Scottish Sanitary Survey Report

Sanitary Survey Report
Gullane Point
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The hydrographic assessment and the shoreline survey and its associated report were undertaken by SRSL, Oban.

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Appendices

I. Executive Summary

Gullane Point is located within along the south side of the Firth of Forth, approximately 20 km east of Edinburgh. The sanitary survey for Gullane Point was undertaken in response to a standard classification application for razor clams (*Ensis* spp.). Fast track classifications for this species have been awarded in the area most years since 2008.

The razor clams are harvested by diving. The fishery is presumed to potentially operate year-round.

The principal sources of faecal contamination in the area are:

- The Gullane WWTW primary treated sewage works outfalls and associated CSOs
- Seabirds and shorebirds at Aberlady Nature Reserve and other areas around the north of the fishery
- Point and diffuse sources of pollution entering West Peffer Burn
- A malfunctioning discharge from a golf club on the south shore of of Aberlady Bay

Contamination from the continuous sources will occur under all weather conditions and will impact at the discharge locations and up to 8 km from this (at spring tides), with the direction of impact depending on the tidal state: to the northwest on a flood tide and to the southeast on an ebb tide, with the greatest transport distance occurring at spring tides. Further contamination will occur after significant rainfall events both from the CSOs and from diffuse pollution entering the watercourses.

It is recommended that the production area be split in two due to the lack of sampling history from the southern end of the fishery, which would be more likely to be impacted by West Peffer Burn than the northern part of the fishery.

It is recommended that the two razor clam production areas cover the expected extent of the bed, and that sampling is undertaken in an RMZ in each, with the intent of reflecting contamination arising from the Peffer Burn in the southern area and Gullane WWTW and CSOs in the northern area. Sampling should be undertaken monthly in light of the limited monitoring data available for the area. Once sufficient monitoring history has been accumulated, the data should be evaluated to determine whether the production areas can be recombined under a single monitoring zone.

II. Sampling Plan

Production Area	Gullane Point North	Gullane Point South
Site Name	Gullane Point razors	Aberlady Bay razors
SIN	TBD	TBD
Species	Razor clams	Razor clams
Type of Fishery	Wild	Wild
NGR of RMZ	Area bounded by lines drawn from NT 4756 8474 to NT 4641 8413 to NT 4641 8380 to NT 4756 8439 and back to NT 4756 8474	Area bounded by lines drawn from NT 4372 8112 to NT 4345 8132 to NT 4323 8043 to NT 4350 8023 and back to NT 4372 8112
Tolerance (m)	Not applicable	Not applicable
Depth (m)	Not applicable	Not applicable
Method of Sampling	Hand (dived)	Hand (dived)
Frequency of Sampling	Monthly	Monthly
Local Authority	East Lothian Council	East Lothian Council
Authorised Sampler(s)		
Local Authority Liaison Officer	Malcolm Elliott	Malcolm Elliott
Production area boundary	Area bounded by lines drawn from NT 4900 8600 to NT 4300 8600 to NT 4300 8250 to NT 4500 8150 to NT 4614 8308 to NT 4652 8319 to NT 4706 8316 and back to NT 4900 8600	Area bounded by lines drawn from NT 4500 8150 to NT 4300 8250 to NT 4200 8000 to NT 4400 8000 and back to NT 4500 8150

III. Report

1. General Description

Gullane is located in the South-East of Scotland on the southern shore of the Firth of Forth. Gullane Bay and Aberlady Bay (containing Gullane Sands) face northwest across the firth. Gullane Point is a promontory separating the two bays. The straight line distance across the two bays is approximately 7 km although the shoreline distance is significantly greater than this.

The main settlements in the immediate vicinity of the fishery are Gullane and Aberlady, with the village of Longniddry immediately to the south. The City of Edinburgh lies approximately 15 km to the southwest with Cockenzie & Port Seton, Prestonpans and Musselburgh in between.

The sanitary survey is being undertaken further to a standard application for classification following a number of fast track applications.

Figure 1.1 Location of Gullane Point

2. Fishery

The fishery at Gullane Point is the subject of a standard application for classification of a razor clam (*Ensis* spp*.)* fishery. Details of the site are contained in Table 2.1.

Table 2.1 Gullane Point Standard Application Details

Production area	Site	SIN	Species
Gullane Point	Gullane Annual	FF-601-1087-16	Razor Clam

Harvest undertaken by hand using SCUBA equipment. The boundaries of the standard track classification area are NT 4850 8500 to NT 4300 8500 to NT 4300 8000 to NT 4350 8000 to NT 4368 8049 to NT 4588 8334 to NT 4655 8355 to NT 4725 8364 to NT 4790 8462 to NT 4850 8500. The application specifies that the production area must be 100 m from the low water mark.

There have previously been multiple fast track classifications for razors in the area. These are summarized in Section 10.

The area covered by the standard application is shown in Figure 2.1. The map also shows the approximate locations of razor clam beds identified by the harvester for the standard track application area at the time of the shoreline survey. No stock assessments have been conducted in the area.

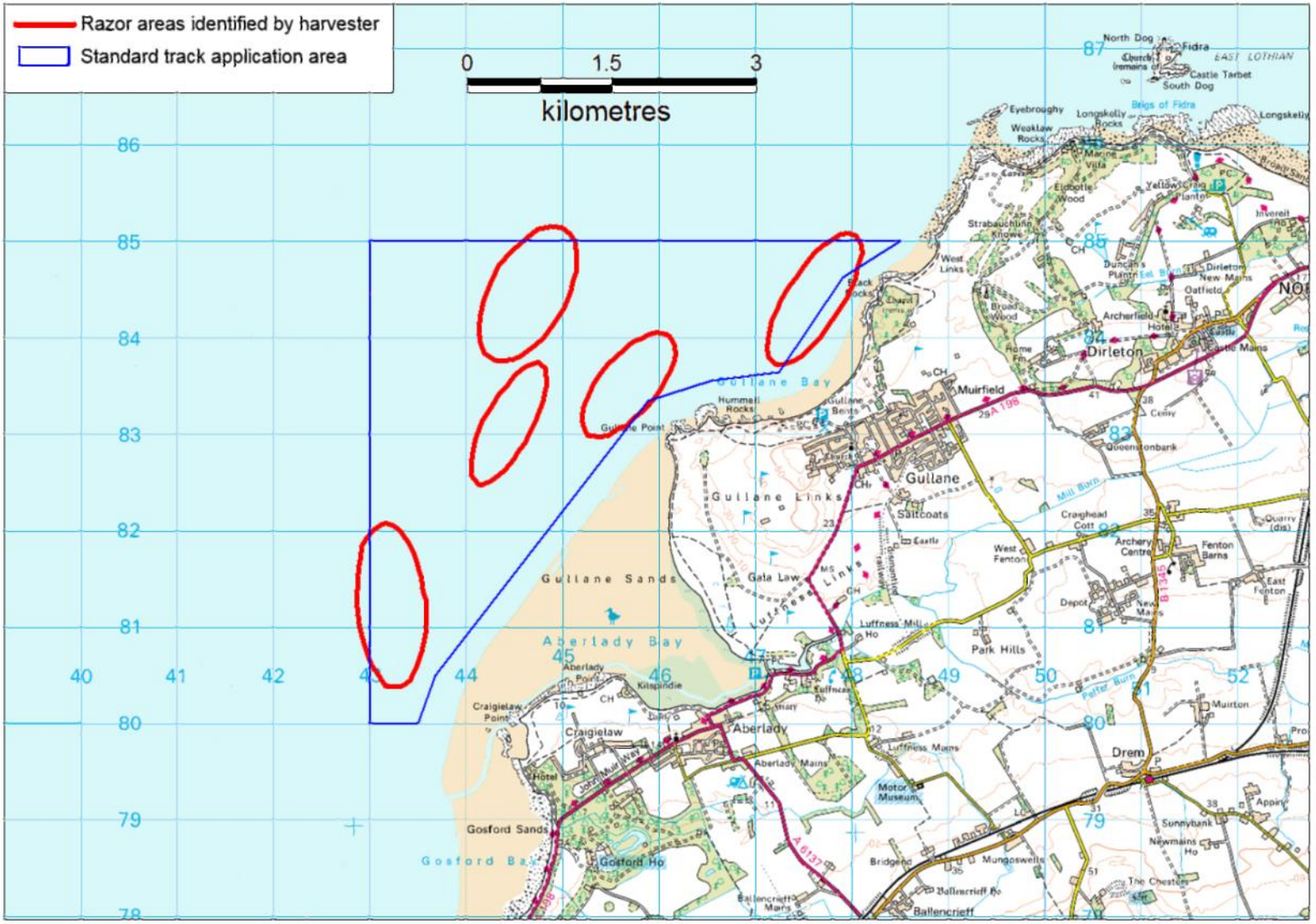


Figure 2.1 Gullane Point razor clam fishery

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 Gullane Point. The last census was undertaken in 2011. In Figure 3.1 the 2011 census data is thematically mapped by population density alongside the 2010 population totals for the localities of Prestonpans, Cockenzie & Port Seton, Long Niddry, Aberlady, North Berwick, Tranent, Macmerry, Haddington and East Linton (General Register Office for Scotland, 2012). The 2011 population totals for the localities were not available at the time of writing this report.

