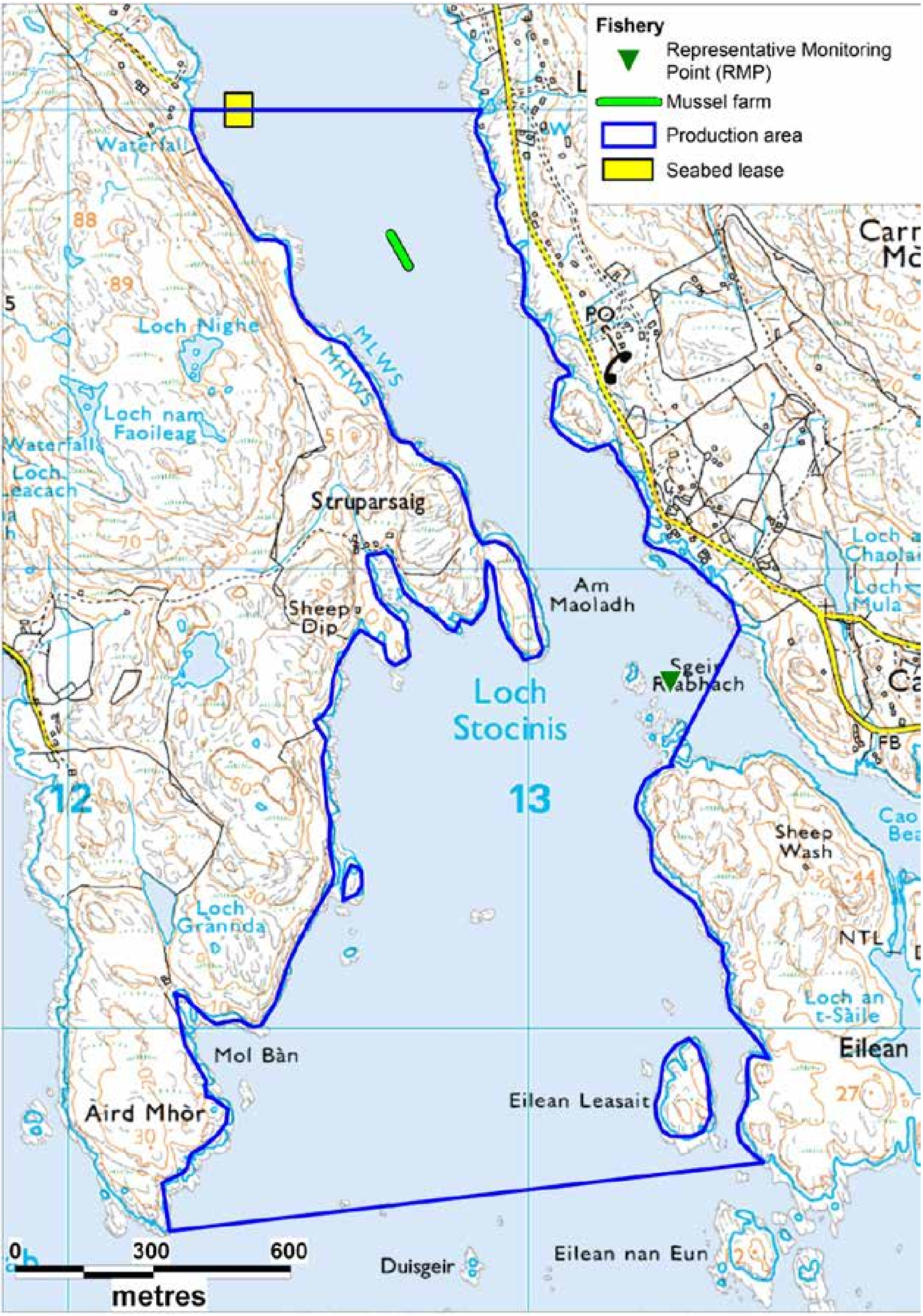


Figure 2.1 Loch Stockinish Fishery

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 Stockinish. The last census was undertaken in 2011. The census output areas surrounding Loch Stockinish are shown thematically mapped by the 2011 population densities in Figure 3.1. The figure shows that the population density for the census output areas surrounding Loch Stockinish is low, with an overall population density of less than ten people per square mile.

The small settlement of Caolas Stocinis is located on the south east shoreline of the loch within the vicinity of the fishery. During the shoreline survey approximately 11 dwellings were observed in and nearby to Caolas Stocinis. The small settlement of Geocrab is located on the northern shoreline of the waterbody west of Loch Stockinish. South of Caolas Stocinis is Stockinish Harbour where a number of boats were observed during the shoreline survey. There are moorings and a small anchorage with pier and pontoon in Poll Scrot, north of Stockinish Island along the outer shore of the loch as well as a further anchorage at the entrance to the NW arm of the loch, near the head. (Clyde Cruising Club, 2005).

Overall, 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, with any effects predominating in the south east where the greater concentration of dwellings are located.

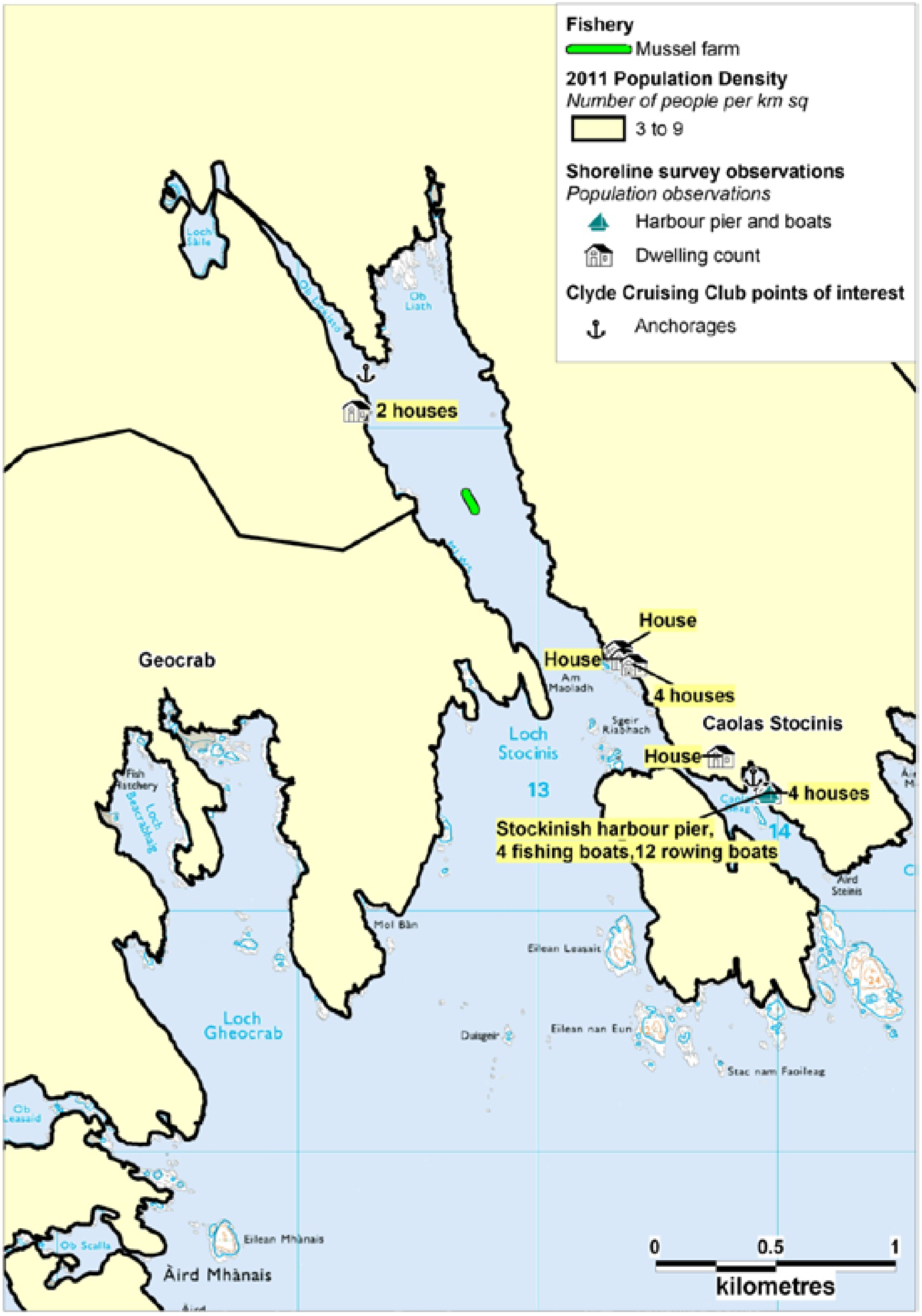


Figure 3.1 Population map of the Loch Stockinish area

4. Sewage Discharges

Information on sewage discharges 5 km around point NG 13084 90740 was sought from Scottish Water and the Scottish Environment Protection Agency (SEPA). The 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, freshwater body or sea), any available dispersion or dilution modelling studies, and whether improvements were in work or planned.

Scottish Water and SEPA datasets were compared to each other. Where differences or omissions were observed, clarification was sought from the data providers. Where new information provided it was included in the summary presented in this section.

Scottish Water Data

Scottish Water provided information of a single septic tank which is listed in Table 4.1.

Table 4.1 Scottish Water Sewage Discharges

Discharge Name	Discharge Licence	NGR of discharge	Level of Treatment	DWF m^3/d	PE
GEOCRAB SEP	WPC/N/60940	See text	Septic Tank	10	16

DWF=Dry Weather Flow PE=Population Equivalent

No information on receiving body was provided for this discharge so this has been assumed from the plotted discharge location and the corresponding information from SEPA.

The discharge grid reference (NGR) provided by Scottish Water plotted to a remote location far from any houses. Scottish Water advised that the location was incorrect and that the location provided by SEPA should be used. This has been done for the discharge location on the map shown in Figure 4.1.

Consented Discharges (SEPA)

SEPA provided information on 84 consents. Seventy-six of the consents are listed as sewage discharges. Of these, 71 are identified as primary treated private sewage discharges, and one as a primary treated public discharge (Geocrab septic tank). The remaining four discharges were only listed as septic tanks. One of the private discharges, discharging to Caolas Beag (between Stockinish Island and Harris) was identified as having a PE of 50. However, SEPA have previously identified that this is their normal upper consent limit for private discharges and is given when the applicant has not supplied a p.e. in the consent application.

Thirty-nine discharges were stated to discharge to soakaway, 12 to fresh water and 24 to saltwater bodies. The remaining consents related to three marine cage fish farms, one fish farm hatchery, three sheep dips disposing to land and one filter back wash effluent from a Water Treatment Work. Many of the consents related to discharges outside the production area and immediately adjacent areas. The entire data set received from SEPA is shown in Appendix 6.

Table 4.2 presents information on those discharge consents considered likely to impact on the production area: these were essentially the discharges located landward of a line drawn between Rubha Chliuthair and Aird Mhòr. These discharges are shown on the map in Figure 4.1.

Other Information

A public toilet is listed in the Visit Outer Hebrides tourist site, and is shown as being located in Stockinish Harbour. No usage information or discharge location is noted no consent information was received from SEPA for any associated discharge. Its reported location is plotted in Figure 4.1

Table 4.2 Consented discharges potentially impacting on production area

Licence No.	NGR*	Site Name	Discharge Type	Discharges To	PE	Shoreline Survey Observation
WD79	NG 1350 9130	Kyles Stockinish School House	Septic Tank	Soakaway	10	
WPC/N/60737	NG 1139 8905	Stockinish Pier	Septic Tank	Loch Stockinish	-	
WPC/N/60940	NG 1190 9070	Geocrab Council Houses	Sewage (Public) Primary	Loch Geocrab	16	
CAR/R/1012641	NG 1305 9171	1 Leacklee, Isle of Harris	Septic tank	Soakaway	5	
CAR/R/1015371	NG 1126 9023	1 Ardslave, Isle of Harris	Sewage (Private) Primary	Loch Bheicribhig	5	
CAR/R/1019437	NG 1146 9093	O'er Wather, Geocrab, Isle of Harris	Sewage (Private) Primary	Soakaway	5	
CAR/R/1021910	NG 1198 9243	1 Lickisto, Isle of Harris, HS3 3EL	Sewage (Private) Primary	Soakaway	5	
CAR/R/1022614	NG 1170 9147	Geocrab WTW, Isle of Harris	Sewage (Private) Primary	Loch Na Ba Crubaich	5	
CAR/R/1032541	NG 1096 8952	Manish School & Schoolhouse,Ardslave, Harris	Sewage (Private)	Soakaway	6	
CAR/R/1042855	NG 1123 9057	Lever Cottage, Isle Of Harris	Sewage (Private) Primary	Loch Bheicribhig	5	
CAR/R/1043432	NG 1449 9088	9 Cluer, Isle Of Harris	Sewage (Private) Primary	Soakaway	5	
CAR/R/1043434	NG 1336 9104	Westerlea, Isle Of Harris	Sewage (Private) Primary	Loch Stockinish	7	5
CAR/R/1045038	NG 1459 9087	Roadside Cottage, 9 Cluer, Isle of Harris	Sewage (Private)	Soakaway	5	
CAR/R/1047129	NG 1172 9289	Pairc Liceasto, Isle of Harris	Sewage (Private) Primary	Soakaway	5	7
CAR/R/1047382	NG 1179 9284	Two Waters, Lickisto, Isle of Harris	Sewage (Private)	Soakaway	5	7
CAR/R/1047450	NG 1402 9067	2 Ardvey, Stockinish, Isle of Harris	Sewage (Private)	Soakaway	5	
CAR/R/1048589	NG 1342 9096	55 Stockinish, Isle of Harris	Sewage (Private) Primary	Loch Stockinish	6	3
CAR/R/1051563	NG 1353 9112	Pauline Macleod,5B Stockinish,Isle Of Harris	Sewage (Private)	Soakaway	5	4
CAR/R/1054889	NG 1332 9113	7 Stockinish	Sewage (Private)	Loch Stockinish	5	
CAR/R/1056085	NG 1130 9090	11A Geocrab, Isle of Harris	Sewage (Private) Primary	Soakaway	5	
CAR/R/1056094	NG 1198 9062	3 Geocrab, Isle of Harris	Sewage (Private)	Coastal Loch Geocrab	6	
CAR/R/1056117	NG 1179 9082	6B Geocrab, Harris	Sewage (Private)	Coastal Loch Geocrab	5	
CAR/R/1056122	NG 1182 9101	2 Geocrab, Isle of Harris	Sewage (Private) Primary	U/N W/C	7	
CAR/R/1056284	NG 1440 9098	10 Cluer, Isle Of Harris	Sewage (Private)	U/N W/C	6	
CAR/R/1056299	NG 1162 9313	1 Bayhead Of Ardvey, Isle Of Harris	Sewage (Private)	U/N W/C	7	
CAR/R/1056443	NG 1225 9208	3 Lickisto, Isle Of Harris	Sewage (Private) Primary	Soakaway	5	
CAR/R/1056569	NG 1278 9261	6 Leaklee, Isle of Harris	Sewage (Private) Primary	Soakaway	5	

Licence No.	NGR*	Site Name	Discharge Type	Discharges To	PE	Shoreline Survey Observation
CAR/R/1056658	NG 1117 9050	Cliff Cottage, Beckrivig, Isle of Harris	Sewage (Private)	Soakaway	5	
CAR/R/1056699	NG 1106 8962	4 Ardslave, Isle of Harris	Sewage (Private)	Soakaway	5	
CAR/R/1057001	NG 1181 9095	5 Geocrab, Isle of Harris	Sewage (Private)	Soakaway	5	
CAR/R/1057594	NG 1291 9238	4A Leacklea, Isle of Harris	Sewage (Private) Primary	Soakaway	5	
CAR/R/1059747	NG 1305 9149	8 Stockinish, Isle of Harris	Sewage (Private) Primary	Loch Stockinish	5	
CAR/R/1059944	NG 1284 9237	4B Leacklee, Isle of Harris	Sewage (Private)	Soakaway	5	
CAR/R/1061620	NG 1182 9081	6 Geocrab, Isle of Harris	Sewage (Private) Primary	Loch Geocrab	5	
CAR/R/1063374	NG 1303 9202	Carnan House, 3A Leacklee, Isle of Harris	Sewage (Private) Primary	U/N W/C	5	
CAR/R/1064020	NG 1419 9101	11 Cluer (Mackinnon), Isle of Harris, HS3	Sewage (Private) Primary	Soakaway	5	
CAR/R/1064025	NG 1070 8911	4 Manish, Isle of Harris	Sewage (Private) Primary	Ob Leasaid	5	
CAR/R/1064397	NG 1179 9290	Bardon Hebrides Site Office, Isle of Harris	Sewage (Private) Primary	Loch Stockinish	5	7
CAR/R/1066781	NG 1355 9110	6 Stockinish, Isle of Harris	Sewage (Private)	Soakaway	5	4
CAR/R/1068044	NG 1492 9055	6 Cluer, Isle of Harris	Sewage (Private) Primary	U/T of Loch Chliuthair	5	
CAR/R/1068138	NG 1481 9075	7 Cluer, Harris	Sewage (Private) Primary	U/T of Loch Chliuthair	5	
CAR/R/1068139	NG 1388 9067	3 Stockintosh, Isle of Harris	Sewage (Private) Primary	U/T of Caolas Beag	5	1
CAR/R/1068263	NG 1375 9065	4 Stockinish, Harris	Sewage (Private) Primary	U/N W/C	5	2
CAR/R/1070615	NG 1424 9087	11 Cluer, Isle of Harris	Sewage (Private)	Allt Steinis	5	
CAR/R/1079031	NG 1403 9044	Lochview, 1 Ardvey, Isle of Harris	Sewage (Private) Primary	Caolas Beag	50	
CAR/R/1092392	NG 1133 8996	1 Ardslave (Beckrivig), Bays of Harris	Sewage (Private)	Loch Geocrab	6	
CAR/R/1102432	NG 1128 9078	Glen, Geocrab, Isle of Harris	Sewage (Private) Primary	U/N W/C	5	
CAR/R/1112255	NG 1272 9259	6B Leacklee, Isle of Harris	Sewage (Private) Primary	Soakaway	7	
CAR/S/1023867	NG 1171 9150	Geocrab WTW, Isle of Harris	Filter Backwash	Loch na ba Crubaich		
CAR/L/1001853	NG 1288 9145	Stockinish MCFF, Loch Stockinish	Marine Cage Fish Farm	Loch Stockinish		
CAR/L/1002371	NG 1181 9032	Geocrab MCFF, Loch Geocrab	Marine Cage Fish Farm	Loch Geocrab		
CAR/L/1004185	NG 1124 9056	Geocrab Hatchery	Fish Farm Hatchery	Loch Beacrabhaig		
CAR/R/1007722	NG 1370 9088	Ardvey,GWR-BH1	Sheep Dip onto Land	Soakaway		
CAR/S/1089180	NG 1403 9095	Grosebay Common Grazings,GWR-BH1	Sheep Dip onto Land	Soakaway		

- No data provided, U/T = Unnamed Tributary, U/N W/C = Unnamed Watercourse, WTW= Water Treatment Works, NGRs rounded to nearest 10 m

Shoreline Survey Discharge Observations

Seven observations of sewage infrastructure were noted during the shoreline survey. These are listed in Table 4.3.

Table 4.3 Discharge-associated observations made during the shoreline survey

No.	Date	Associated photograph	Description
1	22/07/2013	Appendix 6; Fig 4	House with sewage pipe running into harbour.
2	22/07/2013	Appendix 6; Fig 5	House on hill above loch with septic tank.
3	22/07/2013	Appendix 6; Figure 10	Pipe from septic tank, no flow
4	22/07/2013	Appendix 6; Fig 9	Septic tank at house. Four additional Private dwellings on hillside above loch on the other side of the road also with their own septic tanks.
5	22/07/2013	Appendix 6; Fig 6 ,7 & 8	Sewage pipe from house noted in observation 4 onto rocks on shore, small trickle running from pipe. Another pipe from same house no flow noted.
6	22/07/2013	Appendix 6; Figure 12	Septic tank pipe dripping onto shore. No further access to shoreline, fenced to edge of steep rock.
7	22/07/2013	Appendix 6; Fig 15	Septic tank at Private dwelling, pipe onto shore, no flow.
8	22/07/2013	Appendix 6; Fig 17	Two Private dwellings with septic tanks. End of survey for this day.

Observation 1 relates to a house with a pipe, going into the harbour, coming from what appears to be an old septic tank on the shore. No discharge was noted. This possibly relates to consent CAR/R/1068139, a private septic tank at Stockinish discharging to an unnamed tributary of Caolas Beag.

Observation 2 relates to a house on hillside with a septic tank. No discharge was noted. This discharge possibly relates to consents CAR/R/1068263, a private septic tank at Stockinish discharging to an unnamed watercourse.