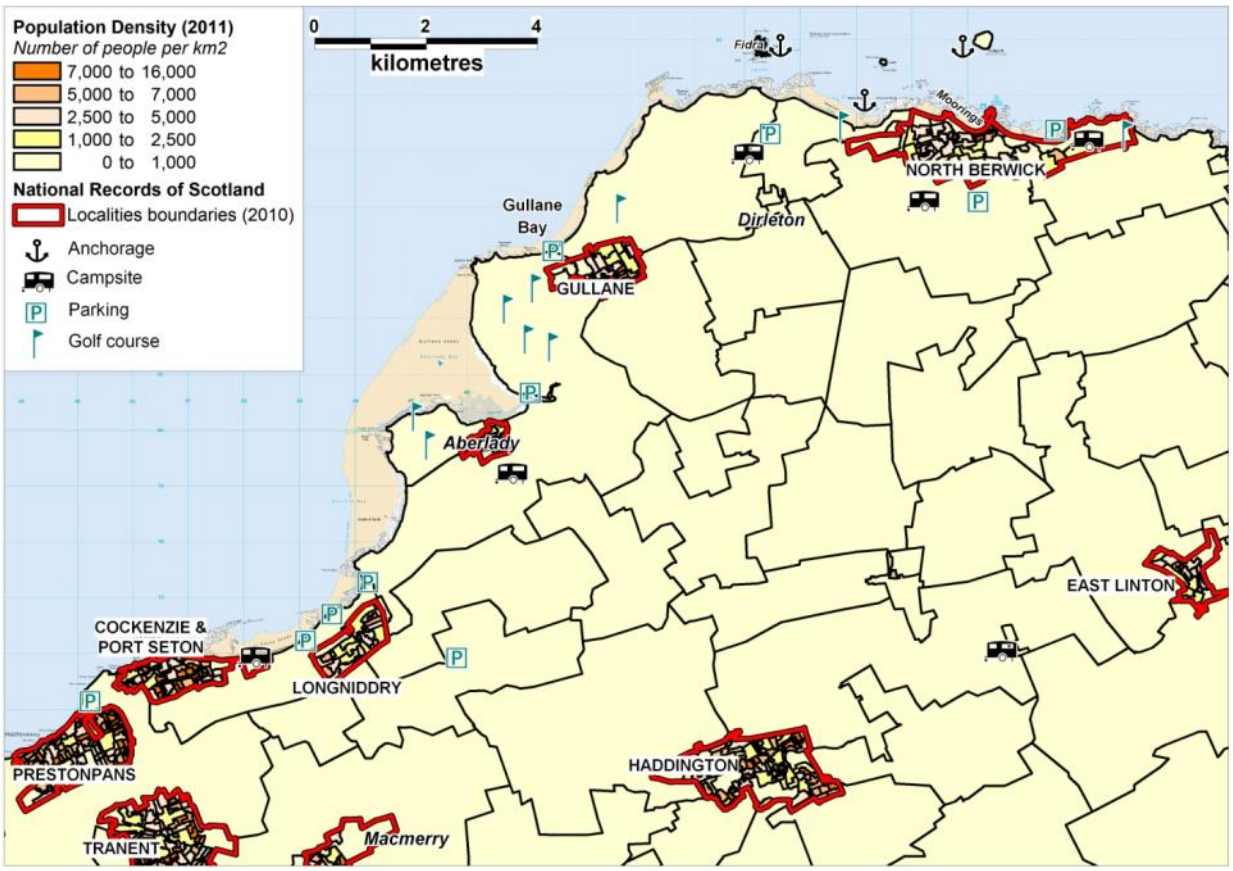


Figure 3.1 Population map for Gullane Point

Localities are described by the General Register Office for Scotland as “more recognisable towns and cities which can be found within settlements and have a minimum population of 500 people” (National Records of Scotland, 2012). The 2010 populations of the localities in the survey area are listed in Table 3.1.

Figure 3.1 and Table 3.1 show that both the total population and the population density are high for the settlements of Prestopans, Cockenzie & Port Seton, Longniddry, Aberlady and North Berwick and moderate for the settlements of Gullane and Aberlady which lie closest to the fishery. The population density for the census output areas

surrounding these settlements is low. The City of Edinburgh and the town of Musselburgh lie to the southwest of the fishery and represent large conurbations.

Table 3.1 2010 Localities Total Population

Localities	2010 Total population
Prestonpans	8500
Cockenzie & Port Seton	5660
Long Niddry	2410
Aberlady	1120
Gullane	2480
North Berwick	6640
Tranent	10590
Macmerry	1330
Haddington	8810
East Linton	1710
Total Population	49250

The coastline adjacent to the fishery has numerous golf courses scattered in between settlements, four caravan parks/campsites, a bathing water at Gullane Bay and access to most of the coastline via a road that runs parallel to the shoreline. The bathing water is a popular family beach and used often by windsurfers and canoeists, who are likely to use the area year round. The campsite west of Longniddry has over 600 mostly static pitches. The Aberlady campsite has 35 touring pitches, 15 hard standing pitches and camping pods. The campsite east of North Berwick has a total of 116 pitches, including 38 hardstanding (The Caravan Club, 2013). The holiday park south of North Berwick has over 250 pitches, including holiday chalets to buy, caravans to rent and camping cabins. The holiday park to the east of North Berwick has over 250 pitches including pitches for touring caravans, motor homes, tents and holiday homes for sale and to rent and wigwams to rent. There is likely to be additional holiday accommodation in this area. Aberlady Nature Reserve draws large numbers of bird watchers, with a rare visiting bird attracting approximately 2,500 human visitors over the 5 days it was resident at the reserve (Aberlady Community Association, 2013).

Three anchorages and additional moorings are located off the coastline north west of North Berwick. Offshore between Aberlady Bay and Gullane Bay, one small boat and three large boats were observed during the shoreline survey.

Due to the developed urban areas and close proximity of Gullane and Aberlady to the fishery, it is likely that sewage discharges from both settlements will contribute to the faecal contamination of the shellfish bed. Due to the number of caravan and campsites in the area, it is expected that the population of the area will increase significantly during the summer holiday months. Impacts from human sources to the water quality of the shellfish bed are likely to be seasonal, peaking during the summer months when visitor numbers are higher.

4. Sewage Discharges

Information on sewage discharges within a 7km radius around Gullane Point and for the settlements of Gullane, Aberlady and North Berwick was sought from Scottish Water and the Scottish Environment Protection Agency (SEPA). Data requested included the name, location, type, size (in either flow or population equivalent), level of treatment, sanitary or bacteriological data, spill frequency, discharge destination (to land, waterbody or sea), any available dispersion or dilution modelling studies, and whether improvements were currently being undertaken or were planned.

Scottish Water and SEPA datasets were compared to each other and also to information taken from Gullane bathing water profile (SEPA, 2010).

Public discharges

Scottish Water provided information on 15 intermittent and continuous sewage discharges for the area surrounding Gullane Point. These are detailed in Table 4.1. SEPA provided information on 10 public sewer discharges, 9 of which corresponded with discharges identified by Scottish Water.

The remaining discharge identified by SEPA; A198/B1348 Junct CSO, was also identified by Scottish Water. However, the data from Scottish Water placed this discharge approximately 15 km inland at Auchendinny where it was unlikely to impact on the production area. It was not possible to reconcile the location of this CSO so for the purposes of this assessment the location reported by SEPA location data has been used.

Public sewer discharges are listed in Table 4.1. Those discharges where differences were not reconciled or where only provided by one provider have been noted.

All reported discharges are shown mapped in Figure 4.1 together with sewage related observations made during the shoreline survey.

Table 4.1 Public discharges provided by SEPA and Scottish Water

CAR Licence	NGR	Discharge Name	Discharge Type	Discharges To	Level of Treatment	Flow (m3/d)	PE
CAR/L/1001105	NT 5769 8668	North Berwick WWTW FE	Continuous	Firth of Forth	Primary	2000	9100
CAR/L/1026194	NT 5433 8588	Fidra WWPS CSO/EO	Intermittent	Firth of Forth	-	-	-
CAR/L/1026194	NT 5556 8573	North Berwick, 1 Melbourne Road CSO	Intermittent	Firth of Forth	-	-	-
CAR/L/1026194	NT 5314 8567	Wester Dunes WWPS CSO/EO	Intermittent	Firth of Forth	-	-	-
CAR/L/1026194	NT 516 854	Dirleton WWPS CSO/EO	Intermittent	U/N W/C	-	-	-
CAR/L/1001105	NT 5670 8543	North Berwick WWPS CSO/EO	Intermittent	Firth of Forth	6 mm Screen		
CAR/L/1001550	NT 4480 8260	Gullane WWTW FE	Continuous	Firth of Forth	Primary	1584	4000
CAR/L/1001550	NT 4527 8234	Gullane WWTW CSO	Intermittent	Firth of Forth	6 mm Screen	-	-
CAR/L/1001550	NT 4651 8021	Aberlady Nature WWPS CSO	Intermittent	Aberlady Bay	6 mm Screen	-	-
CAR/L/1001550	NT 4650 8020	Aberlady Nature WWPS EO	Intermittent	West Peffer Burn, Aberlady Bay	6 mm Screen	-	-
CAR/L/1026086	NT 4371 7757	Longniddry WWPS Lyars Rd CSO/EO	Intermittent	Gosford Bay	6 mm Screen	1438	-
CAR/L/1026086	NT 4379 7670	Longniddry Golf Club CSO	Intermittent	U/N WC	-	-	-
CAR/L/1026086	NT 4418 7714	Longniddry Golf course/B1348 Junction CSO	Intermittent	Firth of Forth	-	-	-
CAR/L/1026086	NT 4411 7726	A198/B1348 Junct CSO	Intermittent	Firth of Forth	-	-	-
CAR/L/1026302	NT 4666 7991	Gullane, Loan Cottage CSO	Intermittent	Aberlady Bay	-	-	-
WPC/E/20941	NT 4885 8510	Gullane WWPS CSO/EO	Intermittent	Firth of Forth	-	-	-

- No data available CSO = Combined Sewer Overflow, EO = Emergency Overflow, FE = Final Effluent, WWTW = Waste Water Treatment Works, WWPS = Waste Water Pumping Station -SEPA location data used -SW data only

North Berwick WWTW discharges approximately 10 km west of the production area and has a PE of 9100 and MDF of 2000 m^3/d.

Gullane WWTW, which has a population equivalent of 4000 and a mean daily flow (MDF) of 1584 m^3/d, discharges directly into the production area. The Gullane WWTW CSO also discharges through this same outfall. Gullane WWPS CSO/EO discharges near the northeastern boundary of the production area.

West Peffer Burn receives discharges from Aberlady Nature Reserve WWPS CSO, Aberlady Nature WWPS EO and Gullane Loan Cottage CSO before flowing into Aberlady Bay.

Nine other intermittent discharges are over 2.5 km from the production area. No information on spill frequency/volume and sanitary or microbiological monitoring results were provided for these discharges.

Private discharge consents

SEPA provided information on 81 private sewage works or septic tanks. The largest of these discharges related to the Fenton Barns STW (Number 1, Table 4.2). This has a relatively large PE of 300, however effluent receives secondary treatment before discharging to Mill Burn just above West Peffer Burn.

The remaining consents pertain mainly to septic tanks with PEs below 60.

Thirty of these discharge into watercourses. Of those 28 are in the catchment for West Peffer Burn, which flows into Aberlady Bay directly adjacent to the production area. These have a combined PE of 465. However, PE values were not given for three of the discharges.

Four private discharges release effluent directly to the sea. Two discharge to the south of the production area into Gosford Bay; Gosford House septic tank which has a PE of 46 and Greencraig Hotel septic tank with a PE of 8. Two discharge into Aberady bay directly adjacent to the production area; Kilspindie Cottages septic tank which serves four properties and has a PE of 20; and Kilspindie Golf Club septic tank which has a PE of 5.

Private discharges identified as going to sea or to watercourses likely to impact on the fishery are listed in Table 4.2.

Table 4.2 Private discharges likely to impact the production area.

No	Consent Ref.	NGR	Name	Level of Treatment	PE	Discharge to
1	CAR/L/1001317	NT 5105 8062	Fenton Barns STW North Berwick	STW (secondary)	300	Mill Burn
2	CAR/R/1015215	NT 4997 8478	Greenkeepers Maintenance Shed	-	-	-
3	CAR/L/1004835	NT 4850 7800	Ballencrieff Steading, Ballencreiff	STW (secondary)	-	Un/Wc
4	CAR/R/1025020	NT 5107 8063	D C Watson & Sons, Fenton Barns	ST	5	West Peffer Burn
5	CAR/R/1074759	NT 4957 7876	Mungoswells Farm, Drem	ST	5	U/T West Peffer Burn
6	CAR/R/1083288	NT 4864 7989	Luffness Mains Farm, Longniddry	STW (secondary)	5	U/T West Peffer Burn
7	CAR/R/1090531	NT 4960 7860	Camptoun Holdings, North Berwick	ST	7	U/T West Peffer Burn
8	CAR/R/1074188	NT 4958 7878	Mungoswell Farmhouse, Drem	ST	7	Un/Wc
9	CAR/R/1045952	NT 4906 8142	West Fenton Cottages	ST	9	Mill Burn
10	CAR/R/1025018	NT 5193 8053	D C Watson & Sons, Fenton Barns	ST	9	West Peffer Burn
11	CAR/R/1078316	NT 5194 8142	Farmhouse, East Fenton	ST	10	U/T West Peffer Burn
12	CAR/R/1078319	NT 5195 8141	The Coach House, East Fenton	ST	10	U/T West Peffer Burn
13	CAR/R/1045249	NT 5036 8184	Garleton View & Redroofs	ST	10	Un/Wc
14	CAR/R/1045286	NT 5035 8196	Craighead Cttg & Braeside Cttg	ST	10	Un/Wc
15	CAR/R/1072601	NT 4893 8090	Riding Arena, West Fenton Farm	STW (secondary)	18	West Peffer Burn
16	CAR/R/1074743	NT 4818 7931	Bridgend, Drem, North Berwick	ST	20	U/T West Peffer Burn

No	Consent Ref.	NGR	Name	Level of Treatment	PE	Discharge to
17	CAR/R/1078320	NT 5195 8140	Cottages, East Fenton Farm	ST	35	U/T West Peffer Burn
18	CAR/R/1074751	NT 4958 7878	Mungoswells , Drem, North Berwick	ST	40	U/T West Peffer Burn
19	CAR/R/1091313	NT 4819 7803	Ballencrieff Cottages, Longniddry	ST	45	U/T Harestanes Burn
20	CAR/R/1042641	NT 4950 7720	Byres Farm Cottages, Longniddry	STW (secondary)	≤12	Un/Wc
21	CAR/R/1036150	NT 5210 8056	Prora Farm Steading, Drem	STW (secondary)	≤15	River Peffer
22	CAR/S/1028512	NT 5047 8289	Queenstonbank Farm	STW (secondary)	≤25	U/T Mill Burn
23	CAR/S/1099867	NT 5230 8060	Prora Wellness Centre, Drem	STW (secondary)	≤27.06	Mill Burn
24	CAR/S/1069089	NT 4890 8102	Muirfield RDA, West Fenton Farm	STW (secondary)	≤39	West Peffer Burn
25	CAR/S/1025202	NT 5107 8063	Fenton Barns, North Berwick	ST	≤60	West Peffer Burn
26	CAR/R/1019617	NT 4960 7860	Camptoun Holdings	ST	≤7	Gosford Burn
27	CAR/R/1018572	NT 5108 7950	Newhouses, Drem	ST	≤9	U/T West Peffer Burn
28	CAR/R/1055198	NT 5175 8053	Farmhouse Muirton Farm	ST	≥20	West Peffer Burn
29	CAR/R/1056270	NT 4893 7950	Woodbine Cottage, Longniddry	ST	≥5	Un/Wc
30	CAR/R/1048229	NT 5019 8230	Barleyrig, North Berwick	ST	-	Mill Burn
31	CAR/R/1078874	NT 4573 8035	Kilspindie Golf Club, Aberlady	ST	5	Firth of Forth
32	CAR/R/1078794	NT 4460 7945	Green Craig Hotel, Aberlady	ST	8	Gosford Bay
33	CAR/R/1078877	NT 4574 8033	Kilspindie Nos, Aberlady	ST	20	Firth of Forth
34	CAR/R/1058306	NT 4453 7843	Gosford House	ST	46	Firth of Forth