Observation 3 relates to a pipe coming from a septic tank. No flow was noted from the pipe. This possibly relates to consent CAR/R/1048589, a private septic tank discharging to Loch Stockinish, which plots 30 m away from the observation location.

Observation 4 relates to a septic tank observed at a house. Four other houses with septic tanks on the hillside above were observed across the road. These could relate to consents CAR/R/1051563 and CAR/R/1066781, private septic tanks discharging to soakaway.

Observation 5 relates to a pipe running from the house noted in Observation 4 onto a rocky shore. A small flow was recorded. This discharge is likely to relate to consent CAR/R/1043434 for a private septic tank discharging to Loch Stockinish. A second pipe with no flow was noted.

Observation 6 relates to a pipe running from a septic tank dripping a small amount of effluent. No sample was taken. No consent was identified relating to this location.

Observation 7 relates to a septic tank with pipe going to shore. No flow was recorded. Three consents relating to septic tanks are reported as close to this observation by SEPA. However, only the discharge for CAR/R/1064397 is given as going to Loch Stockinish.

Observation 8 relates to two houses with septic tanks. No discharge pipes were observed. No consent was identified relating to this location.

Summary

Discharges to the production area are located mainly on the eastern shore especially at the mouth of the loch. These are primarily private septic tanks. There is one public discharge, Geocrab Septic tank, which discharges to Loch Geocrab and has a PE of 16. There are also several consented private discharges around Loch Geocrab.

List of Acronyms

CSO	Combined Sewage Overflow	PS	Pumping Station
DWF	Dry weather flow	ST	Septic Tank
EO	Emergency Overflow	WWPS	Wastewater Pumping Station
FE	Final Effluent	WWTW	Wastewater Treatment Work
PE	Population Equivalent		

Figure 4.1 Location of discharges at Loch Stockinish

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 Harris parish. Reported livestock populations for the parish 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 Harris agricultural parish 2012

	Harris	
	502 km^2	
	Holdings	Numbers
Pigs	*	*
Poultry	44	597
Cattle	35	442
Sheep	233	30,621
Other horses and ponies	*	*

The livestock census numbers relate to a very large parish area (covering the whole Isle of Harris), therefore it is not possible to determine the spatial distribution of the livestock in relation to the Loch Stockinish 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. The livestock numbers indicate that sheep are the more dominant livestock type compared to poultry and cattle which are present in low numbers.The number of pigs and other horses and ponies were not reported due to the small number of holdings.

The South Harris Agricultural Show takes place at Leverburgh approximately 12 km southwest of Loch Stockinish and takes place every July. A large number of livestock including cattle, sheep and poultry are shown at the show each year. Due to the location of the show on the west coastline of Harris is not likely to result in an increase in faecal contamination reaching the fishery.

An additional significant 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 22nd July 2013 (see Table 5.1). 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 survey sheep were observed grazing along the shoreline adjacent to the fishery. In total approximately 12 sheep were observed grazing along the western shoreline and 6 sheep were observed along the northern shoreline. In addition 3 horses were observed at the head of the loch.

Stockinish Island is stated to be used for grazing (http://en.wikipedia.org/wiki/ Stockinish_Island; Accessed 05/11/13).

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.

Overall, agricultural-source faecal contamination is likely to be low and dispersed around the area of the loch.

Produced by Cefas Weymouth Laboratory. Ordnance Survey licence number [GD100035675]

Figure 5.1 Agricultural census livestock densities and shoreline survey livestock observations at Loch Stockinish

6. Wildlife

Pinnipeds

The Outer Hebrides forms an important colony of both Harbour and grey seals (Visit Hebrides, 2013). In a report by SCOS (2012) it was noted that the harbour seal population in the Outer Hebrides was in decline, and had decreased by 35% since 1996, equating to 3% per annum. From a study by SMRU it is estimated that the colony close to Loch Stockinish is between 51 and 100. In 2010 the population was noted at 1804. Comparatively the grey seal population is experiencing a period of boom, with 12857 pups born in 2010, a 6.14% increase on the 2009 population.

It has also been noted that common seals haul out approximately 4 miles southwest at rocks and skerries at Fionsabhaigh (Visit the Outer Hebrides, 2013). Furthermore there are anecdotal accounts that the loch is excellent for seal watching (The Cottage Guide, 2013).

During the shoreline survey 11 seals were observed in Loch Stockinish. Although there was no information regarding populations of seals in the loch, this high density of seals observed may indicate a resident population.

Cetaceans

The water body between the Outer Hebrides and mainland Scotland is known as the Minch and is recognised as an important sheltered passageway used by cetaceans including killer whales, minke whales and bottlenose dolphins. These cetaceans use the Outer Hebrides for socialising and feeding (Visit Hebrides, 2013). No information was available on cetaceans in Loch Stockinish specifically and no cetaceans were observed during the shoreline survey.

Birds

Seabird 2000 census data (Mitchell, *et al*., 2004) was queried for the area around Loch Stockinish: no significant bird populations noted in the close vicinity. However, it should be noted that a significant special protection area (SPA) is located approximately 30 km to the northeast at Shiant Isles. This site supports approximately 200,000 individual birds during the summer months, with species including; guillemots, kittiwakes, fulmars, puffins, shags and razorbills. During the winter a population of approximately 172 pairs of Greenland barnacle geese are also known to use these islands (JNCC, 2001). It is stated that these birds are likely to use the surrounding areas for foraging and it is possible that they may range as far as Loch Stockinish. Anecdotal accounts noting that Loch Stockinish is an excellent area for bird watching (The Cottage Guide, 2013).

During the shoreline survey birds were the only wildlife observed. Species included herring gulls which were the most abundant, one blacked headed gull, oystercatchers, cormorants and nine pink footed geese.

Deer

Red Deer are an introduced species to the Outer Hebrides and are now known to be prevalent in all areas, with just over 4000 in Lewis and Harris. These deer are usually distributed on high land during the summer and come down to sea level during winter months (Visit Hebrides, 2013). No deer were observed during the survey, though it is expected that they may have a small impact on contamination levels entering the fishery, particularly during winter months.

Otters

The Eurasian otter (*Lutra lutra*) are common on the Isle of Lewis (Visit Hebrides, 2013). Lock Stockinish is anecdotally recognised as being an excellent area to watch otters (The Cottage Guide, 2013). It is expected that otters may contribute to contamination levels crossing the fishery, particularly from the western side of the loch which is uninhabited.

Overall

Species potentially impacting on Loch Stockinish includes seals, seabirds, deer and otters. However, the impacts of these on the fishery are likely to be unpredictable, with no identified seal haul out sites, seabird nesting areas or specific areas used by otters of deer recognised.

Figure 6.1 Shoreline survey wildlife observations around Loch Stockinish

7. Land Cover

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

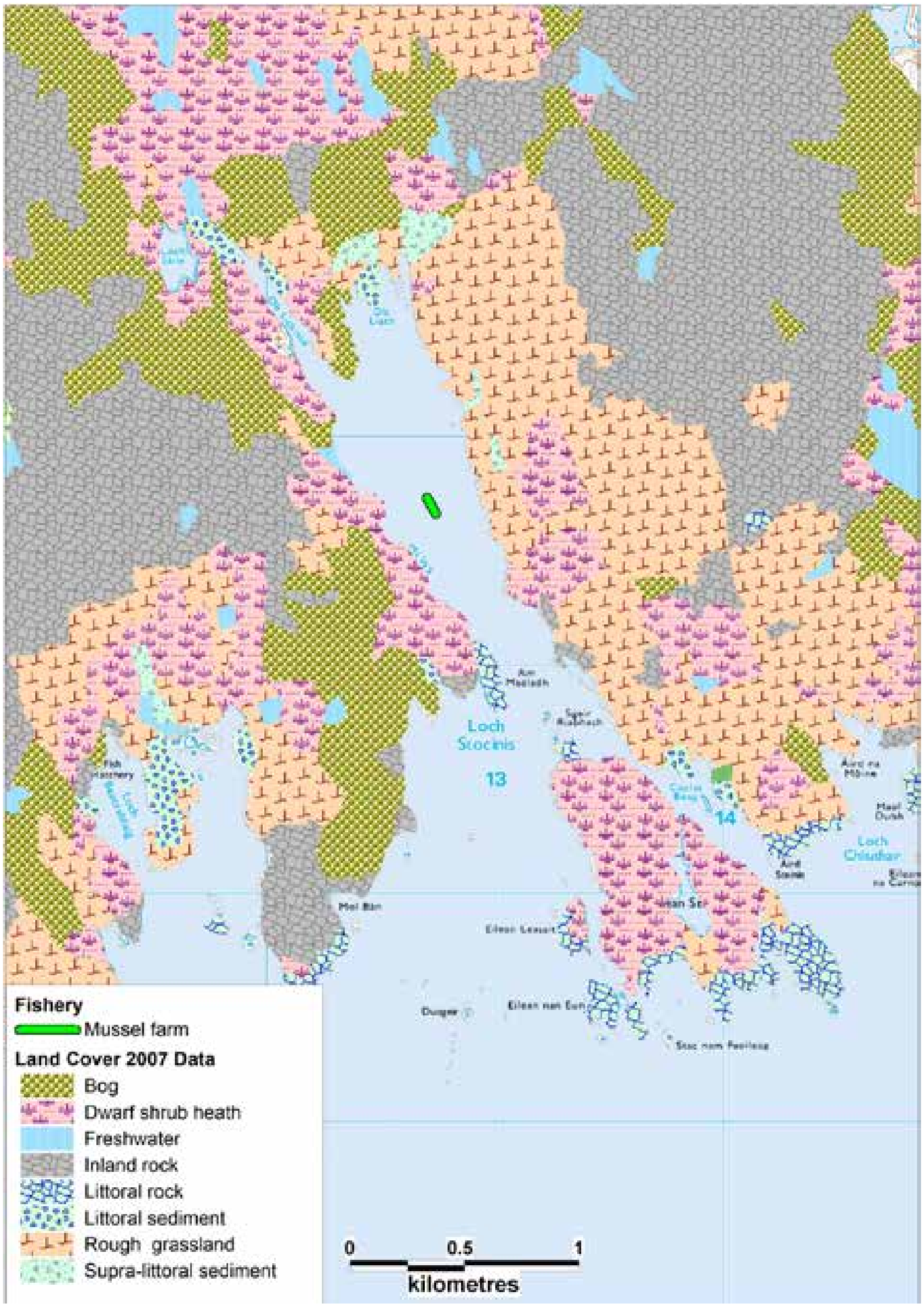


Figure 7.1 LCM2007 land cover data for the area around Loch Stockinish

Rough grassland, dwarf shrub heath, bog and inland rock are the predominant land cover types on the shoreline adjacent to the Loch Stockinish fishery. There are also smaller areas of littoral rock, littoral sediment and supra-littoral sediment. There are no identified areas of suburban or urban development and improved grassland.

A brief description of land cover was noted in the shoreline survey report (Appendix 5): the immediate area surrounding the loch was noted to be rough boulder strewn hillside with sparse vegetation of predominantly bracken and heather.

Faecal indicator organism export coefficients for faecal coliform bacteria have been found to be approximately 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., 2008a). 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., 2008a).

The risk of faecal contamination based on landcover type is therefore considered to be low but would increase to some extent after rainfall (no improved grassland was identified in the area).

8. Watercourses

There are no gauging stations on watercourses entering into Loch Stockinish. The only available data came from the measurements and samples taken during the shoreline survey. The weather during the survey was dry with no rainfall recorded in the week prior to the survey either.

During the survey, nine major watercourses were noted, the details of which are listed in Table 8.1. The majority of are unnamed watercourses. There were also two areas of dry land drainage along the eastern shoreline and one area of stagnant bog water to the south.

Table 8.1 Watercourse loadings to Loch Stockinish

No.	Description	NGR	Width (m)	Depth (m)	Flow (m^3/d)	Loading (*E. coli*/day)
1	Unnamed watercourse	NG 1343 9099	0.60	0.02	1.10	$3.2x10^5$
2	Unnamed watercourse	NG 1229 9269	0.40	0.05	600.00	$2.4x10^8$
3	Flow from Loch Glumradh Beag	NG 1257 9290	6.50	0.14	23000.00	$1.4x10^{10}$
4	Unnamed watercourse	NG 1265 9276	0.40	0.15	300.00	$3.4x10^7$
5	Unnamed watercourse	NG 1282 9229	0.40	0.04	2.20	$3.9x10^6$
6	Unnamed watercourse	NG 1292 9201	0.80	0.03	1.10	$5.7x10^6$
7	Unnamed watercourse	NG 1308 9151	0.78	0.17	1200.00	$8.2x10^9$
8	Flow from Loch na Craobhaig	NG 1193 9263	1.10	0.07	230.00	$4.5x10^7$
9	Unnamed watercourse	NG 1225 9207	1.00	0.05	0.40	$4.1x10^6$

E. coli loadings to Loch Stockinish were estimated to be low to moderate. The highest contamination input comes from Glumradh Beag, which enters approximately 800 m northeast of the current location of the mussel farm.

Three watercourses enter into the loch within 500 m of the current location of the mussel farm. The highest of these loadings enters from the southeast at 8.2 x 10^9 *E. coli* per day and is therefore expected to significantly impact the southern extent of the fishery during flood tides. The other two enter from the north; one from the west and one from the east. Both these watercourses have low *E. coli* loadings, though may still have some contamination impact on the northern extents of the fishery during ebb tides.

Overall the effect of contamination from freshwater sources at the mussel farm is likely to be low with the most significant source lying to the southeast. It is expected that the dry weather preceding the survey will have lead to low contamination levels, which in turn will have resulted in low loadings. Following rainfall, freshwater inputs may represent a more significant source of *E. coli*.

Figure 8.1 Watercourse shoreline survey observations at Loch Stockinish.

9. Meteorological Data

The nearest weather station for which rainfall data was available is located at Harris Quidnich, situated approximately 5 km to the south west of the fishery. Rainfall data was available for January 2007 – December 2012. The nearest wind station is Stornoway Airport, situated approximately 53 km north east 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 Stockinish.

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.; (Lee & Morgan, 2003; Mallin, et al., 2001)). 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 *.

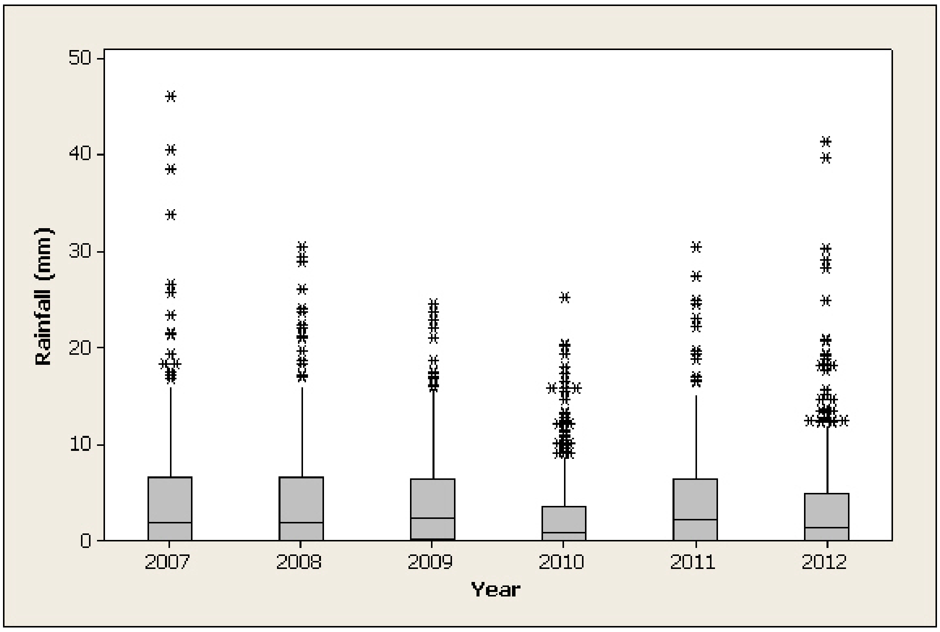


Figure 9.1 Box plot of daily rainfall values by year at Harris Quidnich (2007 – 2012)

Total rainfall varied markedly from year to year, with 2010 being the driest year (a total of 977 mm). The wettest year was 2007 (a total of 1633 mm). High daily rainfall values of more than 30 mm/d occurred in 2007, 2008, 2011 and 2012 and an extreme rainfall event of nearly 50 mm/d was seen in 2007.

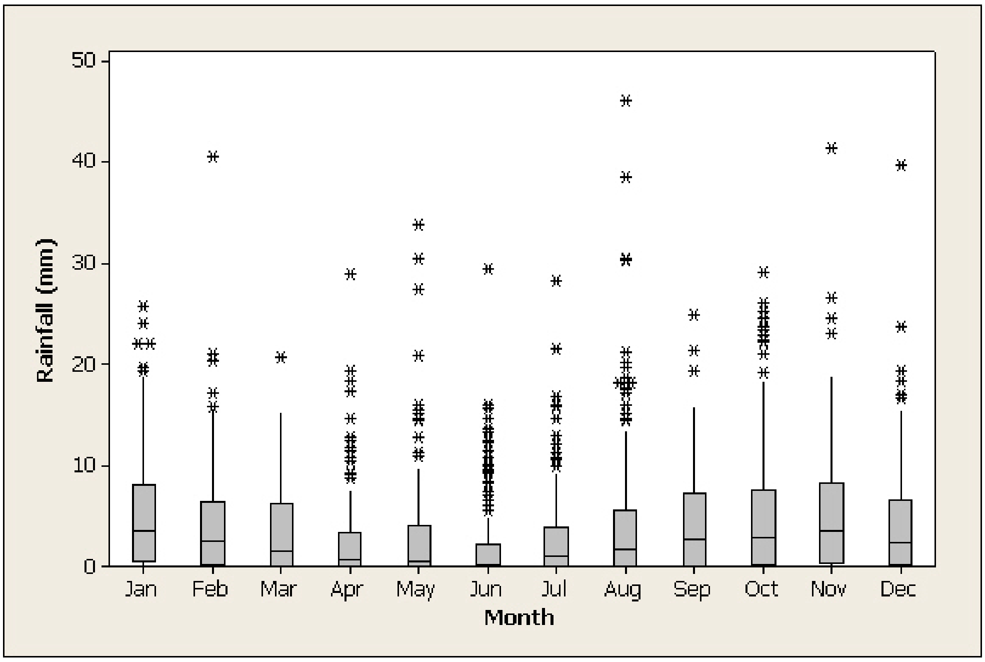


Figure 9.2 Box plot of daily rainfall values by month at Harris Quidnich (2007 – 2012)

Rainfall was lowest between April and July and highest from August to March. Rainfall values exceeding 30 mm/d were seen in February, May, August, November and December. The 2007 extreme event occurred in August.

For the period considered here (2007 – 2012) 43 % of days received daily rainfall of less than 1 mm and 12 % of days received rainfall of over 10 mm.

It is therefore expected that run-off due to rainfall will 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 has accumulated on pastures when greater numbers of livestock were present.