- Information not provided ST=Septic tank (primary treated); STW=Sewage treatment Works (secondary treated)

The remaining 46 small private discharges all discharge to land. Many of these lie close to watercourses or drainage ditches which could lead to partially treated effluent being released into the water course and eventually making its way into the production area.

Sewage infrastructure recorded during the shoreline survey along with any sample results are listed in Table 4.3

Table 4.3 Discharges and septic tanks observed during shoreline surveys

No.	*E. coli* cfu/ *100 ml*	Discharge observations
1	-	Concrete pipe on shore with metal drain cover sitting above. No flow at time of survey but running water audible.
2	200	Concrete double-headed outflow pipe running down the intertidal.
3	-	Metal pipe in rock situated at the top of the shore on the border between rough grass area and sandy beach.
4	-	Metal pipe in rock situated at the top of the shore on the border between rough grass area and sandy beach.
5	1500	Three plastic pipes draining into West Peffer Burn, sample was taken downstream of these pipes. All pipes trickling.
6	-	Small car park with public toilets.
7	-	Two sanitary towels washed up on shore.
8	-	Large brick and concrete drain with metal cover.
9	<100	Two concrete pipes side by side, covered by metal bars. One flowing. Both coming from under road.
10	2300000	Metal pipe with a storm flap, flowing heavily. Extremely bad smell. Raw sewage coming out of pipe. Golf course behind.
11	-	Metal pipe. No flow. Pipe running from golf course onto shore.
12	100000	Very bad smell. 'Milky' looking outflow from metal pipe.

- No sample taken

During the shoreline survey twelve observations of potential sewage inputs to the production area were noted.

Observations 1 and 2 are both located on the shore at the far east of the production area and relate to concrete pipes. Observation 2 plots within 20 m of Gullane WWPS CSO/EO. At the time of the survey a sample was taken returning a low value of 200 cfu/100 ml and the flow was measured at 100 ml a second. This gave an estimated loading of 1.7 x10^7 *E. coli* per day. This may represent surface water drainage using the same outflow as the CSO/EO.

Observations 3 and 4 were located within 5 m of each other and were both metal pipes buried into rock. These correspond directly with springs identified on maps. Water draining from these pipes is unlikely to be contaminated.

Observation 5 relates to three plastic pipes draining into West Peffer Burn. A sample taken from the burn returned a value of 1500 cfu/100 ml indicating the burn is moderately contaminated. Although none of the consented discharges identified by SEPA plot in the vicinity, these pipes are of a type usually associated with septic tanks.

Observation 6 relates to a car park with public toilets. No discharge was observed nor did the location correspond to any discharges provided by SEPA or Scottish Water.

Observation 7 relates to sanitary towels on the shoreline. This is usually an indication of raw untreated sewage being released, usually through CSOs or EOs. The day prior to the survey there was heavy rain throughout the day, which may have caused CSO activation.

Observation 8 relates to a manhole cover set in concrete and bricks. No discharge was noted at this location.

Observation 9 relates to two concrete pipes with metal bars. These plot to the same location as a surface water overflow outlet, through which Loan Cottage CSO discharges. At the time of the sanitary survey only one of the pipes was flowing, at 7.5 ml/s. A sample returned <100 *E. coli* cfu/100ml indicating vary low levels of contamination.

Observation 10 was of a metal pipe with storm flap, flowing heavily. An extremely bad smell was noted and the effluent was considered by the surveyors to be raw sewage. A sample taken of the effluent returned a very high result of $2.3x10^6$ *E. coli* cfu/100 ml and a flow rate of 30 ml/s. This gives the discharge an estimated loading of $6.0x10^{10}$ *E. coli* per day. The discharge does not plot close to any discharges for which information was provided by SEPA or Scottish Water.

Observation 11 relates to a metal pipe with no flow and a diameter of 18 cm. This location does not correspond with any discharges for which information was provided by SEPA and Scottish Water.

Observation 12 relates to a 12 cm metal pipe flowing at 6 ml a second. The effluent was a milky colour and returned a result of 100000 *E. coli* cfu/100 ml when sampled. The flow rate increased for about 30 seconds periodically, suggesting that something connected to the outfall was pumping out water. Although located approximately 60 m NW of the consented discharge location identified by SEPA, this is presumed to be septic tank outfall from the Green Craig Hotel (PE = 8).

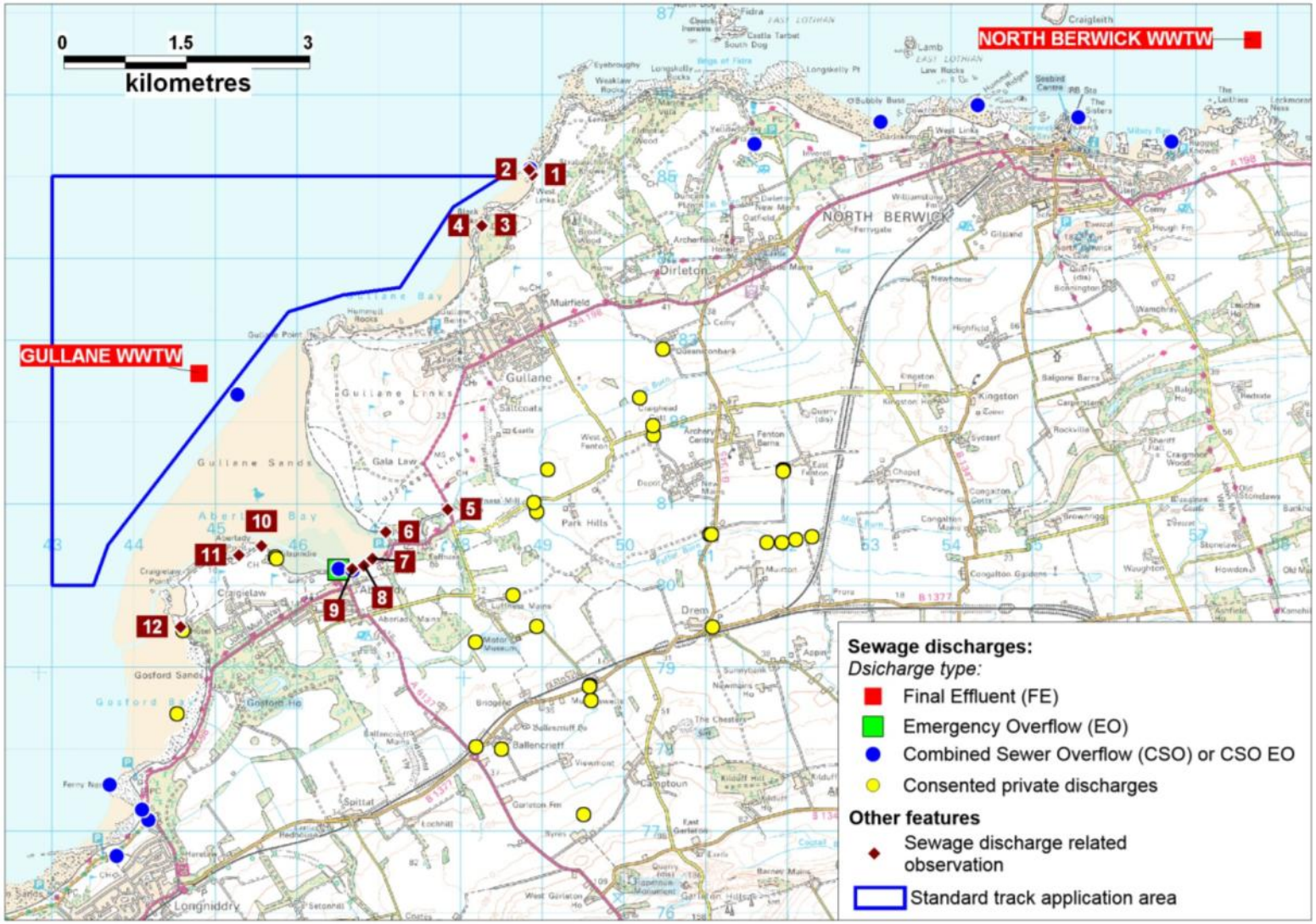


Figure 4.1 Map of discharges for Gullane Point

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 Tranent, Gladsmuir, Aberlady, Haddington, Athelstaneford, Dirleton and North Berwick parishes. Reported livestock populations, total crops and grass coverage and rough grazings area 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 Selected agricultural census data for parishes along the Gullane Point coastline 2012

	Tranent		Gladsmuir		Aberlady		Haddington		Athelstaneford		Dirleton		North Berwick	
	25 km^2		28 km^2		18 km^2		50 km^2		21 km^2		39 km^2		22 km^2	
	Holdings	Numbers/ Km^2	Holdings	Numbers/ Km^2	Holdings	Numbers/ Km^2	Holdings	Numbers/ Km^2	Holdings	Numbers/ Km^2	Holdings	Numbers/ Km^2	Holdings	Numbers/ Km^2
Pigs	0	*	*	*	*	*	0	-	*	*	0	0	0	-
Poultry	*	*	*	*	*	*	10	176	*	*	*	*	*	*
Cattle	*	*	*	*	0	-	8	1034	5	321	*	*	*	*
Sheep	*	*	*	*	*	*	8	389	7	138	*	*	0	-
Other horses and ponies	8	37	8	100	*	*	16	96	6	39	8	101	7	24
Total crops and grass	17	11.3	24	27.1	19	12.2	72	39.8	22	15.6	25	28.3	17	12.1
Rough grazings	*	*	*	*	*	*	6	0.2	*	*	0	0	*	*

Numbers of pigs, poultry and sheep for all parishes were low and in most cases numbers were not reported due to the small number of holdings. The inland parishes of Haddington and Athelstaneford had the largest reported numbers of livestock, with cattle predominating.

The Haddington Agricultural Show takes place annually in June near Athelstanford. However, the show ground lies well inland and is not likely to result in an increase in faecal contamination reaching the fishery.

The total coverage of crops and grass reported for each parish ranged from 44% (Tranent) to 97% (Gladsmuir) of the total parish area. Tranent is the only parish with less than half of the land used in production of crops or grass. Any run-off of organic fertilisers such as sludge or slurry applied to these areas would be likely to contribute to faecal contamination of watercourses draining the area. This may particularly affect

West Peffer Burn, which flows through Dirleton Parish (73% crop and grass) and discharges to Aberlady Bay.

The river basin management plan (RBMP) water body information for West Peffer/Mill Burn identified arable farming as the principal pressure resulting in the overall bad ecological status of the waterbody. The main pressures were from diffuse source pollution and water abstraction (SEPA, 2010)

No livestock, farms or agricultural buildings were observed along the survey route during the site visit undertaken during 27th – 30th May 2013.

Overall, agricultural-source faecal contamination to the fishery is likely to be moderate particularly around Aberlady Bay and the mouth of West Peffer Burn.

Figure 5.1 Agricultural parish boundaries

6. Wildlife

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

Most of the coastal area around the survey area is part of the Firth of Forth Special Protection Area (SPA) noted especially for its assemblage of birds.

The species most likely to contribute to faecal indicator levels at the Gullane Point razor clam fishery are considered below.

Seals

Two species of seals are found in the water surrounding Gullane Point. These are the common/harbour seal (*Phoca vitulina*) and the grey seal (*Halichoerus grypus*).

In a report by SCOS (2011) an estimated 11-25 harbour seals were observed at Gullane Point between 2007 and 2009. Between 2007 and 2010 a total of 148 harbour seals were observed in the Firth of Forth, though no estimates were available for grey seals.

A grey seal colony has been noted in the Firth of Forth (Duck, 2010). Grey seals preferentially haul out on rocky, uninhabited coasts. East of Gullane Point lays the Isle of May, West Cliffs, Craigleith and Bass Rock. These are known to be haul out sites for grey seals, with regular sightings reported (Scottish Seabird Centre, 2013).

No seals of either species were observed during the shoreline survey.

Whales and dolphins

Minke whales and Bottlenose dolphins are regularly spotted in the Firth of Forth (SeaWatch Foundation, 2006). Due to the shallow nature of the water that surrounds Gullane Point, it is unlikely that large cetaceans will come in close to shore. However there are anecdotal accounts of harbour porpoise in the local area (*Phocoena phocoena*) (Aberlady Community Association, 2013).

Birds

Seabird 2000 census data (Mitchell, et al., 2004) was queried for the area within a 5 km radius of Gullane Point and the results summarised in Table 6.1. This census was undertaken between 1998 and 2002 and covered 25 species of seabird that breed regularly in Britain and Ireland.

Table 6.1 Seabird counts within 5 km of Gullane Point.

Common name	Species	Count*	Qualifier
Razorbill	*Alca torda*	668	Individuals on land & Occupied sites
Atlantic puffin	*Fratercula arctica*	56817	Individuals on land & Occupied burrows
Northern Fulmar	*Fulmarus glacialis*	1852	Occupied sites
European Herring gull	*Larus argentatus*	7014	Occupied nests
Lesser Black-backed gull	*Larus fuscus*	2938	Occupied sites & Occupied territory
Great Black-backed gull	*Larus marinus*	20	Occupied nests
Northern gannet	*Morus bassanus*	88220	Occupied nests
European shag	*Phalacrocorax aristotelis*	596	Occupied nests
Great cormorant	*Phalacrocorax carbo*	380	Occupied nests
Black-legged kittiwake	*Rissa tridactyla*	4316	Occupied nests
Little tern	*Sterna albifrons*	4	Occupied nests
Common murre	*Uria aalge*	8266	Individuals on land

*The counts have been adjusted where the method used was occupied nests or territories to reflect the probable number of individual birds (ie. counts of nests were doubled).

The majority of the seabirds noted in the Seabird 2000 data were found northeast of Gullane Point, around North Berwick. These birds are present in large colonies, with the densest population found offshore on the island of Bass Rock and another large colony found on Craigleith. These islands lay approximately 16 and 11 km northeast of Gullane Point respectively.

Bass Rock hosts the largest single island colony of Northern gannets in the world, with up to 150000 present during peak season (Scottish Seabird Centre, 2013). Gannets spend the majority of the year at this rock, migrating south to Africa during October and returning again in January. Bass Rock also hosts large number of nesting pairs of puffins, razorbills, guillemots and shags (Scottish Seabird Centre, 2013).

The Aberlady Nature Reserve is located adjacent to Gullane Sands. The area stretches across the foreshore adjacent to Aberlady Bay and is nationally important in winter months when its hosts significant populations of wader and duck species, including up to 17,000 Pink-footed Geese. The site is also important for birds that are in serious decline such as Skylark and Reed Bunting. Other breeding species include: Eider, Shelduck, Lapwing, Lesser Whitethroat & Redshank. In the autumn up to 10, 000 waders may be present, with lapwing and Golden Plover most common, there are also several hundred widgeon that feed in the bay. These birds also bring in large numbers of visitors to the area, for example in 1997 when a Western Sandpiper (an American wader species) was residing in the area for five days, it was reported that it attracted approximately 2,500 human visitors (Aberlady Community Association, 2013).

During the shoreline survey, birds were the most numerous wildlife species observed. Gulls, crows and eider ducks, as well as unidentified ducks, were the most commonly spotted birds, which were present along the entire shoreline surveyed. Other species identified included geese, with goslings, skylarks, swallows, a pheasant, lapwings and oystercatchers.