9.2 Wind

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

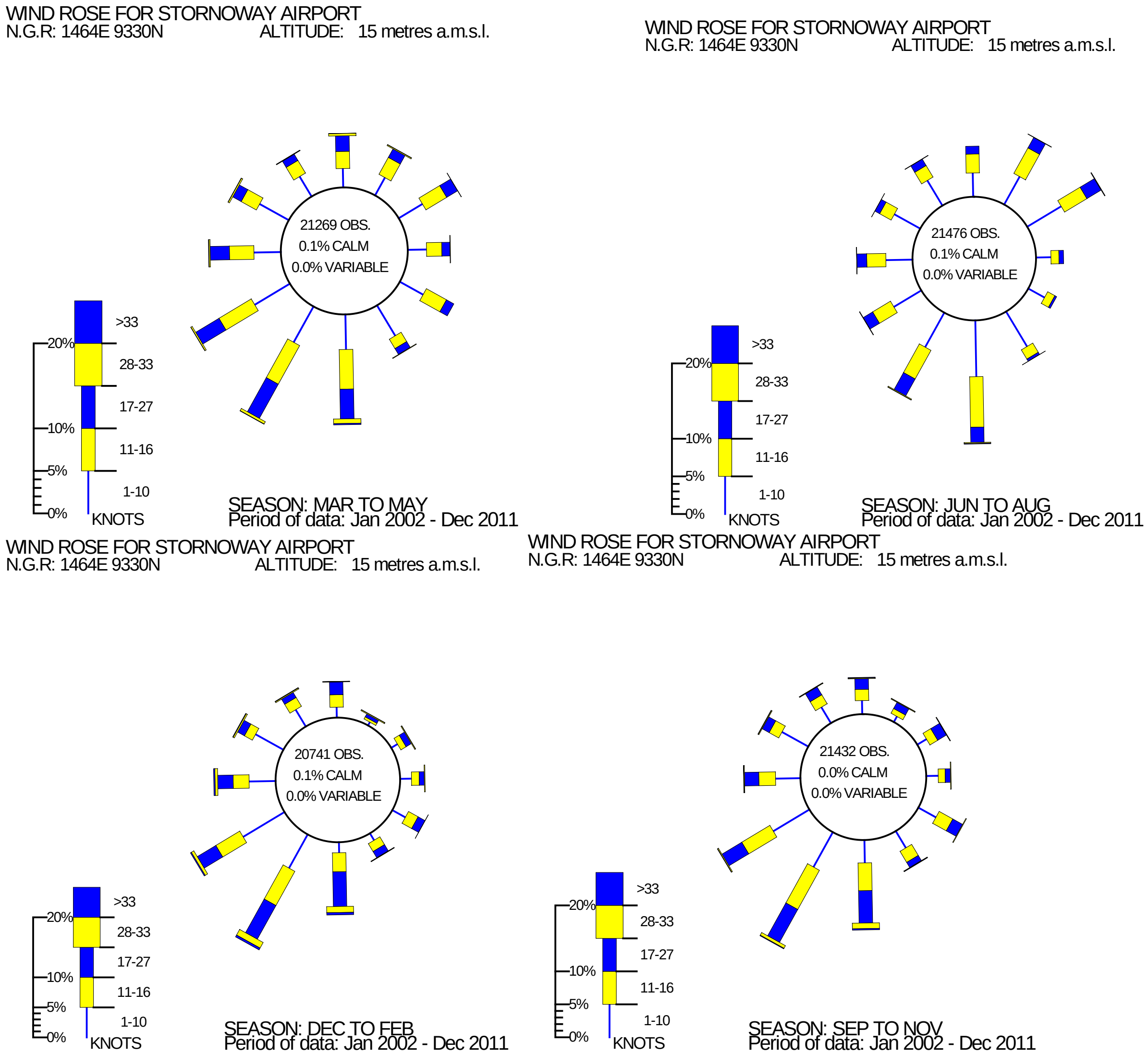


Figure 9.3 Seasonal wind roses for Stornoway Airport

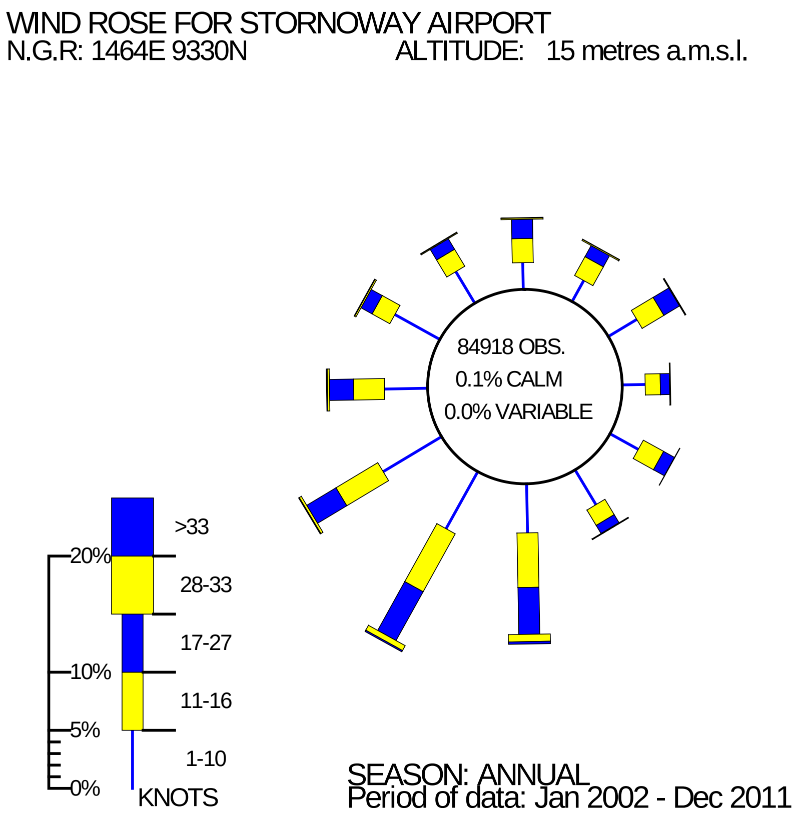


Figure 9.4 Annual wind rose for Stornoway Airport

Overall, winds were predominantly from the southwest. However, during summer, southerly winds predominated and there were also relatively strong winds from the north-west. 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 Stockinish has been classified for harvest of common mussels (*Mytilus edulis*) since 2002. The classification history since 2008 is listed in Table 10.1. The area has been year-round class A since January 2011.

Table 10.1 Loch Stockinish, classification history

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

Data taken from FSA Scotland classification listings.

11. Historical *E. coli* Data

Results for all samples assigned against the Loch Stockinish site for the period 01/01/2008 to the 20/08/2013 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 23/10/2013. 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 *E. coli* MPN / 100 g were reassigned a value of 10 *E. coli* MPN / 100 g for the purposes of statistical evaluation and graphical representation.

All samples were recorded as valid by FSAS. The reported locations for 11 samples lay outside the production area and the associated results were excluded from the analyses. These included two samples that plotted 7.7 km northwest at Seilebost, seven samples that plotted on land 6.3 km to the north, and two samples that plotted on land less than 50 m to the west of the estimated location of the mussel farm but where the location had been reported to 10 m accuracy. All remaining 57 samples were delivered to the laboratory within the 48 hr window and had box temperatures of <8^{o}C. Twenty-one samples had results of <20 *E. coli* MPN / 100 g.

11.1 Summary of microbiological results

Table 11.1 Summary of historical sampling and results

Sampling Summary	
Production area	Loch Stockinish
Site	Loch Stockinish
Species	Common mussels
SIN	LH-203-127-08
Location	Various
Total no of samples	57
No. 2008	3
No. 2009	11
No. 2010	10
No. 2011	11
No. 2012	12
No. 2013	10
Minimum	<20
Maximum	2800
Median	20
Geometric mean	38
90 percentile	282
95 percentile	931
No. exceeding 230/100g	6 (11%)
No. exceeding 1000/100g	2 (4%)
No. exceeding 4600/100g	0
No. exceeding 18000/100g	0

The low number of results given against 2008 is due to the exclusion of those related to samples where the recorded location lay outside the Loch Stockinish production area.

11.2 Overall geographical pattern of results

The reported sampling locations are shown in Figure 11.1, with the symbol graduated by the magnitude of the *E. coli* result. There were two main clusters of reported sampling locations. Twenty-seven samples between January 2008 and February 2011, plus one in May 2011, were reported as having been taken within 500 m of the current estimated mussel farm. Twenty-nine samples between March 2011 and October 2013 were recorded as having been taken within 200 m of the current RMP, located approximately 1 km to the southeast of the present mussel farm (the sampling officer reported that mussels were sampled from a bag attached to a raft in this vicinity).

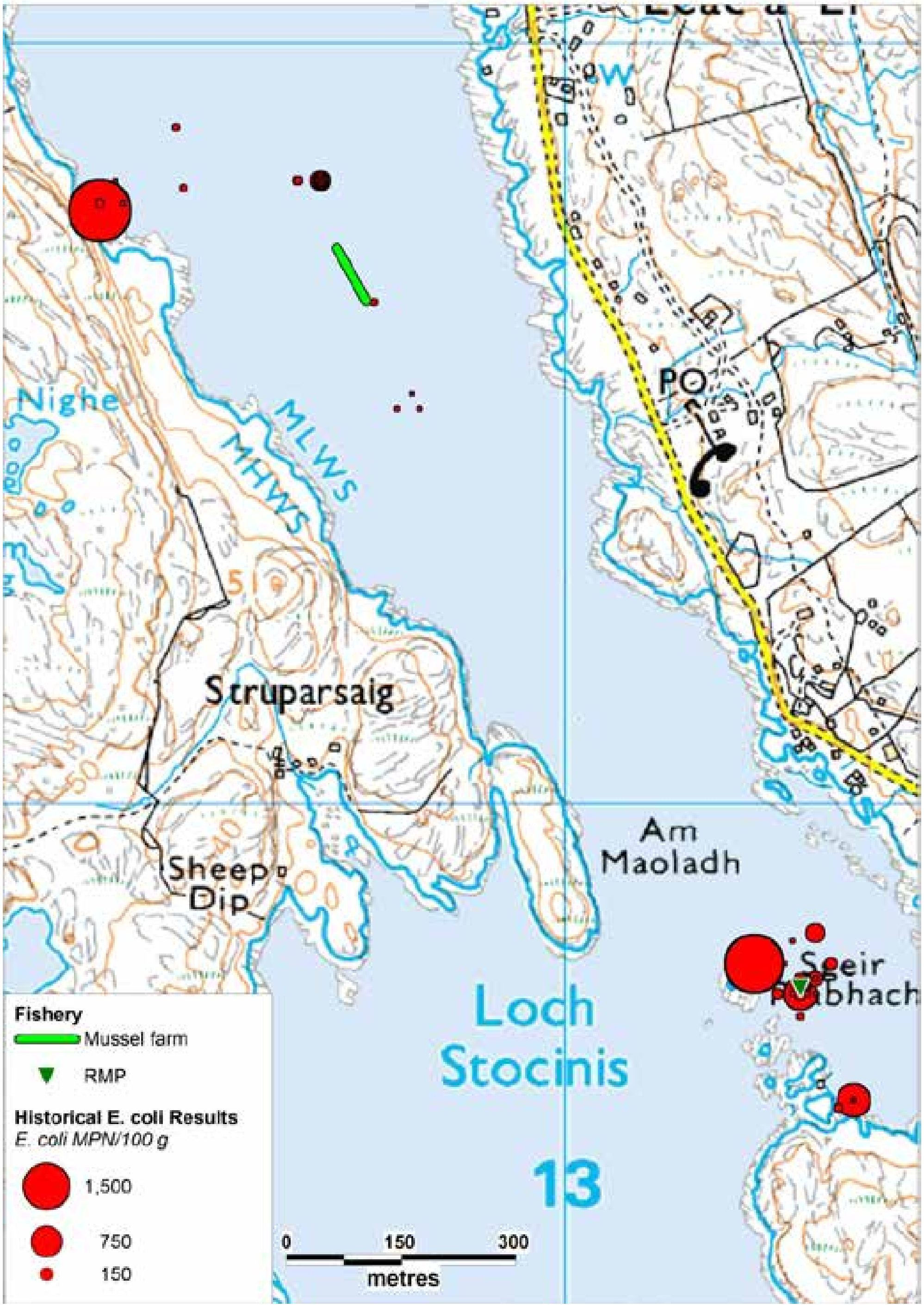


Figure 11.1 Reported sampling locations at Loch Stockinish

The highest result of 2800 *E. coli* MPN/100 g was associated with a sample reported to have been taken in the vicinity of the current mussel farm, but close to MLWS. Geometric means for the two clusters were 37 and 40 *E. coli* MPN / 100 g for the northern and southern clusters respectively. A t-test was carried out to determine whether there was a statistical difference in sampling results between the two sampling areas. No statistical significant difference was found in sampling results between the two clusters (t-test = 0.22, df = 54, p = 0.830).

11.3 Overall temporal pattern of results

A scatterplot of *E. coli* results against date for Loch Stockinish is presented in Figure 11.2. The dataset is fitted with a lowess trend line. Lowess trendlines allow for locally weighted regression scatter plot smoothing. At each point in the dataset an estimated value is fitted to a subset of the data, using weighted least squares. The approach gives more weight to points near to the x-value where the estimate is being made and less weight to points further away. In terms of the monitoring data, this means that any point on the lowess line is influenced more by the data close to it (in time) and less by the data further away. A trend line helps to highlight any apparent underlying trends or cycles.

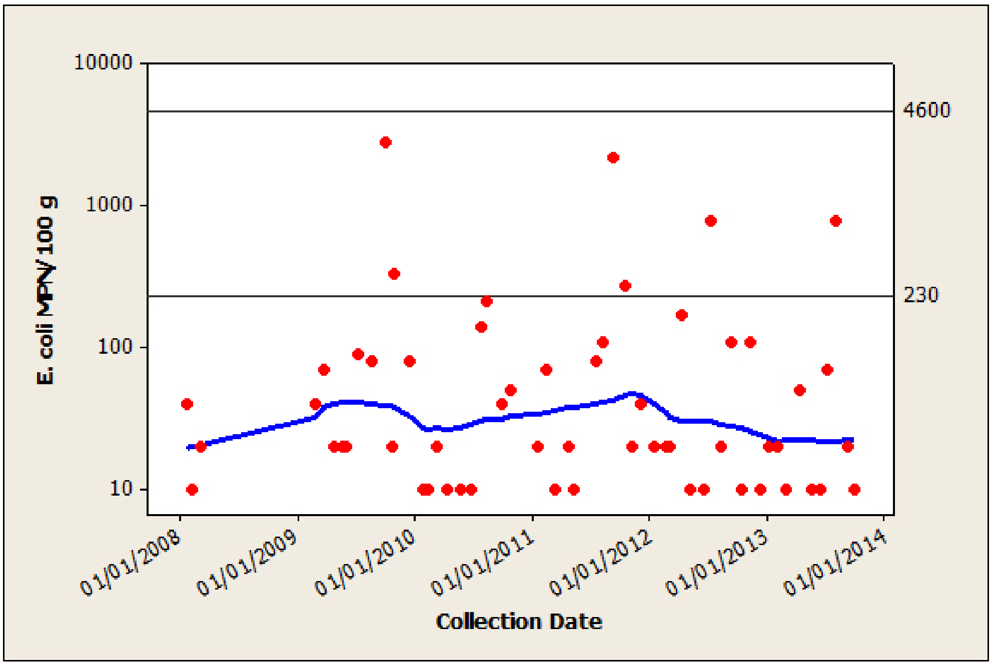


Figure 11.2 Scatterplot of *E. coli* results by collection date at Loch Stockinish, fitted with a lowess line

E. coli levels at Loch Stockinish have largely remained the same across the sampling period. Interpretation of the graph needs to take into account the exclusion of a significant proportion of the 2008 results.

11.4 Seasonal pattern of results

Season dictates not only weather patterns and water temperature, but livestock numbers and movements, presence of wild animals and patterns in human distribution. All of these can affect levels of microbial contamination, causing seasonal patterns in results. A scatterplot of *E. coli* results by month, overlaid by a lowess line to highlight trends is displayed in Figure 11.3. Jittering was applied at 0.02 (x-axis) and 0.001 (y-axis) respectively.

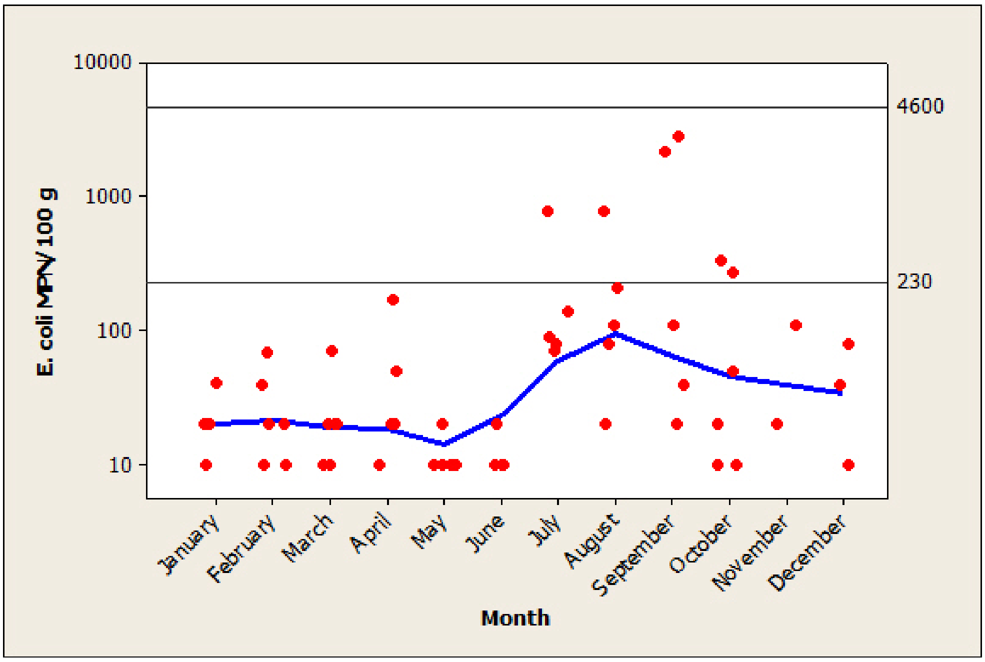


Figure 11.3 Scatterplot of *E. coli* results by month at Loch Stockinish, fitted with a lowess line

Contamination levels show an upward trend from June to August. However, the two highest results have both been taken in September. Sampling has varied across months; February, March and October had six samples, June had four samples, December had three samples and November had two samples. The remaining six months were each sampled five times.

For statistical evaluation, seasons were split into spring (March-May), summer (June-August), autumn (September-November) and winter (December-February). A boxplot of *E. coli* results by season is presented in Figure 11.4.

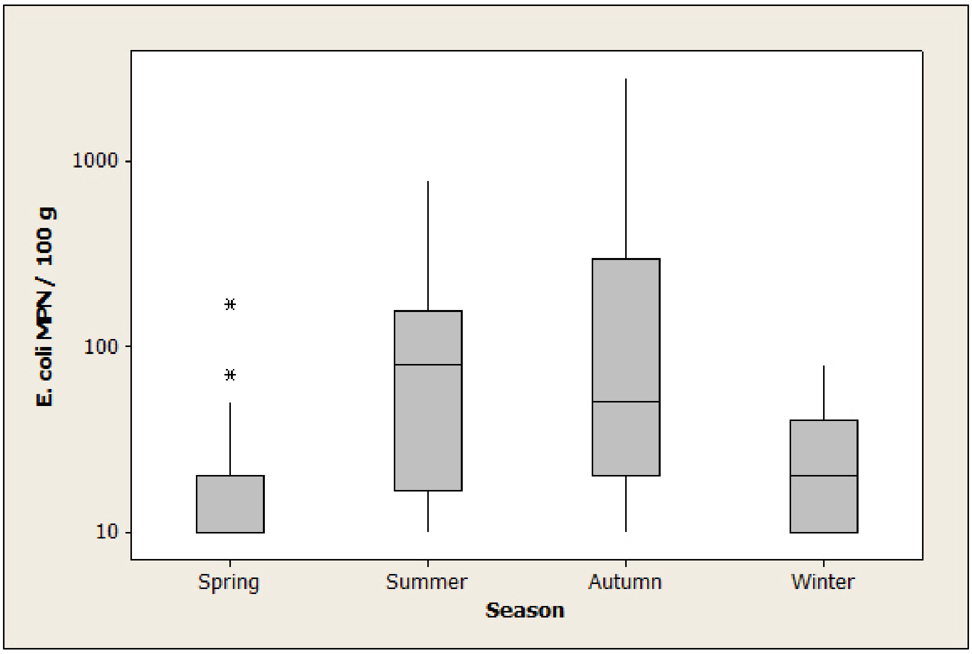


Figure 11.4 Boxplot of *E. coli* results by season at Loch Stockinish

A very highly significant difference was found between *E. coli* results by season (one-way ANOVA, p = 0.005, Appendix 3), with results in autumn higher than those in spring.

11.4.1 Analysis of results against environmental factors

Environmental factors such as rainfall, tides, wind, sunshine and temperature can all influence the flux of faecal contamination into growing waters (Mallin, et al., 2001; Lee & Morgan, 2003). The effects of these influences can be complex and difficult to interpret. This section aims to investigate and describe the influence of these factors individually (where appropriate environmental data is available) on the sample results using basic statistical techniques.

11.4.2 Analysis of results by recent rainfall

The nearest weather station with available rainfall data was at Harrish Quidnich approximately 5 km SW of the Loch Stockinish site. Rainfall data was purchased from the Meteorological Office for the period of 01/01/07 - 31/12/2012 (total daily rainfall in mm). Data was extracted from this for all sample results at Loch Stockinish between 01/01/2008 – 31/12/2012.

11.4.2.1 Two-day rainfall

A scatterplot of *E. coli* results against total rainfall recorded on the two days prior to sampling is displayed in Figure 11.5. Jittering was applied to results at 0.02 (x-axis) and 0.001 (y-axis) respectively.