Deer

Anecdotal reports suggest a relatively small herd of roe deer (*Capreolus capreolus*) lives on Aberlady Reserve, just west of Gullane Point (Windsurf Now, 2013). Four deer were seen during the shoreline survey: one on grassland at Aberlady Nature Reserve and a further three noted 'in the distance' from the northeast shoreline.

Overall

Species potentially impacting on Gullane Point include geese and ducks, seabirds, seals and deer. The greatest concentration of birds occurs to the east of the area in the region of North Berwick and beyond toward the ENE where there are seabird colonies. In the immediate area of the fishery, numbers will be lower and no consistent spatial pattern to contamination arising from wildlife sources is expected. The spatial distribution of animals observed during the shoreline survey, as well as the Seabird 2000 data, are shown in Figure 6.1.

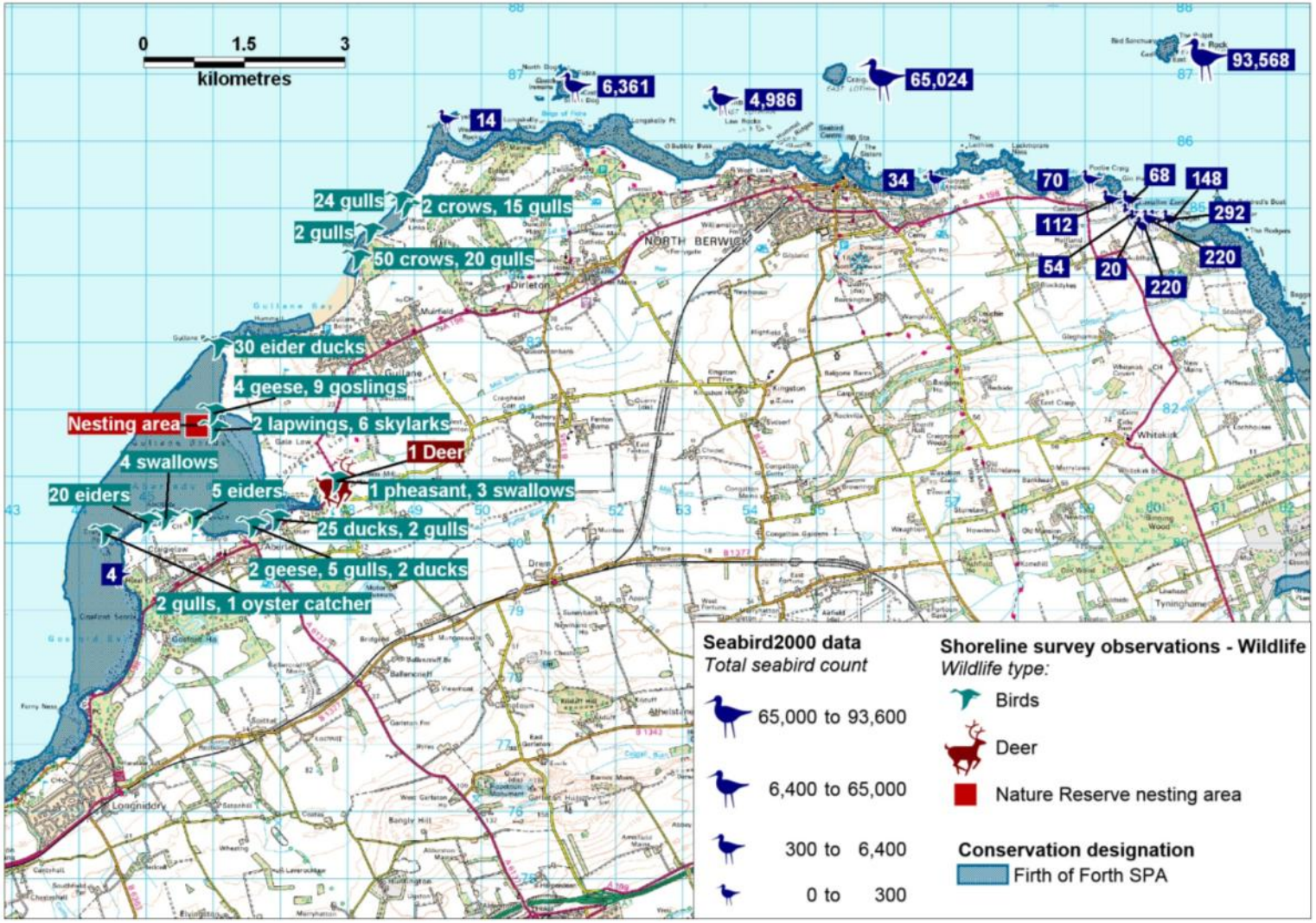


Figure 6.1 Map of wildlife around Gullane Point.

7. Land Cover

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

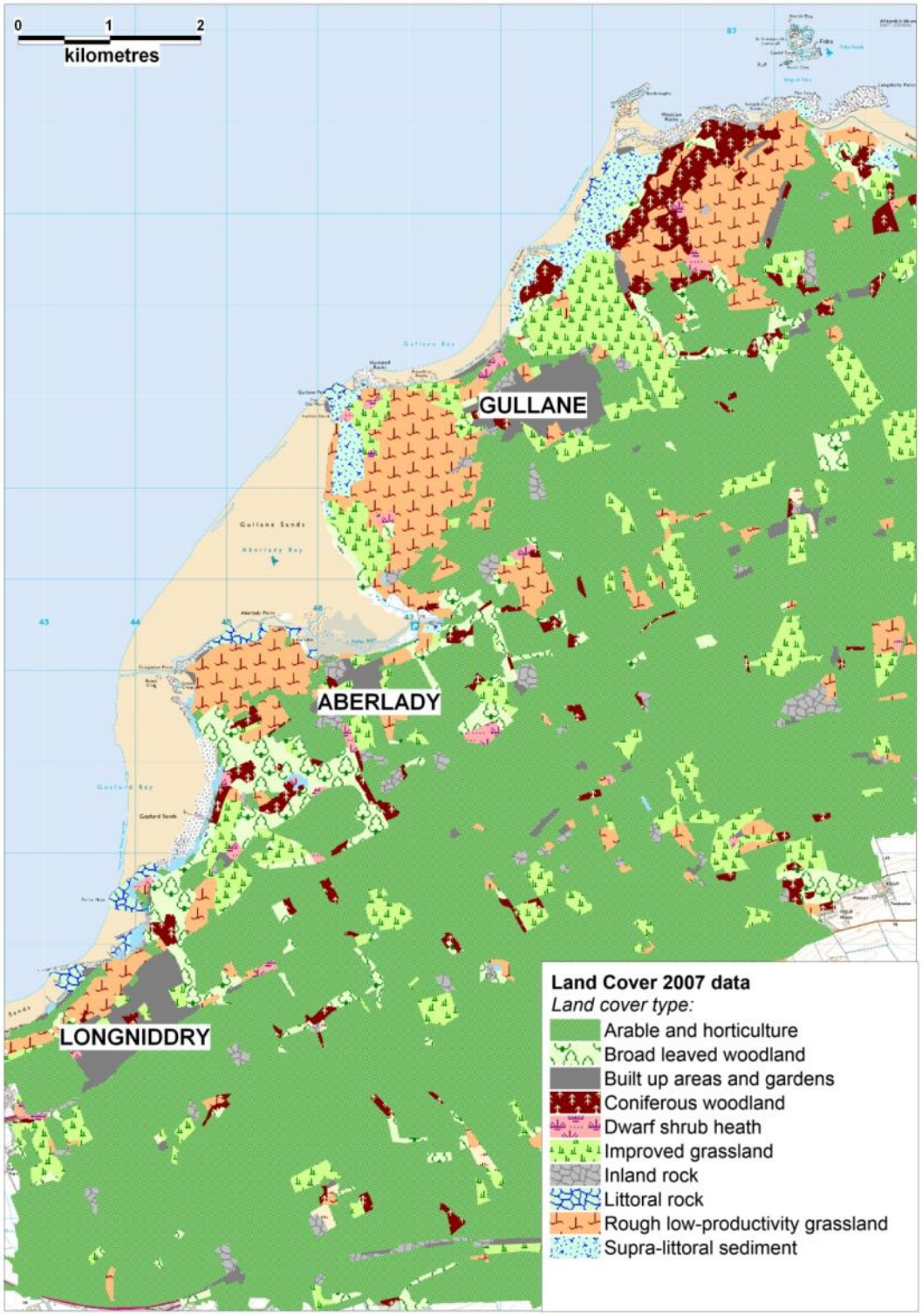


Figure 7.1 LCM2007 land cover data for Gullane Point

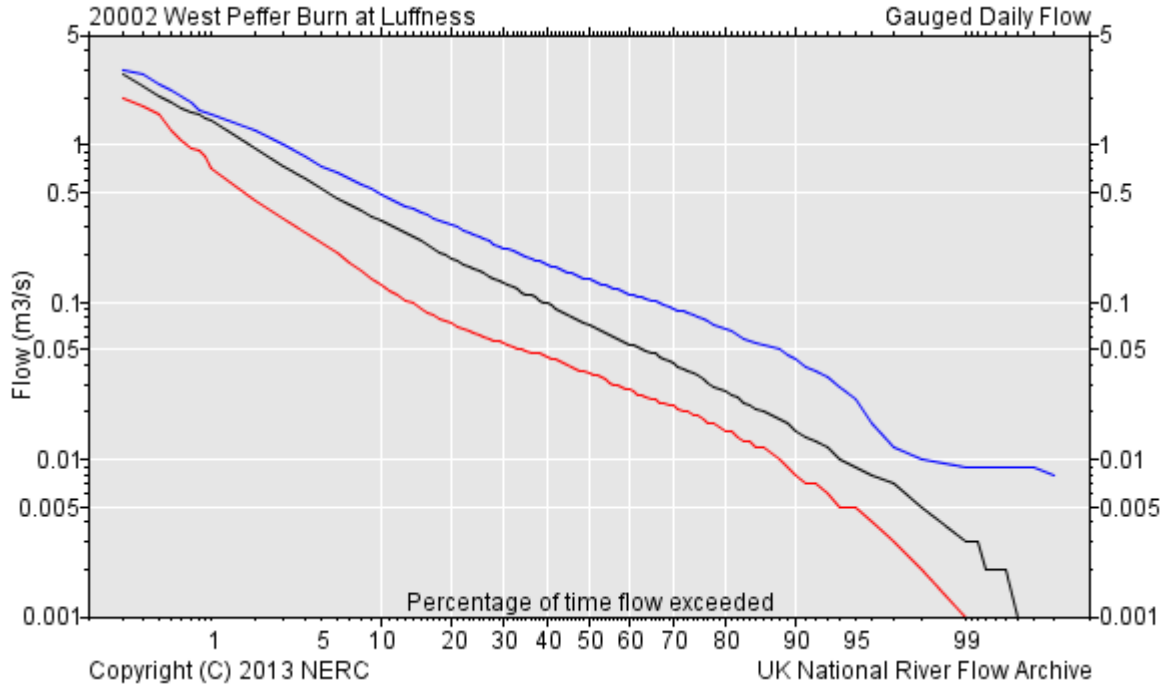
Arable, rough grassland and improved grassland are the predominant land cover types on the low-lying shoreline adjacent to the Gullane Point shellfish bed. The settlements of Longniddry, Aberlady and Gullane are shown as built up areas and gardens, surrounded by arable land, rough grassland and improved grassland. Some of the developed area of Aberlady and Gullane and areas of improved and rough grassland border the shellfish bed.

Faecal indicator organism export coefficients for faecal coliform bacteria have been found to be approximately 1.2 – 2.8x10^9 cfu/km^2/hr for urban catchment areas, approximately 8.3x10^8 cfu/km^2/hr for areas of improved grassland and approximately 2.5x10^8 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 highest potential contribution of contaminated run-off to the Gullane Point shellfish bed is from the built up areas of Aberlady and Gullane, the areas of improved grassland located along the shoreline at Gullane and the areas of arable land located inland. The potential contribution of contaminated run-off to the shellfish farm would be highest in these areas.

8. Watercourses

A gauging station is located on West Peffer Burn at Luffness. Flow data is provided for the period 1966-2012, with mean measured flow at 0.153 m^3/s and a base flow index of 0.48 m^3/s (National River Flow Archive, 2013). The flow duration curve is displayed in Figure 8.1. The x-axis graph shows the percentage of time for which the flows on the left-hand y-axis are exceeded. The Q50 value, the flow which is exceeded for 50% of the time, on an annual basis, is given as 0.072 m^3/s (this corresponds to 6220 m^3/d). The flows are markedly higher in winter (blue line) than in summer (red line).



Key: **Black line - annual; blue line - December to March; red line - June to September.**

Figure 8.1 Flow duration curve for West Peffer Burn, Courtesy of UK NRFA, 2013

The shoreline survey at Gullane Point was conducted between the 28th to the 30th May 2013. Heavy rain fell in the 24 hr prior to conducting the survey. With the exception of a short shower on the first sampling day no rain fell. Three watercourses were observed during the survey. These represent the largest freshwater inputs to Gullane Point production area and are listed in Table 8.1 and displayed in Figure 8.2.

Table 8.1 Watercourse loadings for Gullane Point

No.	NGR	Description	Width (m)	Depth (m)	Flow (m^3/d)	Loading (*E. coli* per day)
1	NT 4494 7891	Harestanes Burn	2.00	0.11	7300	$4.4x10^{10}$
2	NT 4784 8093	West Peffer Burn	2.55	0.10	17500	$2.6x10^{11}$
3	NT 4767 8082	Small stream	4.00	0.69	-	Stagnant

-No data available

The measured estimated flow for West Peffer Burn was markedly higher than the Q50 value obtained from the hydrological data series, presumably due to the heavy rain that fell prior to the shoreline survey. The estimated loadings varied form moderate for watercourse 1 (Harestanes Burn) to high for watercourse 2 (West Peffer Burn). Harestanes Burn discharges to Gosford Bay, whilst West Peffer Burn discharges into Aberlady Bay and the Gullane Sands harvesting area. Watercourse 3 was measured and sampled, though it was noted to be stagnant at the time of the survey. This was a small watercourse that joins West Peffer Burn: given the very low flow that was observed at the time of the shoreline survey, a loading was not estimated.

Due to the close proximity of West Peffer Burn to the fishery area, it is likely that contamination from this watercourse will contribute significantly to contamination levels along the southeastern side of Aberlady Sands.

Overall, the contribution of watercourses to contamination levels within the fishery area as a whole are likely to be moderate.

Figure 8.2 Map of river/stream loadings at Gullane Point

9. Meteorological Data

The nearest weather station is located at Belliston, situated approximately 19 km north of the fishery. Rainfall data was available for January 2007 – December 2012 at the time of writing this report. The nearest wind station is situated at Edinburgh Gogarbank, located 37 km west south west of the fishery. Conditions may differ between this station and the fisheries due to the distances between them. However, this data is still shown as it can be useful in identifying seasonal variation in wind patterns.

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 Gullane Point.

9.1 Rainfall

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

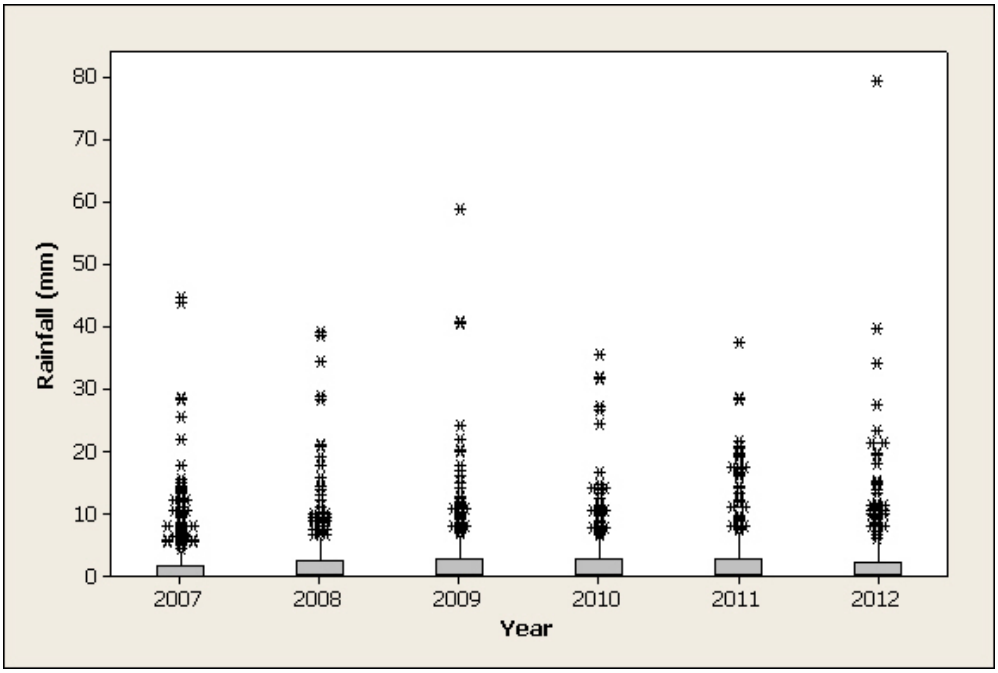


Figure 9.1 Box plot of daily rainfall values by year at Belliston (2007 – 2012)