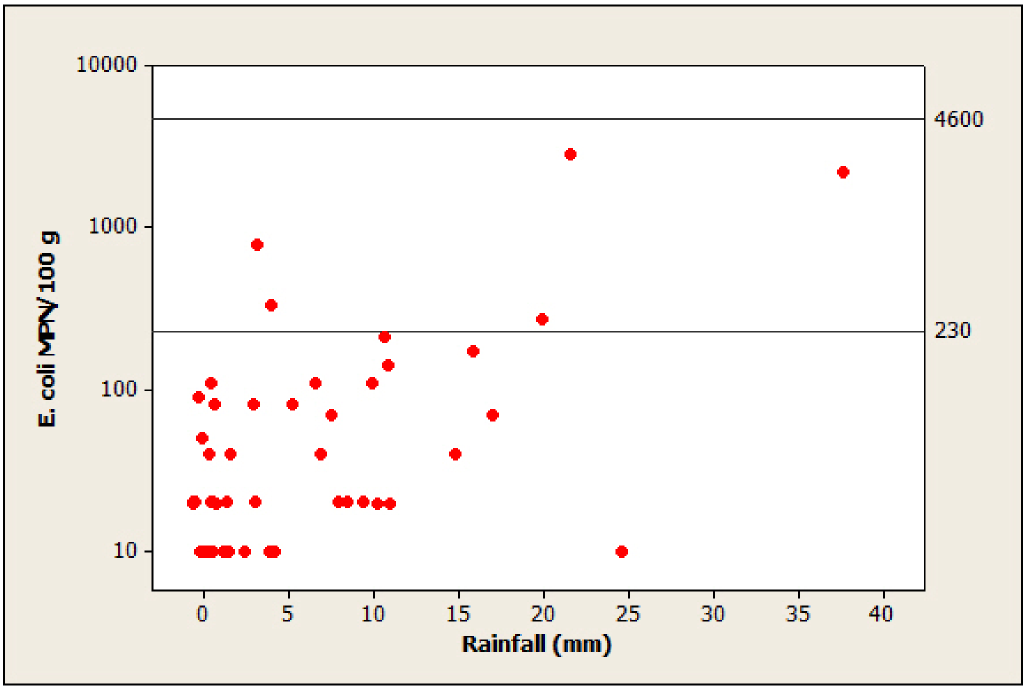


Figure 11.5 Scatterplot of *E. coli* results against rainfall in the previous two days at Loch Stockinish

A very highly significant correlation was found between *E. coli* results and the previous two day rainfall (Spearman's rank correlation r = 0.459, p = 0.001). Higher results were mostly taken at rainfall levels >10 mm over the previous two days.

11.4.2.2 Seven-day rainfall

The effects of heavy rainfall may take differing amounts of time to be reflected in shellfish sample results in different system, the relationship between rainfall in the previous seven days and sample results was investigated in an identical manner to the above. A scatterplot of *E. coli* results against total rainfall recorded for the seven days prior to sampling at Loch Stockinish is shown in Figure 11.6. Jittering was applied at 0.002 (x-axis) and 0.001 (y-axis) respectively.

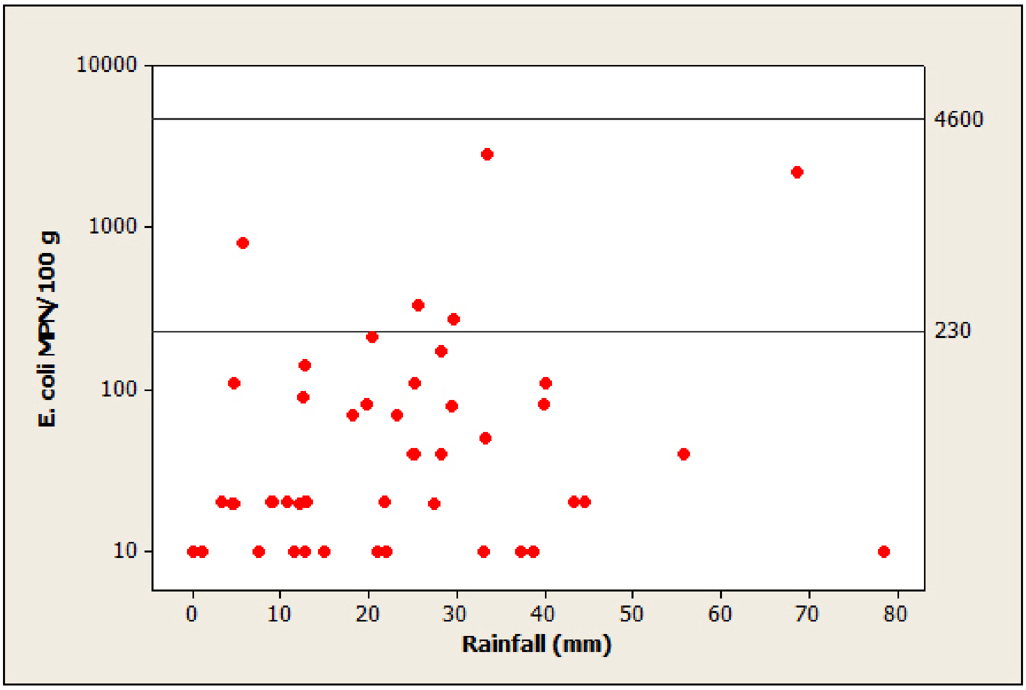


Figure 11.6 Scatterplot of *E. coli* results against rainfall in the previous seven days at Loch Stockinish

No significant correlation was found between *E. coli* results and the previous seven day rainfall (Spearman's rank correlation r = 0.231, p = 0.118), with the highest rainfall level over the seven days prior to sampling returning a low result of <20 *E. coli* MPN/100 g.

11.4.3 Analysis of results by tidal height

11.4.3.1 Tidal state spring/neap

Spring tides are large tides that occur fortnightly and are influenced by the state of the lunar cycle. They reach above the mean high water mark and therefore increase circulation and particle transport distances from potential contamination sources on the shoreline. Figure 11.7 presents a polar plot of *E. coli* results against the lunar cycle**.**The largest spring tides occur approximately two days after the full moon (located at about 45^o in the polar plot), then decrease to the smallest neap tides (at about 225^o), before increasing back to spring tides (at about 0^o). It should be noted local meteorological conditions (e.g. wind strength and direction) can also influence tide height, but is not taken into account in this section.

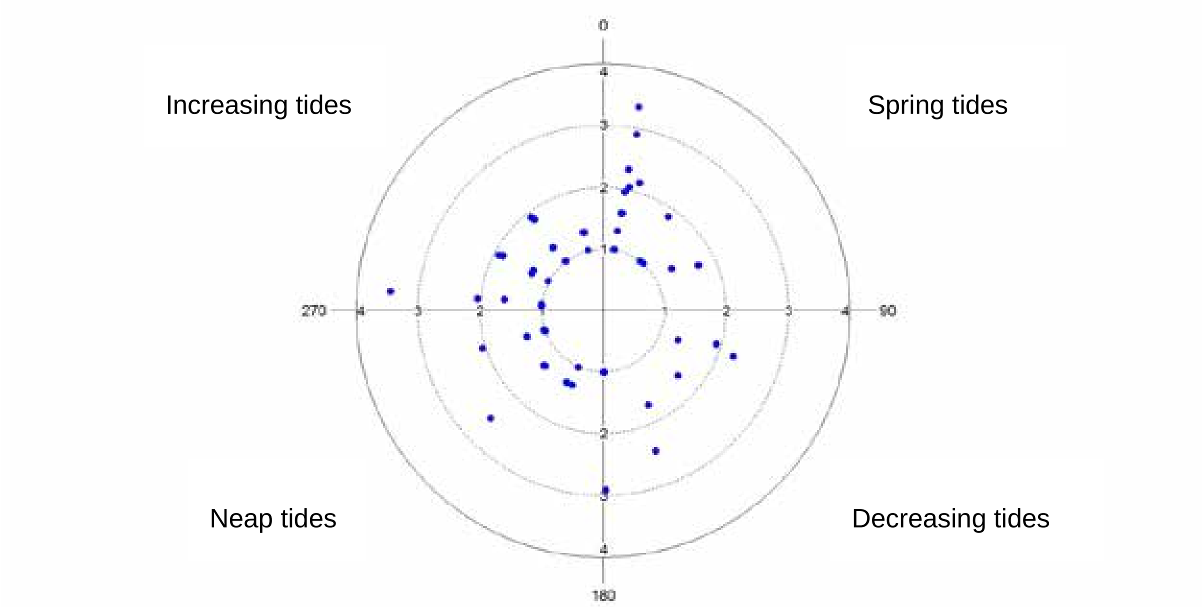


Figure 11**.**7 **Polar plots of Log10 *E. coli* results on the spring/neap tidal cycle at** Loch Stockinish

No significant correlation was found between $\log_{10}$ *E. coli* results and the spring/neap tidal cycle (circular-linear correlation r = 0.217, p = 0.079).

11.4.3.2 Tidal state by high/low water

Tidal state (high/low tide) changes the direction and speed of water flow around production areas. Depending on the location of contamination sources, tidal state may cause marked changes in water quality near the vicinity of the fisheries. Figure 11.8 presents a polar plot of *E. coli* results against the high/low tidal cycle. High water is at 0^o and low water at 180^o.

High and low water data from East Loch Tarbet was extracted from POLTIPS-3 in October 2013. This site was the closest to the production area (approximately 9.5 km northeast) and it is assumed that tidal state will be similar between sites.

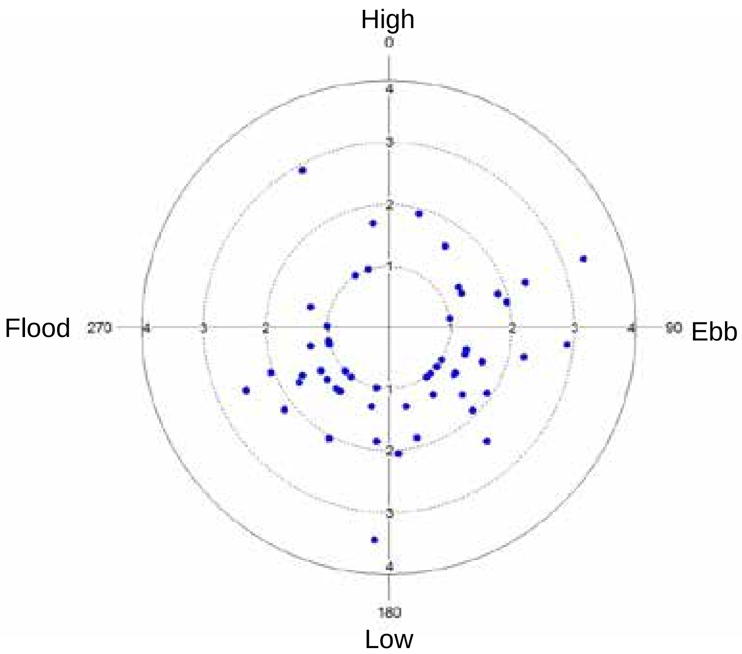


Figure 11.8 Polar plots of log10 *E. coli* results on the high/low tidal cycle at Loch Stockinish

No significant correlation was found between $\log_{10}$ *E. coli* results and the high/low tidal cycle (circular-linear correlation r = 0.189, p = 0.146). The majority of samples were taken around low tide.

11.4.4 Analysis of results by water temperature

Water temperature can affect survival time of bacteria in seawater (Burkhardt, et al., 2000). It can also affect the feeding and elimination rates in shellfish and therefore may be an important predictor of *E. coli* levels in shellfish flesh. Water temperature is obviously closely related to season. Any correlation between temperatures and *E. coli* levels in shellfish flesh may therefore not be directly attributable to temperature, but to the other factors e.g. seasonal differences in livestock grazing patterns. Figure 11.9 presents *E. coli* results against water temperature. Water temperature was recorded for 33/57 samples. Jittering of results was applied at 0.02 (x-axis) and 0.001 (y-axis) respectively.

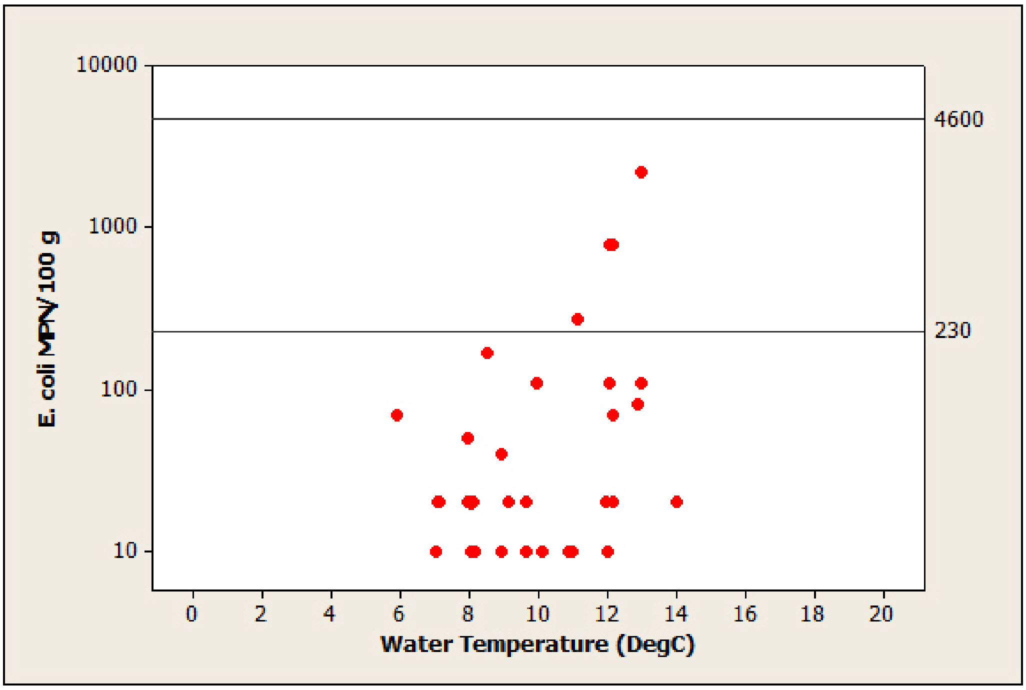


Figure 11.9 Scatterplot of *E. coli* results against water temperature at Loch Stockinish

No significant correlation was found between *E. coli* results and water temperature (Spearman's rank correlation r = 0.328, p = 0.063).

11.4.5 Analysis of results by salinity

Salinity will give a direct measure of freshwater influence and hence freshwater borne contamination at a site. A scatterplot of *E. coli* results against salinity is shown in Figure 11.10. Salinity was recorded for 17/57 samples. Jittering was applied to results at 0.02 (x-axis) and 0.001 (y-axis) respectively.

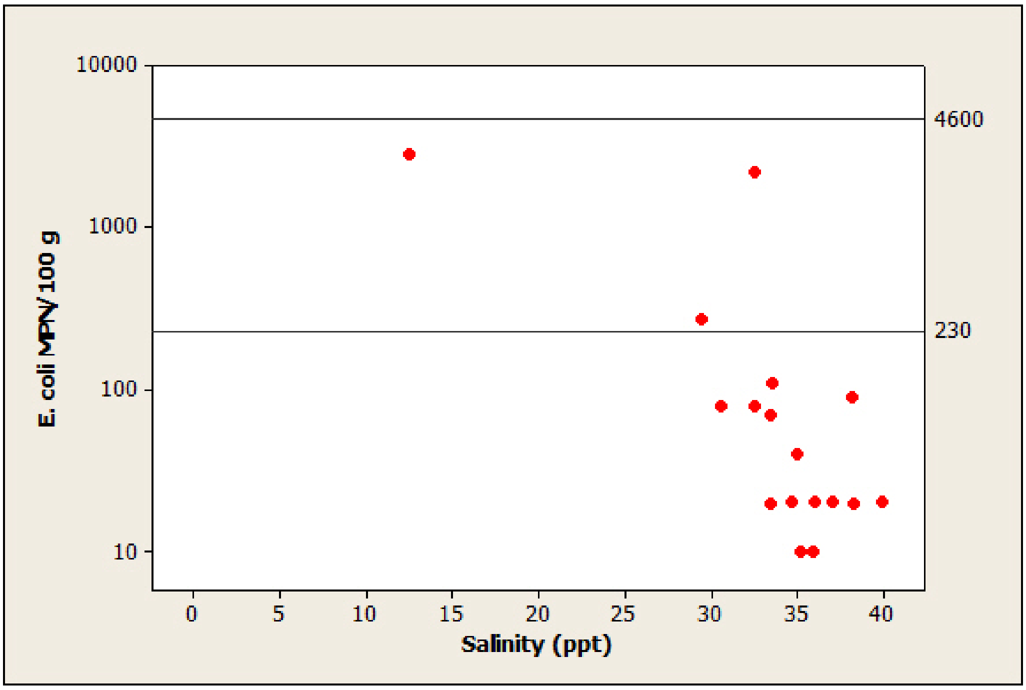


Figure 11.10 Scatterplot of *E. coli* results against salinity at Loch Stockinish

A very highly significant inverse correlation was found between *E. coli* results and salinity (Spearman's rank correlation r = -0.649, p = 0.005). The highest results were taken at salinities <34 ppt.

11.5 Evaluation of results over 230 *E. coli* MPN/100g

In the results from Loch Stockinish, six common mussel samples had results >230 *E. coli* MPN/ 100 g and are listed below in Table 11.2.

Table 11.2 Historic *E. coli* sampling results over 230 *E. coli* MPN/100g at Loch Stockinish

Collection Date	*E. coli* (MPN/100g)	Location	2 day rainfall (mm)	7 day rainfall (mm)	Water Temp (^oC)	Salinity (ppt)	Tidal State (high/low)	Tidal state (spring/neap)
29/09/2009	2800	NG 1239 9178	21.5	34.8	-	12	Low	Increasing
27/10/2009	330	NG 1268 9182	4.6	25.5	-	-	Low	Neap
13/09/2011	2200	NG 1325 9079	37.4	69.1	13	33	High	Spring
18/10/2011	270	NG 1333 9083	20.2	28.6	11	30	Ebb	Decreasing
10/07/2012	790	NG 1331 9075	3.6	5.0	12	-	Flood	Decreasing
06/08/2013	790	NG 1338 9061	-	-	12	-	Ebb	Spring

-No data available

Elevated sample results varied between 270 and 2800 *E. coli* MPN/100 g. Samples were taken in years 2009, 2011, 2012 and 2013, with two results in both 2009 and 2011. The high results were from samples taken between July and October with the two highest from samples taken in September. Sampling locations varied, with early results (those from 2009) recorded against locations in the vicinity of the current mussel farm, whilst the remaining four samples were recorded as having been taken within 200 m of the current RMP.

Rainfall on the two and seven days prior to sampling varied between 3.6 and 37.5 mm and 5.0 and 69.1 mm respectively. Water temperature was recorded for four of the six samples and varied between 11 and 13^{o}C, whilst water salinity varied was supplied for three samples and varied between 12 and 33 ppt.

Tidal states also varied between high/low and spring/neap, with elevated samples occurring on all tidal phases.

11.6 Summary and conclusions

Fifty-seven sample results have been reported at Loch Stockinish, with contamination mostly shown to be low (median of 20 *E. coli* MPN/100 g). Six results have been >230 *E. coli* MPN/100 g, with four of these taken after 2011. A relatively high number of results have had to be omitted from the analysed dataset due to problems with their plotted geographical location. A statistically significant difference was found in sampling results between seasons, with sampling in autumn statistically higher than those taken in spring, with fewer samples taken in autumn.

Sampling location has varied. Samples taken between 2008 and 2010 have all been taken to the northwest of the current RMP, compared to samples taken between 2011 and 2013, which have mostly been taken within <200 m to the RMP at NG 1331 9076. No statistically significant difference was found in sampling results between the two distinct sites.

Statistically significant differences were found between rainfall over the previous two days and results, with higher results generally associated with rainfall levels >10 mm. However no significant difference was found between results and previous seven day rainfall. No significant difference was found between results and water temperature, but a significance was found between results and salinity, with salinities <34 ppt associated with higher results.

No statistically significant differences were found between results and high/low or spring/neap tidal states.

12. Designated Waters Data

The Loch Stockinish fishery does not currently lie within a designated shellfish growing water or a designated bathing water. However, the Scottish Government proposes to designate Loch Stockinish as a new Designated Shellfish Water Protected Area following the repeal of the Shellfish Waters Directive (2006/113/EC) in December 2013 (Scottish Government, 2013). The area to be covered by the proposed shellfish water designation will cover the same area as the current production area boundaries, as shown in Figure 12.1. This is the area bounded by lines drawn between NG 1222 8956 to NG 1352 8971 and between NG 1331 9058 to NG 1346 9087 and from points NG 1227 9200 to NG 1290 9200.

Figure 12.1 Proposed shellfish water designation for Loch Stockinish

13. Hydrographic assesment

13.1 Introduction

13.1.1 The Study Area

Loch Stockinish is situated on the east coast of the Isle of Harris in the Western Isles. It is a southeast facing loch which has a large island, Eilean Stocanais, at its entrance. This location is almost fully enclosed by low lying land affording some degree of shelter. Eilean Stocanais reaches a height of 44 m, and provides additional shelter at the mouth of Loch Stockinish. The mouth of the loch connects with the strongly tidal waters of The Little Minch. There are a number of dwellings around Loch Stockinish mostly along the length of the eastern shore. The study area is shown in Figure 13.1 and is contained within the red line. In addition to Loch Stockinish, there are two other small embayments: Loch Gheocrab and Loch Cliuthair.

Coordinates for the middle of Loch Stockinish:

57° 49.08' N 006° 50.07' W

NG 13028 91200

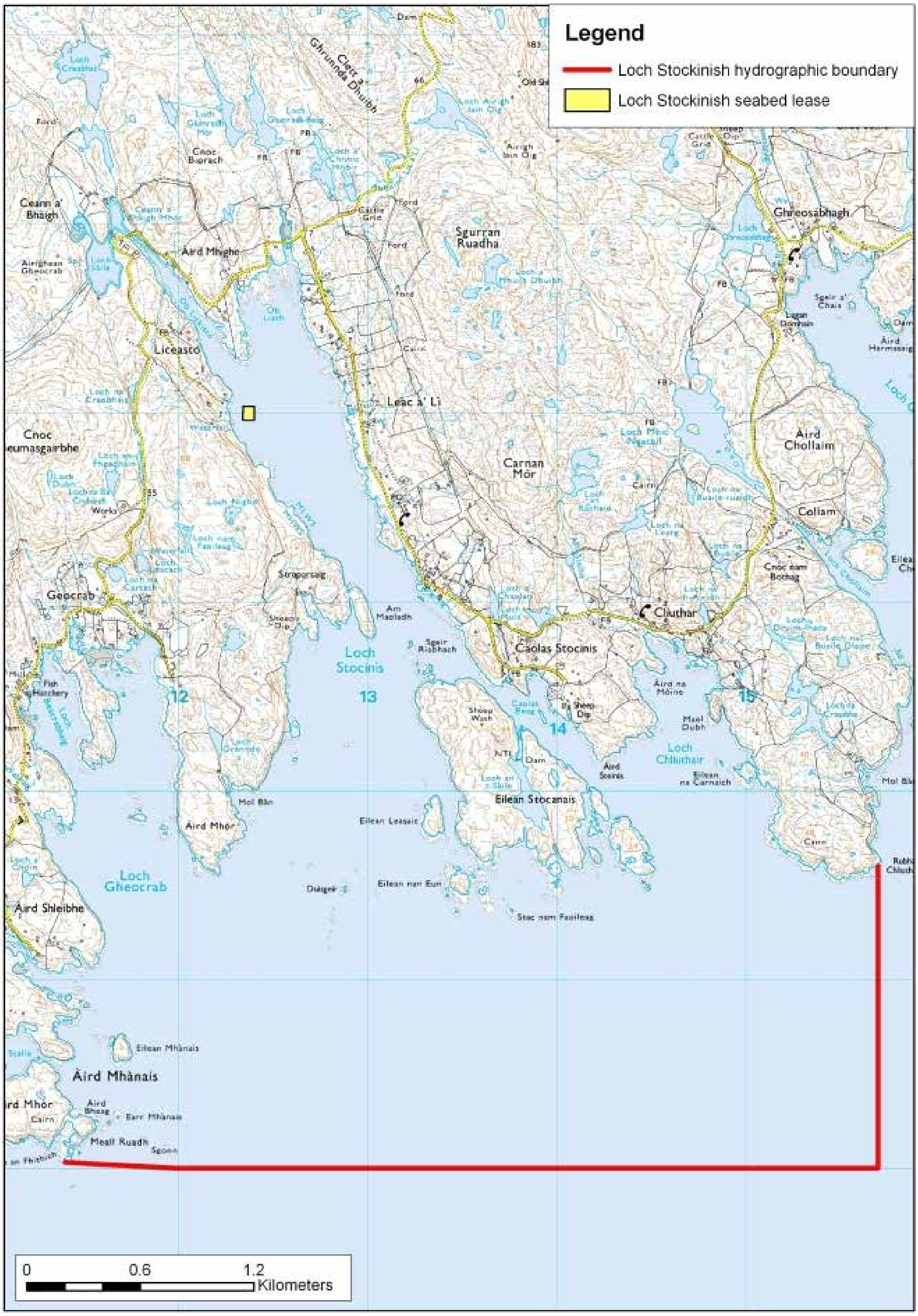


Figure 13.1 Extent of hydrographic study area

13.2 Bathymetry and Hydrodynamics

13.2.1 Bathymetry

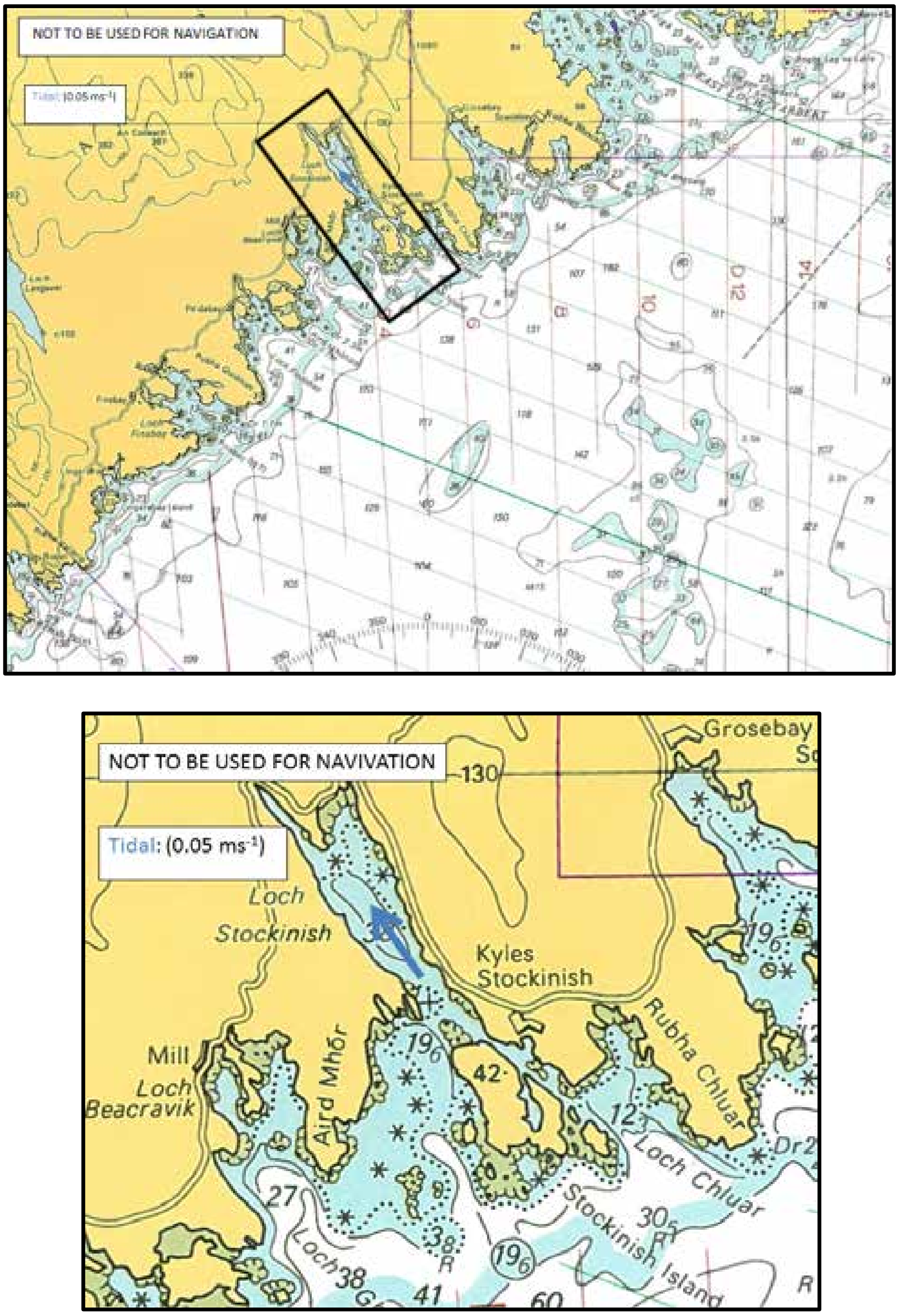


Figure 13.2 Admiralty chart (1795 pub 1978) extract for Loch Stockinish.

The length of the flow arrow equates approximately to the transport distance during the flood phase of the tide, residual flow was found to be negligible. See section 3.1 for further commentary.

Figure 13.2 shows the bathymetry of Loch Stockinish from Admiralty chart 1795, which although the largest scale available, does not display comprehensive or detailed information about the area. The mouth of Loch Stockinish could be defined as extending between Aird Mhor on Harris to the southern shore of Eilean Stocanais.

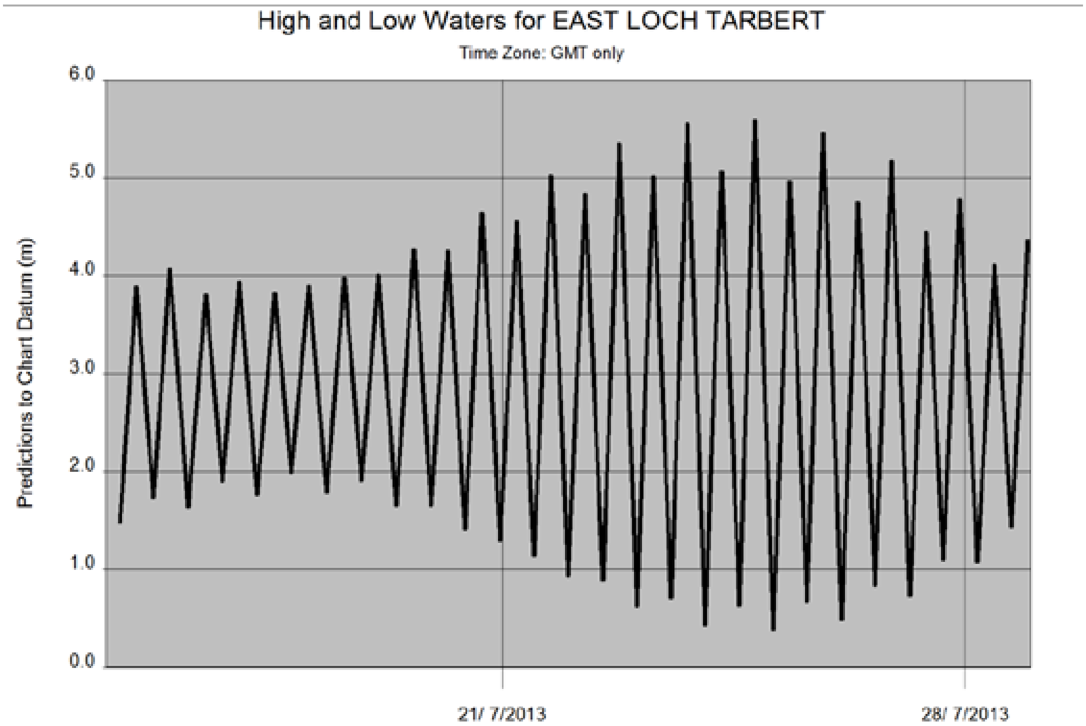
The outer part is rather shallow (depths < 20m), with numerous reefs and isolated rocks. Caolas Mor, with a charted depth of 19 m, marks the entrance to the main body of the inner part of Loch Stockinish where the deepest charted depth is 38 m. As Loch Stockinish opens out onto the Little Minch approximately 500 m from Eilean Stocanais, the depths increase to 40 – 60 m. The length of the loch is reported as being 3.5 km in length with a width of 1.5 km and a volume of 1.8 x 107 m3 (Marine Scotland, 2012). Loch Gheocrab to the southwest is rather smaller at 1.5 km length and 0.6 km width (Marine Scotland, 2012) with a charted depth of 27 m.

Eilean Stocanais at the mouth of the loch provides additional shelter to the main body of the loch. At its widest point it is approximately 0.6 km in width with a maximum height of 44 m. There is a very narrow (< 30 m wide) channel to the north east of Eilean Stocanais, Caolas Beag, which we do not consider important for exchange of waters between the loch and the Little Minch.

13.2.2 Tides

Loch Stockinish has a typical semi-diurnal tidal characteristic. Data on tidal information is given from charted information. The nearest location for tidal predictions is East Loch Tarbert situated approximately 8 km from Loch Stockinish [http://easytide.ukho.gov.uk].

Standard tidal data for East Loch Tarbert are given below and the spring/neap cycle of tidal height around the time of the survey (22-23/07/2013) is shown in figure 13.3:



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

Figure 13.3 Two week tidal curve for East Loch Tarbert.

Tidal Heights for East Loch Tarbert (from Admiralty Chart 1795):

Mean High Water Springs = 5.0 m
Mean Low Water Springs = 0.8 m
Mean High Water Neaps = 3.7 m
Mean Low Water Neaps = 2.1 m

Tidal Ranges:

Mean Spring Range = 4.2 m
Mean Neap Range = 1.6 m

13.2.3 Tidal Streams and currents

There are no tidal diamonds for this area to provide information on large scale flow. Within Loch Stockinish we expect the flows to be rather simple following the axis of the loch. In the vicinity of the shallower waters around Eilean Stocanais there may be enhancement of tidal streams caused by the straights.

There is a single current meter record obtained from SEPA for a survey in Loch Stockinish (Aurora Environmental Ltd, 2006). The data spanned 15 days (4/2/06 – 19/3/06); being the half-lunar period required to capture a spring-neap cycle. In these reports, near-bed refers approximately to 3 m above the seabed, mid-depth is typically 13 m above the seabed and sub-surface is 15 m above the seabed.

Data collected from Loch Stockinish in 2006 (Aurora Environmental Ltd, 2006) is summarised in Table 13.1. The velocity data showed a general semi-diurnal periodicity along with some spring-neap variation. In general, the currents were of a moderate velocity and whilst the tabulated mean velocity is greatest in the near-bed, overall there was similarity between current velocities at all depths. The data has rather little technical narrative accompanying it. This survey reports that flow at all depth in Loch Stockinish generally flow north-west/south-east following the axis of the loch.

Table 13.1 Loch Stockinish current data measured in 2006.

	Near-bed	Mid	Sub-surface
Mean Speed (ms-1)	0.056	0.049	0.045
Principal Axis Amp (ms-1) & Dir (o)	0.050 (300)	0.051 (310)	0.050 (310)
Residual speed (ms-1)	0.001	0.001	0.003
Residual direction (oM)	357	004	014

Based upon a measured surface principal current amplitude of 0.05 m/s (Table 13.1) and the assumption of a uniform sinusoidal tide, the cumulative transport that might be expected in the surface during each phase of the tide has been estimated as approximately 0.7 km. No distinction is made here for springs and neaps, nor has any estimate been made for any seasonal variation.

Dispersion is an important property of a water body with respect to redistribution of contaminants over time. There are no measurements or published data relating to dispersion in Loch Stockinish. Without such data it is difficult to judge what the dispersive environment might be like, but the occurrence of rocky outcrops, islets and a large island plus the presence of narrows may enhance dispersion in the outer part of Loch Stockinish and the wider assessment area.

13.2.4 River/Freshwater Inflow

There are a number of freshwater river inflows into Loch Stockinish which range in size and therefore significance. It is likely that some of the small sources will only flow during periods of high rainfall. The largest collection of freshwater input occurs at the head of the loch where a group of small land-locked lochs meet and flow into Loch Stockinish. Loch Sàile is the largest and enters the loch from the northwest with contribution from Loch Creabhat to the north. South of this, Loch na Craobhaig also enters the loch. Four small land-locked lochs to the north-northeast join and eventually flow into Loch Stockinish. These are named as Loch Glumradh Mòr, Loch Glumradh Beag, Loch a' Chnoic Mhòir and Loch Airigh Iain Oig. There are numerous smaller rivers dotted around the area but they are unnamed on the OS map.

There is no reported discharge of freshwater into this area, but it is likely that at times of high rainfall the freshwater contribution to this small, shallow loch is high.

13.2.5 Meteorology

The Loch Stockinish area is predominantly exposed to southwest winds. However, because of its sheltered position as a result of being surrounded by a landmass which has a northwest axis, Loch Stockinish may therefore be protected from these winds. It is highly likely that the local wind direction will be strongly influenced in Loch Stockinish by the morphology of the surrounding ground.

Wind data were taken from Stornoway approximately 52 km northeast of Loch Stockinish. Due to the distance between the two areas, the wind statistics may not be directly transferrable to the specific production area in Loch Stockinish but they can be used to give a general picture of the seasonal wind conditions on the east of the Western Isles. The data from Stornoway shows that, overall, westerly and southerly winds were stronger than northerly or easterly winds. There is a predominant south-westerly airflow year round for the area.

The closest area with adequate rainfall data is situated at Quidnich on the Isle of Harris which is approximately 5 km to the southwest of Loch Stockinish. The data spanned from January 2007 to December 2012.

There were differing rainfall levels from year to year with the highest rainfall being recorded in 2008 and the lowest in 2010. Rainfall reached more than 30 mm/d throughout 2007, 2008, 2011 and 2012 and in 2007 an extreme level of rainfall of approximately 50 mm/d was recorded.

Rainfall values were, overall, higher during the autumn and winter months. The rainfall generally increases from July onwards and is highest in November and January. April to June are the months with the least rainfall. Levels of rainfall reached more than 30 mm/d in February, May, August, November and December.

43% of days from 2007 to 2012 had rainfall below 1 mm with over 10 mm of rainfall being recorded on 12% of the days. Consequently, it can be assumed that run-off because of rainfall will be high throughout both the autumn and winter months. However, whilst a general seasonal pattern in rainfall can be deduced from the historic data, periods of high rainfall can be recorded in the majority of months.

13.2.6 Model Assessment

There is rather little data available for this location to prepare a refined, three-layer box model for the Loch Stockinish area. However, simple modelling techniques based on tidal prism methods (Edwards & Sharples, 1986) have been employed by others to establish flushing times (Marine Scotland, 2012). The flushing time was estimated at 2.1 days although this method is known to overestimate exchange and therefore under-predict flushing time (Gillibrand, et al., 2002). Further, there will be variations about this value due to wind forcing and freshwater flow.

13.3 Hydrographic Assessment

13.3.1 Surface flow

The site and the meteorological data indicate that there is likely to be a rather significant freshwater discharge into the surface waters of the loch, though the absolute value of discharge has not been measured. The meteorological data indicate a moderate seasonal variation in freshwater discharge.

The Loch is relatively narrow and small in length so there is not likely to be significant variations in the surface properties along the axis of the loch. Further, it is a shallow loch with relatively strong tidal flow so is likely to be well mixed.

Surface flows would be enhanced/retarded by winds blowing out of/into the loch and also further enhance the mixing of the waters through the full depth. However the main axis of the loch is not aligned with the dominating southerly or southwesterly directions, though these winds would enhance flow in the outer part assessment area and potentially force water into the loch.

From the rather limited current meter measurements in Loch Stockinish it is likely that any surface contaminant in the inner part of the loch would be transported primarily along the axis. However, once beyond the entrance at Caolas Mor, there is likely to be effective transport and dispersal into the wider assessment area, except in periods of onshore winds.

Net transport of contaminants is related to the residual flow documented in Table 13.1. The residual surface flow measured in the surface waters of Loch Stockinish (Aurora Environmental Ltd, 2006) follow a generally northerly direction. This can be interpreted as an effect of rather fresh onshore winds during the measurement period, though typically in this setting one would expect a weak residual surface outflow from the loch. With the measured surface residual of order 0.001 m/s, the net transport over a tidal cycle of approximately 12 hours would be less than 50 m, essentially negligible.

13.3.2 Exchange Properties

The simple modelling study (Marine Scotland, 2012) indicates a flushing time for Lock Stockinish of 2.1 days. Given the volume of the loch and the relatively big tidal range, the exchange will be dominated by the tidal volume flux meaning that the exchange of waters in Loch Stockinish is principally a tidally driven process. Hence there is likely to be rather little seasonal variation in the flushing time of the Loch.

One might describe the flushing characteristics of Loch Stockinish as being 'well flushed', with little additional enhancement from the winds. Effective vertical mixing in this shallow system and a relatively deep sill across the mouth means that subsurface exchange will probably have similar exchange characteristics as the surface water.

There is a limited amount of available current meter data for Loch Stockinish and there is a paucity of any measured hydrographic data. However, there is a simple model assessment of exchange available. Therefore the confidence level of this assessment is MEDIUM.

14. Shoreline Survey Overview

The Loch Stockinish shoreline survey was undertaken on the 22nd and 23rd July 2013. No rainfall was recorded in the week leading up to the survey. High levels of cloud cover and temperatures of 22°C recorded on both survey days. Wind speed was recorded as 1.4 km/h on the first day and 0.9 km/h on the second day.

One common mussel long-line fishery operates in Loch Stockinish. It consists of a single line with 23 buoys, with 12 m droppers. The harvester's assistant (Mr Finlay McLeod) commented that the harvester had no immediate plans to expand the fishery. Five mussel samples were taken in total, four of which were taken at the mussel farm and one which was taken from a mooring line close to Stockinish Harbour approximately 1.5 km southeast of the mussel farm. Shellfish samples taken at the northern extent of the farm gave results of <20 and 80 *E. coli* MPN / 100 g at <1 and 12 m respectively. A seawater sample taken at that location returned a result of 4 *E. coli* cfu/100 ml. Shellfish samples taken at the southern extent of the fishery gave results of 80 and 50 *E. coli* MPN / 100 g at <1 and 12 m respectively. A seawater sample taken at that location returned at 6 *E. coli* cfu/100 ml. A mussel sample taken from a mooring rope located close to the harbour yielded a result of 140 *E. coli* MPN/100 g. The associated seawater sample returned a result of 7 *E. coli* cfu/100 ml.

No public sewage discharges were noted in the shoreline survey. Five pipes from a private ST were observed in total, though none were flowing at the time of the survey. A further three observations were made of private STs. Two seawater samples were taken adjacent to sewage pipes; one observed noted entering into the harbour returned a high result of 800 *E. coli* cfu/100 ml and the other observed north of Liceasto returned a result of 8 *E. coli* cfu/100 ml. In total ten freshwater samples were taken from watercourses entering into the loch. The results ranged from <10 to 940 *E. coli* cfu/100 ml

The only seasonal variation in human population is expected to the northwest of the loch, associated with Lickisto Blackhouse campsite and a holiday cottage. At the time of the survey, two static yurts, five tents and four touring caravans were observed at the campsite.

Stockinish Harbour consists of a pier, a slipway and a pontoon. Four fishing boats and twelve small rowing boats were present at the time of the survey.

Farming in the area is limited. Eighteen sheep were observed in total; 12 along the northwest shore, six along the northeast shore and two noted along the southeast shore. Three horses were also observed in a field at the head of the loch. No obvious farm buildings were observed.

Birds were the most common wildlife observed although relatively low numbers were recorded. Eleven common seals were observed at the head of the loch.

Two CTD (conductivity, temperature, depth) casts were made, one at each end of the header line. Salinities were between 34.4 psu and 34.6 psu and differences between the sites and between depths at each site were within the variability of the instrument. However, at each site, the sea temperature decreased rapidly with depth from 14.2°C at near-surface to 12°C at approximately 2.5 m.

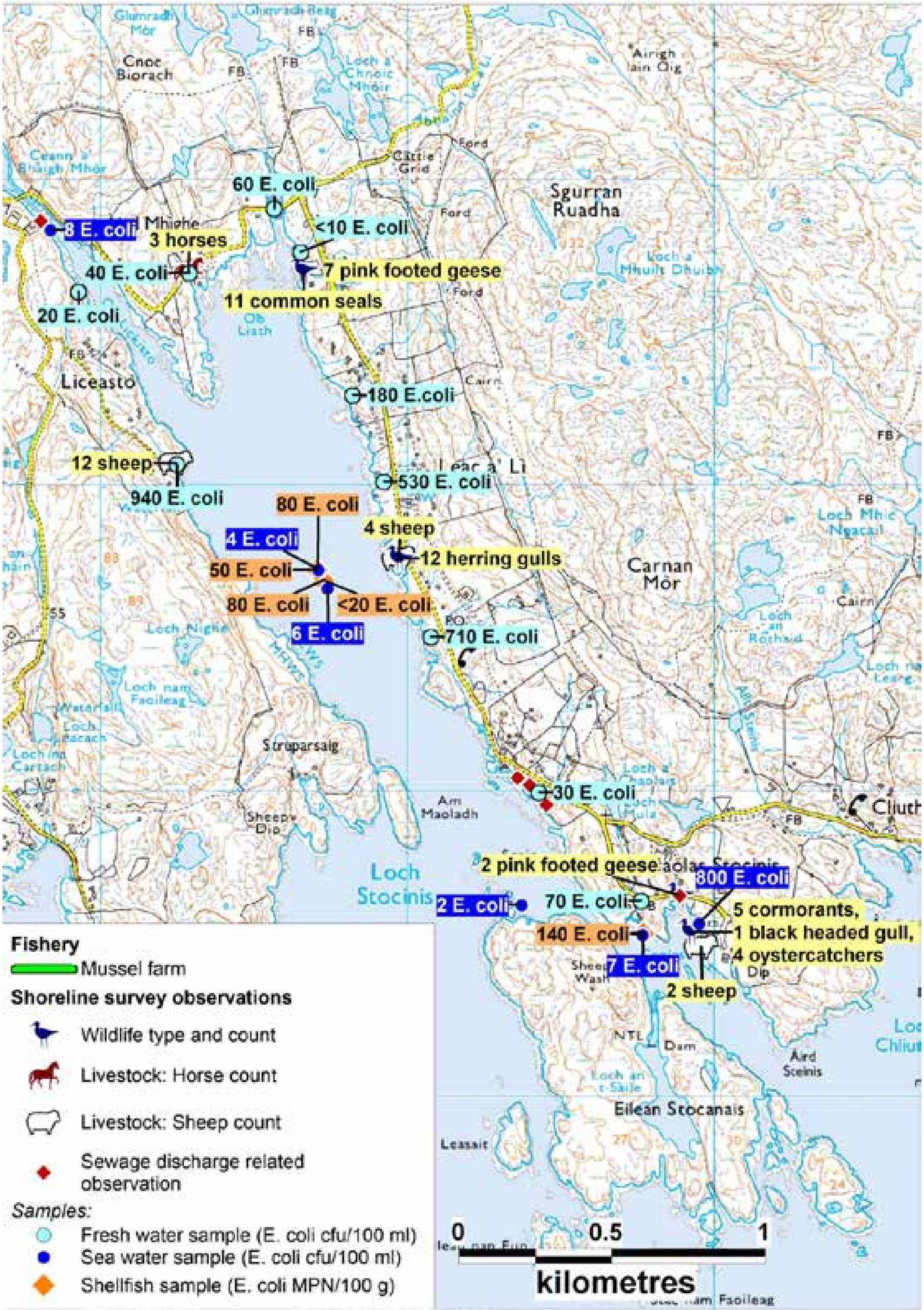


Figure 14.1 Summary of principal shoreline survey findings for Loch Stockinish

15. Overall Assessment

Human sewage impacts

The population in the immediate vicinity of Loch Stockinish is sparse and mainly concentrated along the eastern shore. There is no Scottish Water discharge into the loch itself and the private septic tanks principally lie along the eastern shore with a cluster of potential sources in the vicinity of Caolas Stocinis. A small Scottish Water septic tank and several private septic tanks are located in Loch Gheocrab, a short distance to the west of the mouth of Loch Stockinish.

Agricultural impacts

Farm animal-associated contamination will be mainly from sheep although some horses were seen at the head of the loch during the shoreline survey. The numbers in the area appear to be low and dispersed and thus contamination arising from this source will be minor and not affecting any specific part of the production area more than another.

Wildlife impacts

Contamination from wildlife sources is anticipated to be low and generally dispersed around the area. It is not known how much impact foraging bird populations from the Shiant Isles will have at Loch Stockinish.

Seasonal variation

During the shoreline survey, a campsite was identified to the northwest of the loch and a small B&B was noted at the head. Given the generally low population in the area, a small number of visitors would represent a large proportional change. Mussel *E. coli* results exceeding 230 MPN/100 g have only been seen from July to October and a statistical assessment showed that *E. coli* levels were significantly higher in autumn than in spring.

Rivers and streams

E. coli loadings from watercourses estimated from the shoreline survey measurements and sample results were low to moderate with most of the loading located to the northern end of the loch. However, the shoreline survey was undertaken after a period of dry weather. A watercourse with a moderate estimated *E. coli* loading was located approximately 300 m southeast of the mussel farm. No significant freshwater impact was evident at the farm from the results of the CTD casts but the hydrographic assessment identified that heavy rainfall could cause a significant freshwater input to the loch.

Movement of contaminants

Movement of contaminants over a single tide phase (flood or ebb) was estimated to be in the order of 0.7 km, along the axis of the loch. The estimated net movement over a whole 12 hour tidal cycle was in the order of 50 m, which is very low. No significant effect of either the spring/neap or high/low tidal cycle was found in the analysis of historical *E. coli* data.

Temporal and geographical patterns of sampling results

No marked change was seen in the *E. coli* results over the period from January 2008 to October 2013. Prior to March 2011, recorded sampling locations were broadly in the vicinity of the present mussel farm. Since that date, most recorded sampling locations lie in the vicinity of the present RMP nearer to the mouth of the loch. The sampling officer identified that the latter related to mussels being sampled from a bag attached to a raft. There was no significant difference in the average *E. coli* in mussels from the two clusters and one of the two highest results occurred in samples taken from each.

Conclusions

Most of the identified potential sources of pollution are located at the head of the loch and towards or outside the mouth of the loch (including within Loch Gheocrab). A small number of private septic tanks and two watercourses lie within 300 m of the mussel farm. Given the short length of the loch, many sources lie within the 0.7 km estimated tidal transport distance. As the loading from each source is anticipated to be relatively low, dispersion and dilution will markedly reduce any impact from those outside the immeduiate vicinity.

16. Recommendations

Production area

It is recommended that the southern extent of the production area be reduced to exclude the sources towards the mouth of the loch and be defined as: The area bounded by lines drawn between NG 1277 9128 and NG 1305 9134 and between NG 1227 9200 and NG 1290 9200 extending to mean high water springs. This still includes the southern end of the deep basin within Loch Stockinish.

RMP

Although the general level of contamination appears to be the same at the two previously sampled areas, it is recommended that the RMP be located at NG 1274 9166 in order to reflect the contamination at the farm both at present and in case of future changes in pollution sources that may have a differential impact along the loch.

Tolerance

It is recommended that a tolerance of 40 m be applied in order to allow for movement of the lines with the tide.

Depth of sampling

It is recommended that sampling is undertaken at a depth of between 1 and 3 m as the hydrographic study identified that significant freshwater input could occur on occasions and this would reflect associated contamination.

Frequency

Given that seasonal differences have been identiied in the *E. coli* results to date, it is recommended that monthly sampling be continued.

A map showing the recommendations is given in Figure 16.1.

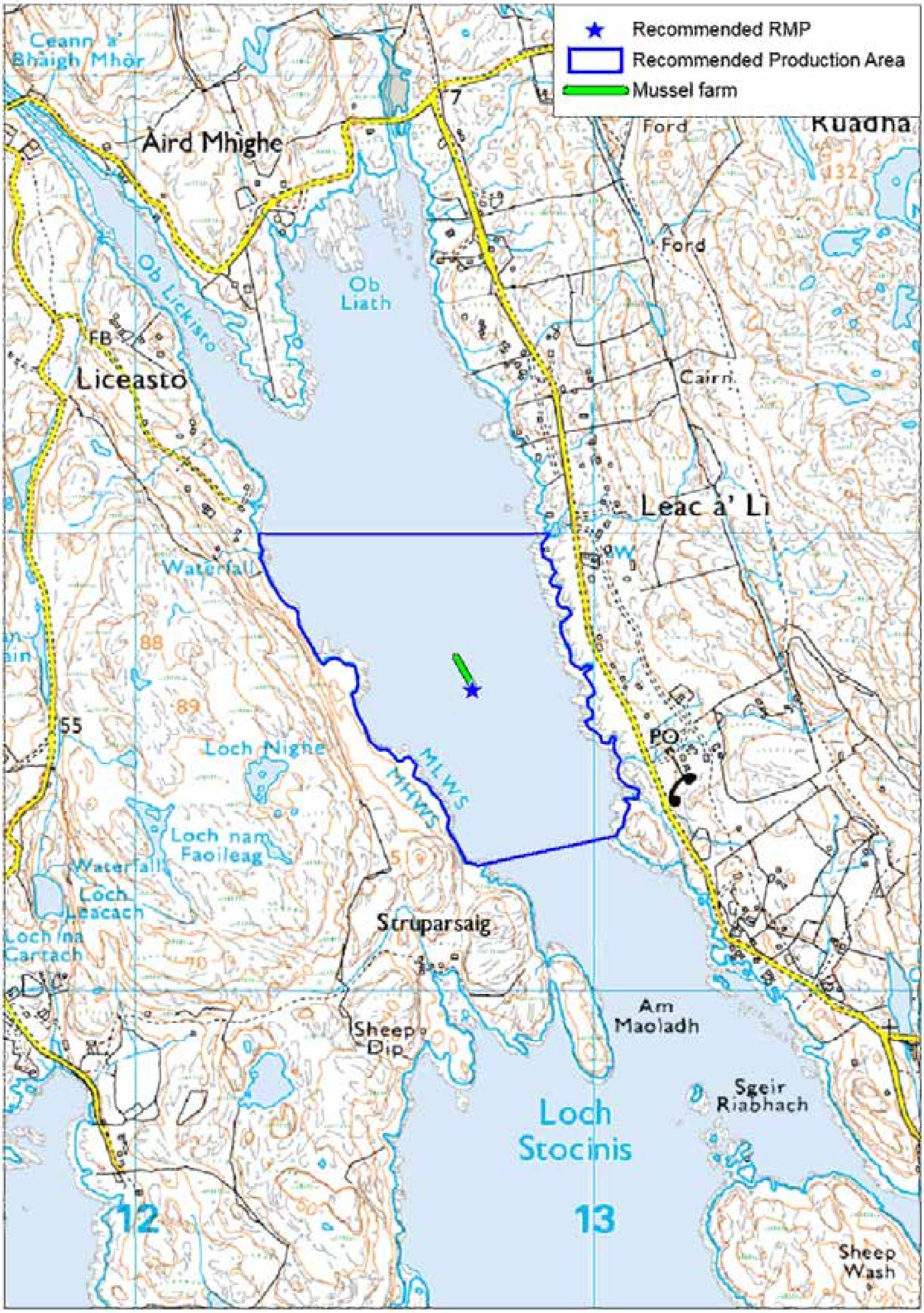


Figure 16.1 Map of recommendations at Loch Stockinish

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4. **Hydrographic Section Glossary**
5. **Shoreline Survey Report**
6. **SEPA Discharge Consents**
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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.

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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.

Table 1 - Geometric mean and 95% confidence intervals of faecal coliform concentrations under base- and high-flow conditions for different levels of sewage treatment

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 2 – 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 3 - 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

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

Document Number	B0067_Shoreline 0018

Revision History

Revision	Changes	Date
A	Issue for internal review	12/08/2013
01	First formal issue to CEFAS	03/09/2013

	Name & Position	Date
Author	Debra Brennan	02/08/2013
Checked	Andrea Veszelovszki, John Hausrath	03/09/2013
Approved	John Hausrath	03/09/2013

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

Shoreline Survey Report

Production area: Loch Stockinish
Site name: Loch Stockinish
SIN: LH-249-129-04
Species: Common Mussels (*Mytilus edulis*)
Harvester: Murdo MacKinnon
Local Authority: Comhairle nan Eilean Siar: Lewis and Harris
Status: Existing area
Date Surveyed: 22/07/2013, 23/07/2013
Surveyed by: Eilidh Cole, Debra Brennan
Existing RMP: NG 1331 9076

Area Surveyed

The shoreline was surveyed for approximately 3.5 km in total including the area around Stockinish Harbour, the East shoreline around the septic tank at NG1342 9099, the North East shore down from the head of the loch and a section heading down the North West side from the head of the loch. Difficulty with access around a headland to the North West of the harbour prevented the entire shoreline on the survey plan being surveyed.

Weather

There was no rainfall recorded for the previous week (from 15/07/2013) leading up to the survey. During the survey, the weather was mostly dry and sunny.

Monday 22/07/2013 - Cloud cover was at approximately 60% at the start of the survey and steadily decreased throughout the day down to about 5%. Temperature was 22°C with the wind speed of 1.4km/h. Sea state 0 calm, no ripples.

Tuesday 23/07/2013 Cloud cover was approximately 90% steadily decreasing throughout the morning. Temperature 22°C, wind speed 0.9km/h. Sea state 0, calm, no ripples.

Stakeholder Engagement during the survey

The sampling officer Mr Paul Tyler was very cooperative and helpful during both pre-survey preparation and planning and also during the survey. Mr Tyler provided liaison with the harvester's assistant, Mr Finlay McLeod, who provided boat access to the site for sampling, also helping with sample collection.

The harvester, Mr Murdo MacKinnon, could not be reached due to other commitments, and all communication in regards of the survey were undertaken through Mr McLeod, mainly with the help of Mr Tyler.

Fishery

Loch Stockinish is a Common Mussel (*Mytilus edulis*) fishery. The main fishery consists of one single line with 23 buoys. The mussels are grown on suspended culture lines with each individual line being approximately 12m in length. Mr Finlay

McLeod commented that the single line was extremely productive and that there were no immediate plan to add more lines.

Sewage Sources

The area surrounding Loch Stockinish is sparsely populated with approximately forty private dwellings, the majority of these on the SE side of the loch with no signs of public sewage provision. Observed sewage discharges appeared to be from septic tank outflows, with three pipes observed during the survey. There was also a café/shop/community centre situated at the head of the loch.

Seasonal Population

Lickisto Blackhouse campsite is situated the hillside to the NW of the loch where two static yurts, five tents and four touring caravans were observed. There were no B& B's or hotels in the area. There was one holiday cottage, 'Two Waters Lodge', at the head of the loch.

Boats/Shipping

The small harbour at Stockinish consists of a pier, slipway and a pontoon. On the day of the survey there were four fishing boats and twelve small rowing boats present. No other vessels were observed on the loch during the survey.

Farming and Livestock

The only livestock observed during the survey were sheep in very small numbers, i.e. twelve at the head of the loch, with a further six observed during the course of the shoreline survey. Three horses were also observed in a field at the head of the loch. There were no obvious farm buildings observed around the loch.

Land Use

There was very little grazing ground around the loch. There were scattered dwellings totalling approximately forty houses mostly along the SE side of the loch next to the single track road. There was no forestry or commercial/industrial industry around the loch.

Land Cover

Most of the immediate area surrounding the loch was rough boulder strewn hillside with sparse vegetation of predominantly bracken and heather.

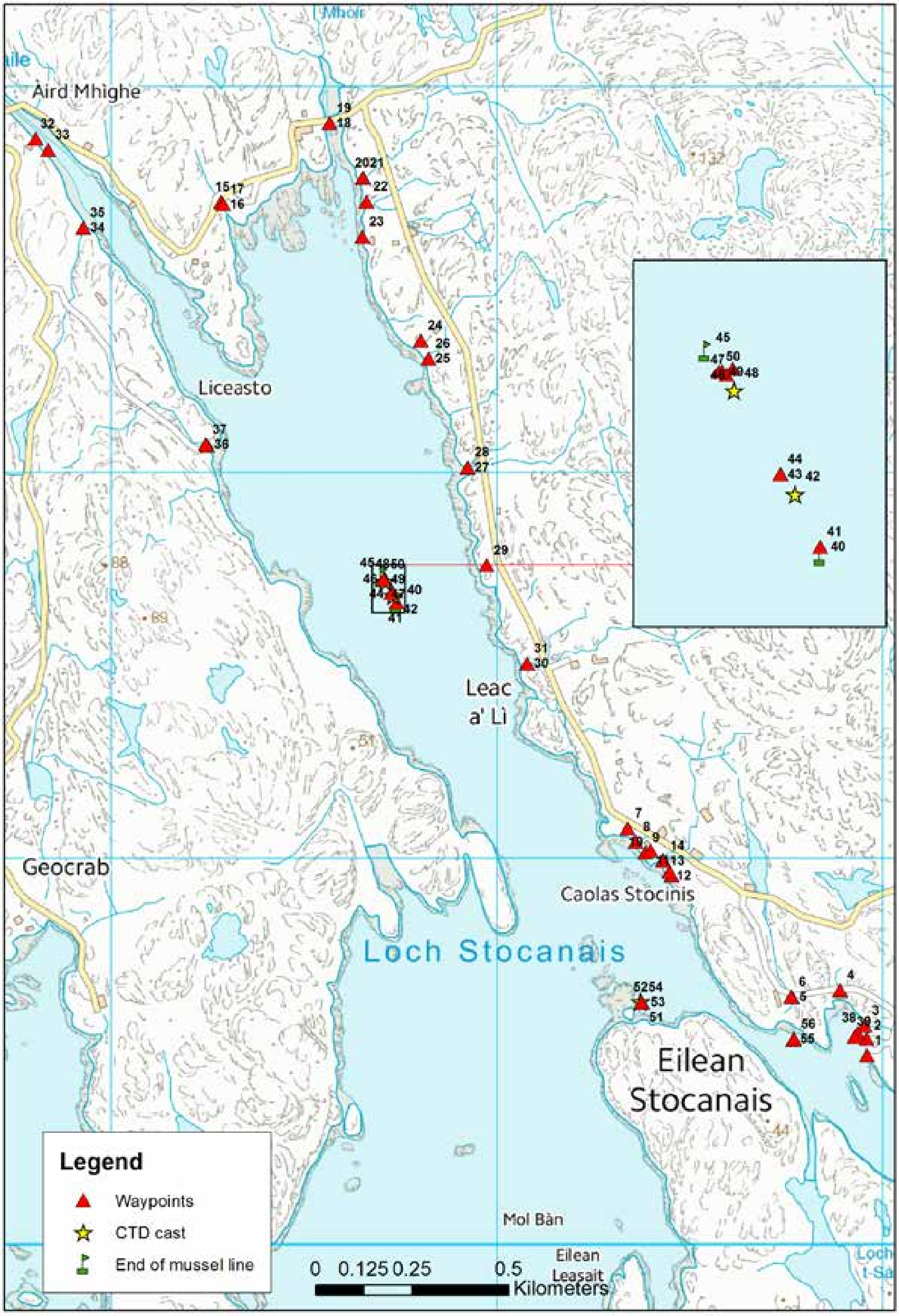
Watercourses

The largest watercourse observed (not named on the OS map), is approximately 6.5m wide and feeds Loch Stockinish from Loch Glumradh Beag - it enters the loch under the road bridge at the head of the loch. All the other watercourses observed including the dry watercourses were small burns of 1m width and less.

Wildlife/Birds

There were 11 Common Seals (*Phoca vitulina)* at the head of the loch. A total of nine Pink Footed Geese, (*Anser brachyrhynchus)* were seen at various locations around the loch: two near the harbour and seven out on the water. There were five Cormorants (*Phalacrocorax carbo*), four Oystercatchers (*Haematopus longirostris*) and one Black Headed Gull (*Chroicocephalus ridibundus*) near the mussel farm at the time of the survey. No other wildlife was observed.

Shoreline Survey Map



Contains Ordnance Survey data © Crown Copyright and Database right (2013)

Figure 1. Loch Stockinish waypoints

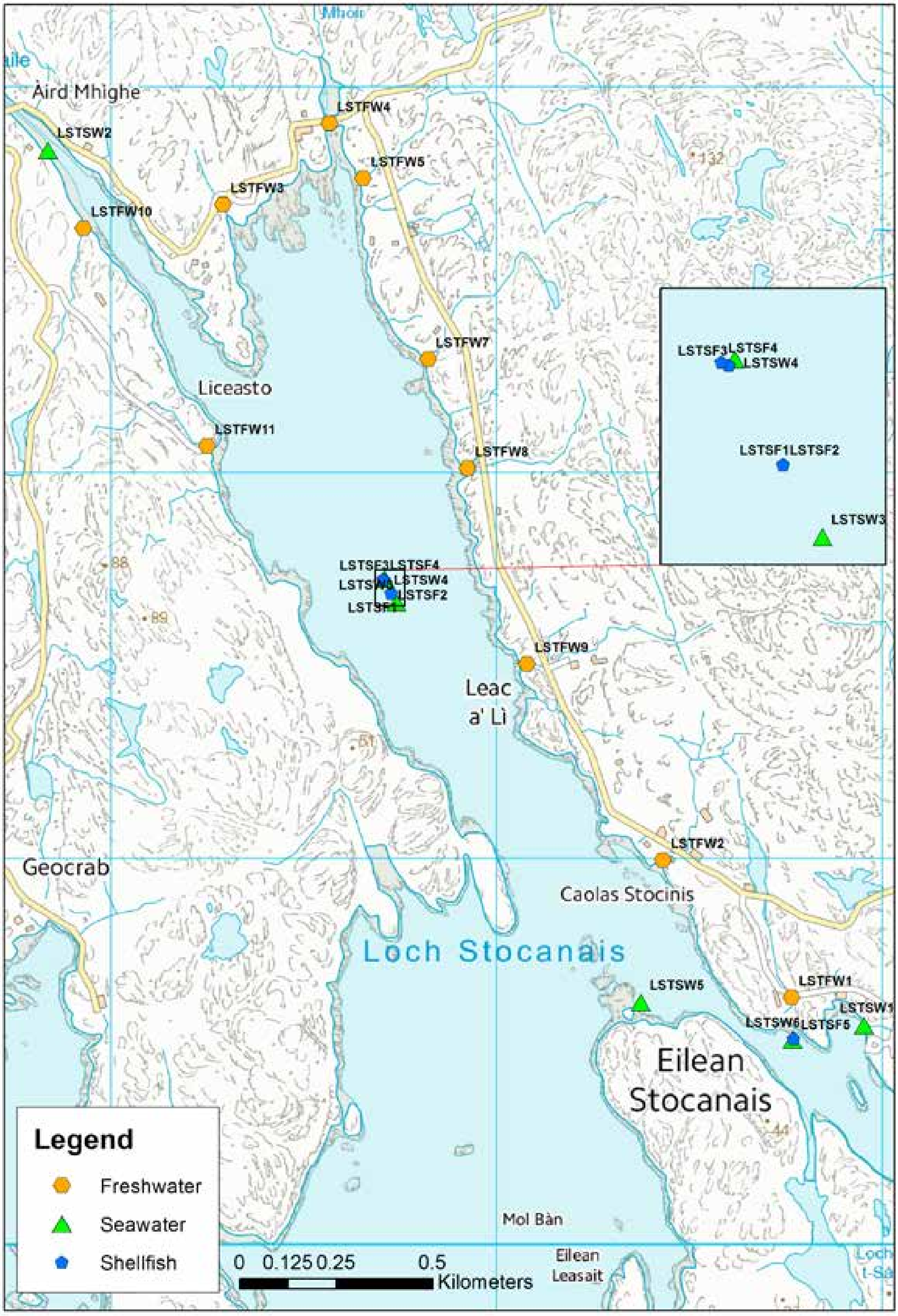


Figure 2. Loch Stockinish samples

Table 1 Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	22/07/2013	10:58	NG 13959 90489	113959	890489			Start of survey at Stockinish harbour pier. Four fishing boats, twelve rowing boats, four private dwellings and two sheep.
2	22/07/2013	11:05	NG 13958 90531	113959	890532	Fig 3		No access around shoreline, steep rocky slopes down to loch.
3	22/07/2013	11:08	NG 13953 90566	113953	890567		LSTSW1	Planned seawater sample LSTSW1.
4	22/07/2013	11:15	NG 13888 90658	113889	890658	Fig 4		House with sewage pipe running into harbour. Two pink footed geese on hill.
5	22/07/2013	11:29	NG 13764 90640	113765	890640		LSTFW1	Planned freshwater sample LSTFW1. Sample associated with waypoint 6.
6	22/07/2013	11:30	NG 13762 90641	113763	890641	Fig 5		Tunnel under road coming from house on hill above loch with septic tank. No obvious flow from watercourse, stagnant pools. Width 1m, depth 40cm.
7	22/07/2013	11:50	NG 13338 91078	113339	891078			Drainage coming from house above shoreline.
8	22/07/2013	11:53	NG 13359 91043	113360	891043	Fig 6,7		Sewage pipe from house onto rocks on shore, small trickle running from pipe.
9	22/07/2013	11:56	NG 13384 91014	113385	891015	Fig 8		Another pipe from same house as in waypoint 8, no flow from pipe. Fish farm visible from this viewpoint.
10	22/07/2013	11:58	NG 13398 91020	113399	891020	Fig 9		Septic tank at same property mentioned in waypoint 8. Four additional private dwellings on hillside above loch on the other side of the road also with their own septic tanks.
11	22/07/2013	12:03	NG 13453 90955	113453	890955	Fig 10		Pipe from septic tank, no flow.
12	22/07/2013	12:12	NG 13447 90965	113448	890966			Dry watercourse.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
13	22/07/2013	12:16	NG 13430 90995	113431	890996		LSTFW2	Planned freshwater sample LSTFW2. Sample associated with waypoint 14.
14	22/07/2013	12:16	NG 13430 90993	113431	890994			Small burn running onto shore, Width 60cm, depth 2cm, flow approximately 12ml/s, estimated by timing how long it took to fill a 20ml sample bottle.
15	22/07/2013	13:02	NG 12285 92700	112286	892701			Head of loch.
16	22/07/2013	13:04	NG 12290 92694	112290	892695		LSTFW3	Planned freshwater sample LSTFW3. Sample associated with waypoint 17.
17	22/07/2013	13:05	NG 12290 92694	112291	892695			Watercourse running through a metal pipe under the road. Pipe diameter 40cm, depth 5cm, flow 0.349ms-1, SD0.014.
18	22/07/2013	13:27	NG 12566 92905	112566	892906		LSTFW4	Planned freshwater sample LSTFW4. Sample associated with waypoint 19.
19	22/07/2013	13:28	NG 12566 92904	112567	892905	Fig 11		Watercourse observations. Burn running into loch. Width 6.5m, depth 14cm, flow 0.294ms-1 SD 0.011.
20	22/07/2013	13:41	NG 12653 92763	112654	892763		LSTFW5	Planned freshwater sample LSTFW5. Sample associated with waypoint 21.
21	22/07/2013	13:41	NG 12652 92763	112653	892763			Small burn. Width 40cm, depth 15cm, flow 0.066 ms-1, SD 0.05.
22	22/07/2013	13:47	NG 12662 92701	112662	892702			Seven pink footed geese, 11 common seals.
23	22/07/2013	13:53	NG 12651 92610	112652	892611	Fig 12		Septic tank pipe dripping onto shore. No further access to shoreline, fenced to edge of steep rock.
24	22/07/2013	14:13	NG 12802 92342	112803	892342			Site of proposed freshwater sample LSTFW6 - no sample taken, watercourse dry. (Sample number was skipped due to mislabelling. Labelling continues on with LSTFW7)

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
25	22/07/2013	14:16	NG 12822 92295	112823	892295		LSTFW7	Planned freshwater sample LSTFW7. Sample associated with waypoint 26.
26	22/07/2013	14:17	NG 12822 92294	112823	892295			Small burn running from hill into loch. Width 40cm, depth 4cm, flow approximately 25ml/s estimated by timing how long it took to fill a 20ml sample bottle.
27	22/07/2013	14:31	NG 12924 92011	112924	892012		LSTFW8	Planned freshwater sample LSTFW8. Sample associated with waypoint 28.
28	22/07/2013	14:32	NG 12924 92013	112925	892013	Fig 13		Two small burns converging above the shoreline. Width 80cm, depth 3cm, flow approximately 12.5ml/s, estimated by timing how long it took to fill a 20ml sample bottle.
29	22/07/2013	14:46	NG 12973 91759	112974	891760	Fig 14		Single mussel line visible from this viewpoint, 23 large black flotation drums. Twelve herring gulls in water, four sheep on the shore.
30	22/07/2013	14:57	NG 13078 91504	113079	891505		LSTFW9	Planned freshwater sample LSTFW9. Sample associated with waypoint 31.
31	22/07/2013	14:58	NG 13078 91505	113078	891505			Watercourse running down the hill into the loch. Width 78cm, depth 17cm, flow 0.101ms-1 SD 0.014.
32	22/07/2013	15:23	NG 11805 92864	111805	892865	Fig 15		Septic tank at private dwelling, pipe onto shore, no flow.
33	22/07/2013	15:28	NG 11837 92835	111838	892836		LSTSW2	Planned seawater sample LSTSW2.
34	22/07/2013	15:36	NG 11928 92633	111928	892633		LSTFW10	Planned freshwater sample LSTFW10.
35	22/07/2013	15:37	NG 11928 92634	111928	892634			Watercourse, coming from hillside into loch. Width 1.1m depth 7cm, Flow 0.034ms-, SD 0.005.
36	22/07/2013	16:03	NG 12249 92069	112250	892069		LSTFW11	Planned freshwater sample LSTFW11. Sample associated with waypoint 37.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
37	22/07/2013	16:04	NG 12245 92072	112245	892072	Fig 16		Small burn running through grassy field into loch. Width 1m, depth 5cm, flow estimated at approximately 5ml/s, estimated by timing how long it took to fill a 20ml sample bottle. Twelve sheep grazing on grass next to burn, 2 private dwellings with septic tanks. End of survey day one.
38	23/07/2013	10:06	NG 13935 90547	113936	890547			Start of survey - day two.
39	23/07/2013	10:07	NG 13926 90538	113927	890538			Five Cormorants, one black headed gull on rocks, four oystercatchers.
40	23/07/2013	10:18	NG 12740 91660	112740	891660			SE end of mussel line (single line).
41	23/07/2013	10:19	NG 12740 91663	112740	891663		LSTSW3	Planned seawater sample LSTSW3.
42	23/07/2013	10:20	NG 12731 91681	112732	891681	Fig 17		CTD cast 1.
43	23/07/2013	10:21	NG 12726 91688	112727	891688		LSTSF1	Planned shellfish sample LSTSF1 from a depth of <1m.
44	23/07/2013	10:24	NG 12726 91688	112726	891688		LSTSF2	Planned shellfish sample from a depth of approximately 12m.
45	23/07/2013	10:28	NG 12700 91730	112701	891730			NW end of mussel line.
46	23/07/2013	10:29	NG 12710 91724	112710	891724		LSTSW4	Planned seawater sample LSTSW4.
47	23/07/2013	10:31	NG 12708 91722	112708	891722		LSTSF3	Planned shellfish sample LSTSF3 from a depth of <1m.
48	23/07/2013	10:31	NG 12710 91716	112711	891717			CTD cast 2.
49	23/07/2013	10:33	NG 12706 91723	112707	891723			Extra waypoint taken but not used.
50	23/07/2013	10:39	NG 12705 91723	112705	891723		LSTSF4	Planned shellfish sample LSTSF4 from a depth of approximately 12m.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
51	23/07/2013	10:51	NG 13376 90626	113376	890626			Required sampling location, but no mussel lines found to be present. A single buoy anchored to seabed with rope was found in the vicinity, but contained to few mussels to collect an appropriate sample, so no shellfish sample taken.
52	23/07/2013	10:52	NG 13374 90627	113374	890627		LSTSW5	Planned seawater sample LSTSW5.
53	23/07/2013	10:53	NG 13372 90628	113373	890629			CTD cast 3.
54	23/07/2013	10:55	NG 13374 90627	113375	890627			Extra waypoint taken but not used.
55	23/07/2013	10:59	NG 13768 90529	113768	890529		LSTSW6	Planned seawater sample LSTSW6.
56	23/07/2013	11:03	NG 13770 90532	113770	890532		LSTSF5	Two mooring buoys 1m apart. Shellfish sample LSTSF5 was taken from rope used as anchorage at this unplanned location at approximately 8m depth.

Photographs referenced in the table can be found attached as Figures 3-17

Sampling

Water samples were collected at the sites marked in Figure 2.

Shellfish samples were taken from the SE and NW side of the single mussel line and from a set of 2 mooring buoys close to Stockinish harbour.

All the samples were transferred to a Biotherm 10 or Biotherm 30 box with ice packs and posted to the Glasgow Scientific Services (GSS) for *E. coli* analysis. All the samples were posted on the day of collection and all the samples were received the following day. The sample temperatures on arrival at the laboratory were recorded at 1.5°C.

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

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

The sample reference number LGFW6 was not used during the survey, due to mislabelling, with sample references continued on from LGFW7.

Table 2. Water Sample Results

(NB – the sample number LGFW6 was not used during the survey – see Sampling section above).

No.	Date	Sample	Grid Ref	Type	*E. coli* (cfu/100ml)	Salinity (ppt)
1	22/07/2013	LSTFW1	NG 13764 90640	Freshwater	70	
2	22/07/2013	LSTFW2	NG 13430 90995	Freshwater	30	
3	22/07/2013	LSTFW3	NG 12290 92694	Freshwater	40	
4	22/07/2013	LSTFW4	NG 12566 92905	Freshwater	60	
5	22/07/2013	LSTFW5	NG 12653 92763	Freshwater	<10	
6	22/07/2013	LSTFW7	NG 12822 92295	Freshwater	180	
7	22/07/2013	LSTFW8	NG 12924 92011	Freshwater	530	
8	22/07/2013	LSTFW9	NG 13078 91504	Freshwater	710	
9	22/07/2013	LSTFW10	NG 11928 92633	Freshwater	20	
10	22/07/2013	LSTFW11	NG 12249 92069	Freshwater	940	
11	22/07/2013	LSTSW1	NG 13953 90566	Seawater	800	36.13
12	22/07/2013	LSTSW2	NG 11837 92835	Seawater	8	18.97
13	23/07/2013	LSTSW3	NG 12740 91663	Seawater	6	36.13
14	23/07/2013	LSTSW4	NG 12710 91724	Seawater	4	36.13
15	23/07/2013	LSTSW5	NG 13374 90627	Seawater	2	35.95
16	23/07/2013	LSTSW6	NG 13768 90529	Seawater	7	35.95

Table 3. Shellfish Sample Results

No.	Date	Sample	Grid Ref	Type	*E. coli* (MPN/100g)
1	23/07/2013	LSTSF1	NG 12726 91688	Shellfish	<20
2	23/07/2013	LSTSF2	NG 12726 91688	Shellfish	80
3	23/07/2013	LSTSF3	NG 12708 91722	Shellfish	80
4	23/07/2013	LSTSF4	NG 12706 91723	Shellfish	50
5	23/07/2013	LSTSF5	NG 13770 90532	Shellfish	140

Salinity Profiles

Salinity profiles were taken at three locations in the production area, one at each end of the mussel line and the other at the SW sampling site close to the harbour. The gathered data will be sent to customer as agreed previously on a separate Excel sheet.

Shoreline Survey Photographs

Figure 3. Illustrating steep rocky shore. Waypoint 2.

Figure 4. Sewage pipe from house to harbour. Waypoint 4.

Figure 5. Tunnel directing watercourse from under road. Waypoint 6. Location of sample LSTFW1.

Figures 6&7. Sewage pipe from dwelling (insert), pipe outflow onto shore. Waypoint 8.

Figure 8. Another pipe from same dwelling in Fig 6 & 7, no outflow. Waypoint 9.

Figure 9. Septic tank also from same dwelling as Figures 6, 7 & 8. Waypoint 10.

Figure 10. Pipe coming from septic tank no outflow. Waypoint 11.

Figure 11. Watercourse associated with waypoint 18 and19. Location of sample LSTFW4.

Figure 12. Septic tank pipe dripping onto shore. Picture illustrates no further access to next part of shoreline. Waypoint 23.

Figure 13. Watercourse associated with waypoint 27 and 28. Location of sample LSTFW8.

Figure 14. A single mussel line visible from this viewpoint. Waypoint 29.

Figure 15. Septic tank from private dwelling. Waypoint 32.

Figure 16. Watercourse running through grassy field. Waypoint 36 and 37. Location of sample LSTFW11.

Figure 17. Mussel line photograph taken from boat looking SE. Waypoint 42. Location of CTD cast 1.

6. SEPA Discharge Consents

Licence No.	NGR	Site Name	Discharge Type	Site Description	Discharges to	PE
CAR/S/1023867	NG 1171 9150	Geocrab WTW, Isle of Harris	Filter Backwash	Geocrab WTW, Loch Na Ba Crubaich, Geocrab, Isle of Harris, HS3 3HB		
CAR/L/1004185	NG 1124 9056	Geocrab Hatchery	Fish Farm Hatchery	Gheocrab Hatchery, TE to Loch Beacrabhaig, Isle of Harris	Loch Beacrabhaig	
CAR/L/1001853	NG 1288 9145	Stockinish MCFF, Loch Stockinish	Marine Cage Fish Farm	Loch Stockinish MCFF, Stockinish	Loch Stockinish	
CAR/L/1002371	NG 1181 9032	Geocrab MCFF, Loch Geocrab	Marine Cage Fish Farm	Loch Gheocrab MCFF, Isle of Harris	Loch Gheocrab	
CAR/L/1003915	NG 1548 9248	Grosebay MCFF, Loch Grosebay	Marine Cage Fish Farm	Grosebay Loch MCFF, Grosebay, Isle of Harris	Loch Ghreosabhagh	
CAR/R/1012028	NG 9960 8906	Flodabay, Isle of Harris	Septic Tank	The Chalet, No 1 Flodabay, Isle of Harris, STE to soakaway	Soakaway	5
CAR/R/1012641	NG 1305 9171	Leacklee, Isle of Harris	Septic Tank	Leacklea, Isle of Harris, STE to land	Soakaway	5
CAR/R/1014053	NG 1517 9144	Cluer, Isle of Harris	Sewage (Private) Primary	Cluer, Isle of Harris, STE to land	Soakaway	5
CAR/R/1014785	NG 1537 9300	Roadside Cottage, Grosebay, Isle of Harris	Sewage (Private) Primary	Roadside Cottage, STE to land, Grosebay	Soakaway	5
CAR/R/1015371	NG 1126 9023	Ardslave, Isle of Harris	Sewage (Private) Primary	Ardslave, Isle of Harris,STE to Loch Bheicribhig	Loch Bheicribhig	5
CAR/R/1019437	NG 1146 9093	O'er Wather, Geocrab, Isle of Harris	Sewage (Private) Primary	O'er Wather, STE to land, Geocrab, Isle of Harris	Soakaway	5
CAR/R/1021910	NG 1198 9243	Lickisto, Isle of Harris, HS3 3EL	Sewage (Private) Primary	Lickisto, STE to land, Isle of Harris	Soakaway	5
CAR/R/1022614	NG 1170 9147	Geocrab WTW, Isle of Harris	Sewage (Private) Primary	Geocrab WTW, STE to U/T of Loch Na Ba Crubaich, Geocrab, Isle of Harris	Loch Na Ba Crubaich	5
CAR/R/1024835	NG 9800 8867	Flodabay, Isle of Harris	Sewage (private)	Flodabay, Isle of Harris, HS3 3HA	Soakaway	6
CAR/R/1032541	NG 1096 8952	Manish School & Schoolhouse,Ardslave, Harris	Sewage (private)	Manish School & Schoolhouse, Ardslave, Isle of Harris, HS2 3EY	Soakaway	6
CAR/R/1038784	NG 1515 9144	Cnoc A Chlachain, 1A Cluer, Isle of Harris	Sewage (private)	Cnoc A Chlachain, 1a Cluer, Isle Of Harris, HS3 3EP	Soakaway	5

Licence No.	NGR	Site Name	Discharge Type	Site Description	Discharges to	PE
CAR/R/1040974	NG 1498 9301	Grosebay, Isle Of Harris	Sewage (Private) Primary	Grosebay, STE to Loch Ghreosabhagh, Isle Of Harris	Loch Ghreosabhagh	5
CAR/R/1041824	NG 1516 9124	Cluer	Sewage (private)	Cluer, Isle of Harris, HS3 3EP	Soakaway	10
CAR/R/1042644	NG 1008 8947	Nurse's Cottage, Isle Of Harris	Sewage (private)	Nurses Cottage, Manish, Isle of Harris, HS3 3EZ	Soakaway	≤5
CAR/R/1042855	NG 1123 9057	Lever Cottage, Isle Of Harris	Sewage (Private) Primary	Lever Cottage, STE to Loch Bheicribhig, Geocrab, Isle Of Harris	Loch Bheicribhig	≤5
CAR/R/1043383	NG 1565 9280	Croft House, Isle Of Harris	Sewage (Private) Primary	Croft House, STE to Loch Grosebay, 1 Grosebay, Isle Of Harris	Loch Ghreosabhagh	≤5
CAR/R/1043432	NG 1449 9088	Cluer, Isle Of Harris	Sewage (Private) Primary	Cluer, STE to soakaway, Isle Of Harris	Soakaway	≤5
CAR/R/1043434	NG 1336 9104	Westerlea, Isle Of Harris	Sewage (Private) Primary	Westerlea, STE to Loch Stocinis, Stockinish, Isle of Harris	Loch Stockinish	≤7
CAR/R/1045038	NG 1459 9087	Roadside Cottage, 9 Cluer, Isle of Harris	Sewage (private)	Roadside Cottage, 9 Cluer, Isle of Harris, HS3 3EP	Soakaway	5
CAR/R/1047129	NG 1172 9289	Pairc Liceasto, Isle of Harris	Sewage (Private) Primary	Pairc, STE to soakaway, Lickisto, Isle of Harris	Soakaway	≤5
CAR/R/1047382	NG 1179 9284	Two Waters, Lickisto, Isle of Harris	Sewage (private)	Two Waters, Lickisto, Isle of Harris, HS3 3EL	Soakaway	5
CAR/R/1047450	NG 1402 9067	Ardvey, Stockinish, Isle of Harris	Sewage (private)	Ardvey, Stockinish, Isle Of Harris, HS3 3EJ	Soakaway	5
CAR/R/1047455	NG 1517 9131	Cluer, Isle of Harris	Sewage (Private) Primary	Cluer, STE to soakaway, Isle Of Harris	Soakaway	5
CAR/R/1047482	NG 9840 8869	Flodabay, Isle of Harris	Sewage (Private) Primary	Flodabay, STE to Loch Fhleoideabhaigh, Isle Of Harris	Loch Fhleoideabhaigh	5
CAR/R/1048589	NG 1342 9096	Stockinish, Isle of Harris	Sewage (Private) Primary	Stockinish, STE to Loch Stockinish, Isle of Harris	Loch Stockinish	≥6
CAR/R/1051563	NG 1353 9112	Pauline Macleod, Stockinish,Isle Of Harris	Sewage (private)	Stockinish,Isle Of Harris, HS3 3EN	Soakaway	5
CAR/R/1052277	NG 1544 9135	Grosebay, Grosebay, Isle of Harris	Sewage (private)	Grosebay, Isle of Harris, HS3 3ER	Coastal Loch Chollaim	6
CAR/R/1054889	NG 1332 9113	Stockinish	Sewage (private)	Stockinish, Isle of Harris, HS3 3EN	coastal Loch Stockinish	≥5

Licence No.	NGR	Site Name	Discharge Type	Site Description	Discharges to	PE
CAR/R/1056085	NG 1130 9090	Geocrab, Isle of Harris	Sewage (Private) Primary	Geocrab, STE to soakaway, Isle of Harris	Soakaway	5
CAR/R/1056094	NG 1198 9062	Geocrab, Isle of Harris	Sewage (private)	Geocrab, Isle of Harris, HS3 3HB	Coastal Loch Gheocrab	6
CAR/R/1056117	NG 1179 9082	Geocrab, Harris	Sewage (private)	Geocrab, Isle of Harris, HS3 3HB	Coastal Loch Gheocrab	5
CAR/R/1056122	NG 1182 9101	Geocrab, Isle of Harris	Sewage (Private) Primary	Geocrab, STE to u/n w/c, Isle Of Harris	U/N W/C	7
CAR/R/1056284	NG 1440 9098	Cluer, Isle Of Harris	Sewage (private)	Cluer, Isle of Harris, HS3 3EP	U/N W/C	6
CAR/R/1056299	NG 1162 9313	Bayhead Of Ardvey, Isle Of Harris	Sewage (private)	Bayhead, Lickisto, Isle of Harris, HS3 3EL	U/N W/C to Lickisto	7
CAR/R/1056443	NG 1225 9208	Lickisto, Isle Of Harris	Sewage (Private) Primary	Lickisto, STE to soakaway, Isle of Harris	Soakaway	5
CAR/R/1056569	NG 1278 9261	Leaklee, Isle of Harris	Sewage (Private) Primary	Leacklee, STE to Soakaway, Isle of Harris	Soakaway	5
CAR/R/1056620	NG 1530 9289	Caiream, Grosebay, Isle of Harris	Sewage (private)	Caiream, Grosebay, Isle of Harris, HS3 3EF	Loch Ghreosabhagh	6
CAR/R/1056658	NG 1117 9050	Cliff Cottage, Beckrivig, Isle of Harris	Sewage (private)	Cottage, Beckrivig, Isle of Harris, HS3 3EX	Soakaway	5
CAR/R/1056699	NG 1106 8962	Ardslave, Isle of Harris	Sewage (private)	Ardslave, Isle of Harris, HS3 3EY	Soakaway	5
CAR/R/1057001	NG 1181 9095	Geocrab, Isle of Harris	Sewage (private)	Geocrab, Isle of Harris, HS3 3HB	Soakaway	5
CAR/R/1057594	NG 1291 9238	Leacklea, Isle of Harris	Sewage (Private) Primary	Leacklea, STE to soakaway, Isle Of Harris	Soakaway	5
CAR/R/1059620	NG 1041 8919	Manish, Isle of Harris	Sewage (private)	Manish, Isle of Harris, HS3 3EZ	Soakaway	5
CAR/R/1059627	NG 1059 8900	Manish, Isle of Harris	Sewage (Private) Primary	Manish, STE to soakaway, Isle of Harris	Soakaway	5
CAR/R/1059652	NG 1503 9276	Loch View, Grosebay, Isle of Harris	Sewage (private)	Loch View, Grosebay, Isle of Harris, HS3 3EF	Soakaway	5
CAR/R/1059701	NG 1049 8929	Manish, Isle of Harris	Sewage (Private) Primary	Manish, STE to Soakaway, Isle of Harris	Soakaway	5
CAR/R/1059747	NG 1305 9149	Stockinish, Isle of Harris	Sewage (Private) Primary	Stockinish, STE to Loch Stockinish, Isle of Harris	Loch Stockinish	5

Licence No.	NGR	Site Name	Discharge Type	Site Description	Discharges to	PE
CAR/R/1059788	NG 1567 9279	Harmasaig House, 1 Grosebay, Isle of Harris	Sewage (Private) Primary	Harmasaig House, STE to Loch Ghreosabhagh, Isle of Harris	Loch Ghreosabhagh	5
CAR/R/1059910	NG 1727 9224	Hillhead, Scadabay, Isle of Harris	Sewage (private)	Hillhead, Scadabay, Isle of Harris, HS3 3ED	U/N W/C	7
CAR/R/1059944	NG 1284 9237	Leacklee, Isle of Harris	Sewage (private)	Leacklee, Isle of Harris, HS3 3EH	Soakaway	5
CAR/R/1060058	NG 1729 9228	Allt Beag, Scalpay, Isle of Harris	Sewage (private)	Allt Beag, Scalpay, Isle of Harris, HS3 3ED	Allt Beag discharging to Loch Scadabay	7
CAR/R/1061620	NG 1182 9081	Geocrab, Isle of Harris	Sewage (Private) Primary	Geocrab, STE to Loch Geocrab, Isle of Harris	Loch Gheocrab	5
CAR/R/1061721	NG 9710 8904	Flodabay, Harris	Sewage (Private) Primary	Flodabay, STE to Soakaway, Isle of Harris	Soakaway	6
CAR/R/1061744	NG 9950 8935	Tigh An Tobair, Flodabay, Harris	Sewage (Private) Primary	Tigh an Tobair, STE to Tidal Pool of Loch Flodabay, Isle of Harris	Tidal Pool of Loch Flodabay	5
CAR/R/1061746	NG 1009 8927	The Cottage, Manish, Isle of Harris	Sewage (Private) Primary	The Cottage, STE to Loch Fhleoideabhaigh, Isle Of Harris	Loch Fhleoideabhaigh	5
CAR/R/1063374	NG 1303 9202	Carnan House, Leacklee, Isle of Harris	Sewage (Private) Primary	Leacklee (Carnan House), STE to U/T to Loch Stocinis, Isle of Harris	U/N W/C	5
CAR/R/1064020	NG 1419 9101	Cluer (Mackinnon), Isle of Harris, HS3	Sewage (Private) Primary	Cluer (Mackinnon), STE to Land, Isle of Harris	Soakaway	5
CAR/R/1064025	NG 1070 8911	Manish, Isle of Harris	Sewage (Private) Primary	Manish, STE to Ob Leasaid, Isle of Harris	Ob Leasaid	5
CAR/R/1064397	NG 1179 9290	Bardon Hebrides Site Office, Isle of Harris	Sewage (Private) Primary	Bardon Hebrides site office, STE to Loch Stockinish, Aird Mhighe, Harris	Loch Stockinish	5
CAR/R/1066765	NG 1693 9247	Scadabay Isle of Harris	Sewage (private)	3 properties Scadabay, Isle of Harris, HS3 3ED	Loch Scadabay	15
CAR/R/1066781	NG 1355 9110	Stockinish, Isle of Harris	Sewage (private)	Stockinish, Isle of Harris, HS3 3EN	Soakaway	5
CAR/R/1068044	NG 1492 9055	Cluer, Isle of Harris	Sewage (Private) Primary	Cluer, STE to U/T of Loch Chliuthair, Isle Of Harris	U/T of Loch Chliuthair	5
CAR/R/1068138	NG 1481 9075	Cluer, Harris	Sewage (Private) Primary	Cluer, STE to U/T of Loch Chliuthair, Isle of Harris	U/T of Loch Chliuthair	5

Licence No.	NGR	Site Name	Discharge Type	Site Description	Discharges to	PE
CAR/R/1068139	NG 1388 9067	Stockintosh, Isle of Harris	Sewage (Private) Primary	Stockintosh, STE to U/T of Caolas Beag, Isle Of Harris	U/T of Caolas Beag	5
CAR/R/1068263	NG 1375 9065	Stockinish, Harris	Sewage (Private) Primary	Stockinish, STE to Unknown Watercourse, Isle of Harris	U/N W/C	5
CAR/R/1070615	NG 1424 9087	Cluer, Isle of Harris	Sewage (private)	Cluer, Isle of Harris, HS3 3EP	Allt Steinis (burn)	5
CAR/R/1075725	NG 1510 9297	Grosebay, Isle of Harris	Sewage (Private) Primary	Grosebay, STE to Soakaway, Isle of Harris	Soakaway	5
CAR/R/1075734	NG 1516 9291	Caravans, Grosebay, Isle of Harris	Sewage (Private) Primary	Caravans, STE to soakaway, 5 Grosebay, Isle Of Harris	Soakaway	6
CAR/R/1076641	NG 9980 8908	Sruth House, Flodabay, Harris	Sewage (Private) Primary	Sruth House, STE to Loch Fhleoideabhaigh, Flodabay	Loch Fhleoideabhaigh	5
CAR/R/1079031	NG 1403 9044	Lochview, Ardvey, Isle of Harris	Sewage (Private) Primary	Loch View, STE to Caolas Beag, 1 Ardvey, Isle of Harris	Caolas Beag	50
CAR/R/1092392	NG 1133 8996	Ardslave (Beckrivig), Bays of Harris	Sewage (private)	Ardslave (Beckrivig), Bays of Harris, HS3 3EX	Coastal Loch Gheocrab	6
CAR/R/1102432	NG 1128 9078	Glen, Geocrab, Isle of Harris	Sewage (Private) Primary	Glen, STE to u/n w/c, Geocrab, Isle of Harris	U/N W/C	5
CAR/R/1106511	NG 9820 8879	Flodabay Farm Motorhome Park	Sewage (private)	Flodabay, Isle of Harris, HS3 3HA	Soakaway	9
CAR/R/1112255	NG 1272 9259	Leacklee, Isle of Harris	Sewage (Private) Primary	Leacklea, STE to Soakaway, Isse of Harris	Soakaway	7
WD79	NG13591 3591	Kyles Stockinish School House	Septic Tank		Soakaway	10
WPC/N/60737	NG11399 9891	Stockinish Pier	Septic Tank		Loch Stockinish	
WPC/N/60940	NG 1190 9070	Geocrab Council Houses	Sewage (Public) Primary		Loch Gheocrab	16
CAR/S/1022666	NG 8880 8821	Finsbay & Borsham Common Grazing, Harris	Sheep Dip onto Land	Finsbay & Borsham Common Grazings, SDD (12) to land, Finsbay, Isle of Harris	Soakaway	
CAR/S/1089180	NG 1403 9095	Grosebay Common Grazings,GWR-BH1	Sheep Dip onto Land	Grosebay Common Grazings, SDD(3) to land	Soakaway	
CAR/R/1007722	NG 1370 9088	Ardvey,GWR-BH1	Sheep Dip onto Land	Ardvey, Leacklea & Stockinish Township, 1 Ardvey, Stockinish, Harris, SDD2lnd	Soakaway	

7. Loch Stockinish 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_20130723_092018
% Cast time (local)	23/07/2013 10:20
% Sample type	Cast
% Cast data	Processed
% Location source	GPS
% Start latitude	57.8220792
% Start longitude	-6.8399562
% Start GPS horizontal error(Meter)	1.539999962
% Start GPS vertical error(Meter)	2.549999952
% Start GPS number of satellites	7
% Cast duration (Seconds)	224.6
% 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)
0.148973996	14.21748733	34.37322208
0.446864172	13.73004152	34.59786404
0.744685089	13.13958764	34.75091444
1.042488783	12.6782481	34.47338278
1.34030938	12.48724384	34.43046971
1.638118204	12.3176971	34.48419645
1.935916568	12.20011108	34.44866875
2.233711153	12.07591543	34.45484125
2.531497927	11.95977728	34.45582088
2.829274746	11.87347975	34.49061934
3.127042248	11.81931135	34.50126182
3.424807238	11.7707351	34.48496293
3.722568925	11.71738755	34.50288585
4.02032514	11.71600074	34.51728288
4.318081613	11.69259208	34.49164263
4.615838113	11.66828668	34.50255423
4.913589144	11.68013075	34.53416586
5.211340757	11.682148	34.49777176
5.509095386	11.61747788	34.48936172
5.806846981	11.57301275	34.49545262
6.104597761	11.55489376	34.4786048
6.402348857	11.52291097	34.47768683
6.700097059	11.48946019	34.48564214

Depth (Meter)	Temperature (Celsius)	Salinity (Practical Salinity Scale)
6.997842618	11.48159589	34.48828234
7.29558607	11.47923483	34.4989113
7.593327288	11.53027074	34.51674927
7.891067095	11.4993878	34.51325302
8.188808941	11.47468018	34.48243108
8.486552873	11.43923841	34.47743621
8.784296378	11.44432283	34.47601456
9.082039917	11.41235802	34.46777135
9.379782813	11.39491836	34.4669995
9.677523822	11.38440274	34.47488626
9.975262894	11.36921955	34.47509625
10.27300186	11.36449721	34.46809813
10.57074056	11.36688973	34.47399226
10.86847957	11.35146801	34.4592526
11.16622286	11.35286631	34.42979159
11.46396957	11.35174317	34.42600432
11.76171704	11.35384239	34.42036514
12.05946403	11.34247075	34.42506966
12.30171293	11.34633726	34.41712554

Cast 2 Data Header

Device	10G100653
File name	10G100653_20130723_092856
Cast time (local)	10:28:56
Sample type	Cast
Cast data	Processed
Location source	GPS
Default latitude	32
Default altitude	0
Start latitude	57.8225068
Start longitude	-6.8404707
Start GPS horizontal error(Meter)	6.849999905
Start GPS vertical error(Meter)	8.909999847
Start GPS number of satellites	9
End GPS number of satellites	9
Cast duration (Seconds)	417.2
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)

Depth (Meter)	Temperature (Celsius)	Salinity (Practical Salinity Scale)
0.148976065	14.22010082	34.35495113
0.446870352	13.9026088	34.62859031
0.744727185	13.29099605	34.4875507
1.042563876	12.93443382	34.54920132
1.340395233	12.80298682	34.40562889
1.638232273	12.63240705	34.41850781
1.936053106	12.44882653	34.45691505
2.233849696	12.29347625	34.54567555
2.531628762	12.16093746	34.53776014
2.829407319	12.09945914	34.49910209
3.127183125	12.02252424	34.5250712
3.424947242	11.95648803	34.5647258
3.722703952	11.9216482	34.5631102
4.020460099	11.89673181	34.55213185
4.318213138	11.86048727	34.57279253
4.615963222	11.82215688	34.55720285
4.91371854	11.79084346	34.50645157
5.21147487	11.73478283	34.52406216
5.509224917	11.68375907	34.53328818
5.806970679	11.6522715	34.53917276
6.104712066	11.61494441	34.55253954
6.402451796	11.58608597	34.53498196
6.700189805	11.54808777	34.54877854
6.997923471	11.52216304	34.55520102
7.295655144	11.50231005	34.55251975
7.593386029	11.494817	34.55268088
7.891115594	11.47697717	34.55520375
8.188844246	11.46144752	34.5498314
8.486571996	11.44900956	34.5535643
8.784297415	11.43120429	34.56031957
9.082022701	11.42735183	34.54661297
9.379748061	11.41126803	34.55194294
9.677471784	11.40840798	34.5536492
9.975194975	11.40058675	34.55114891
10.27291692	11.39962297	34.55967131
10.57063789	11.39324383	34.5550227
10.86835885	11.38772933	34.55398079
11.16608014	11.38089484	34.54614129
11.46379974	11.33255823	34.55298
11.761516	11.33020133	34.56070657
12.05922916	11.35426176	34.58271274
12.35694551	11.35486719	34.53515986

Depth (Meter)	Temperature (Celsius)	Salinity (Practical Salinity Scale)
12.65466575	11.32729016	34.5390349
12.95238228	11.30888957	34.55408305
13.25009652	11.31574042	34.55366527
13.54781017	11.30518136	34.55535796
13.84552239	11.29716019	34.55908482
14.04468377	11.31322049	34.56151665