Daily rainfall values varied from year to year, with 2007 being the driest year. The wettest year was 2011. High rainfall values of more than 30 mm/d occurred in all years but an extreme rainfall event of nearly 80 mm/d was seen in 2012.

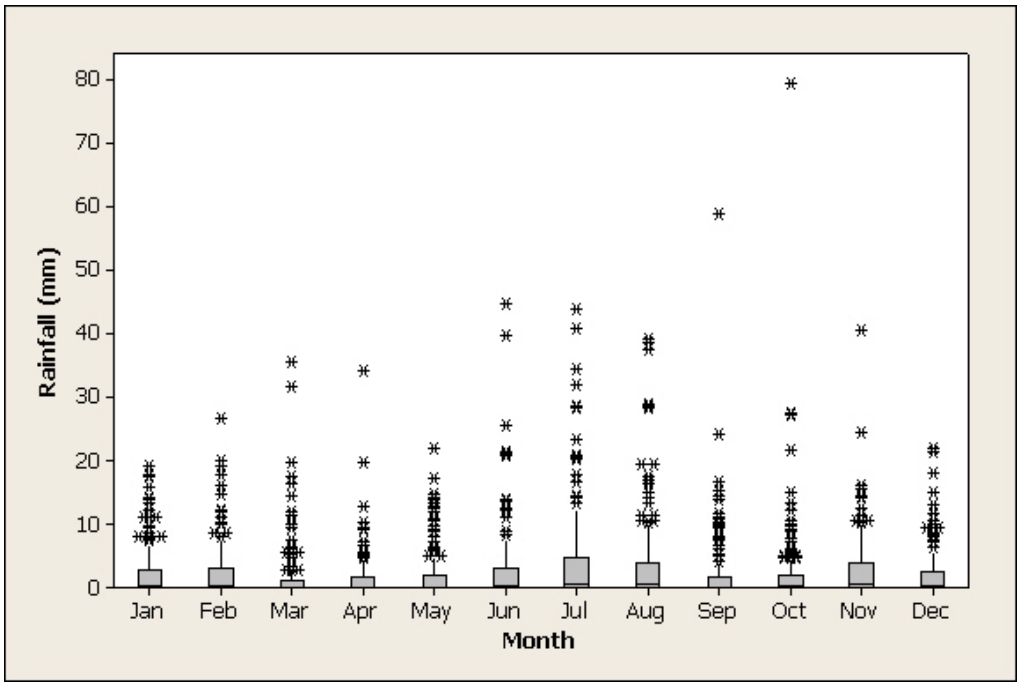


Figure 9.2 Box plot of daily rainfall values by month at Belliston (2007 – 2012)

Daily rainfall values were higher during the summer and winter. Rainfall was highest in July. Weather was drier from March to May. Rainfall values exceeding 30 mm/d were seen in all months except December, January and February (i.e. winter) and May. The 2012 extreme event occurred in October.

For the period considered here (2007 – 2012) 62 % of days received daily rainfall of less than 1 mm and 6 % of days received rainfall of over 10 mm.

It is therefore expected that run-off due to rainfall will be higher during the summer and winter months. However, extreme rainfall events leading to episodes of high run-off can occur in most months and when these occur during generally drier periods, 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 Edinburgh Gogarbank and summarised in seasonal wind roses in Figure 9.3 and annually in Figure 9.4.

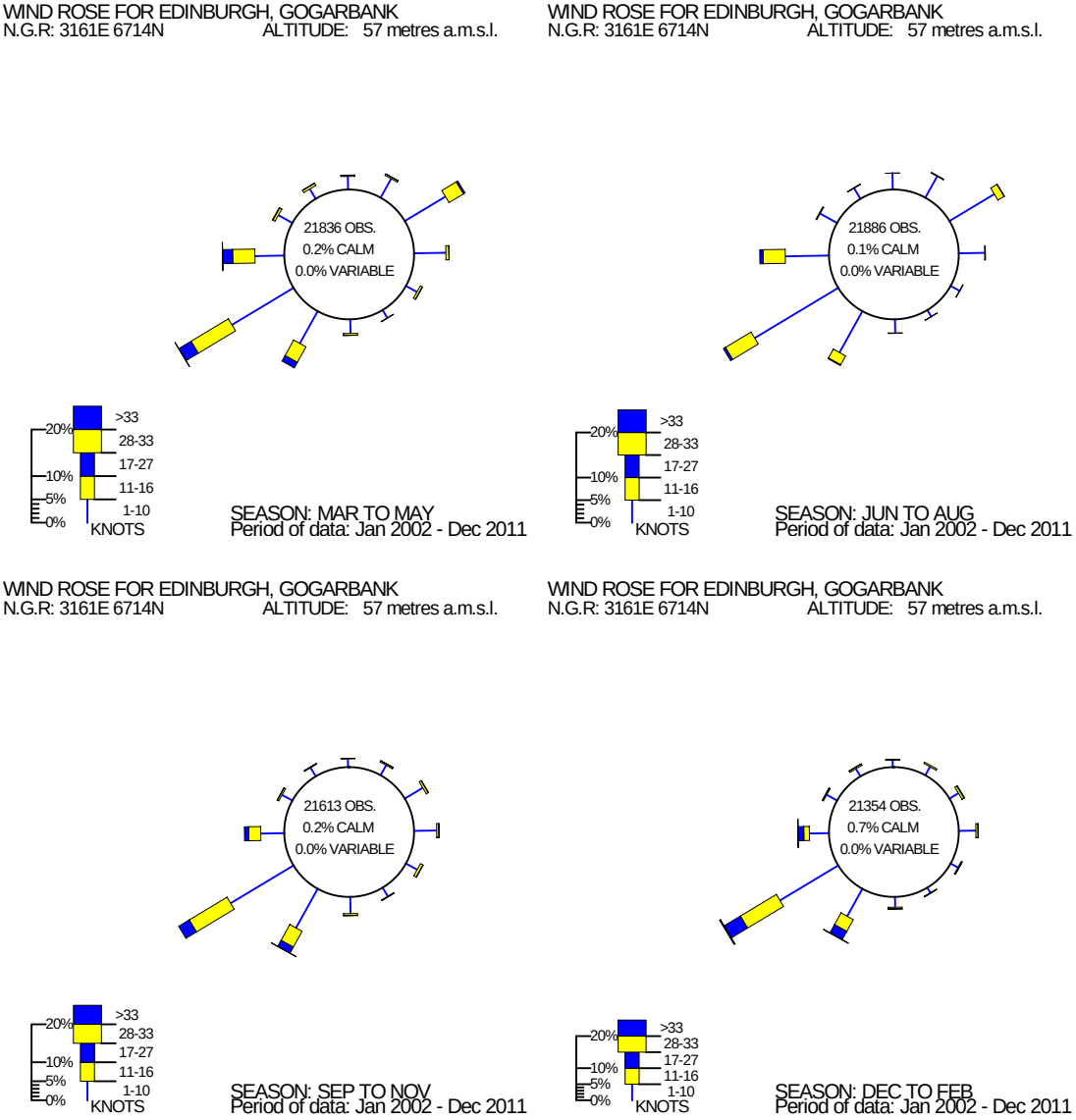


Figure 9.3 Seasonal wind roses for Edinburgh Gogarbank

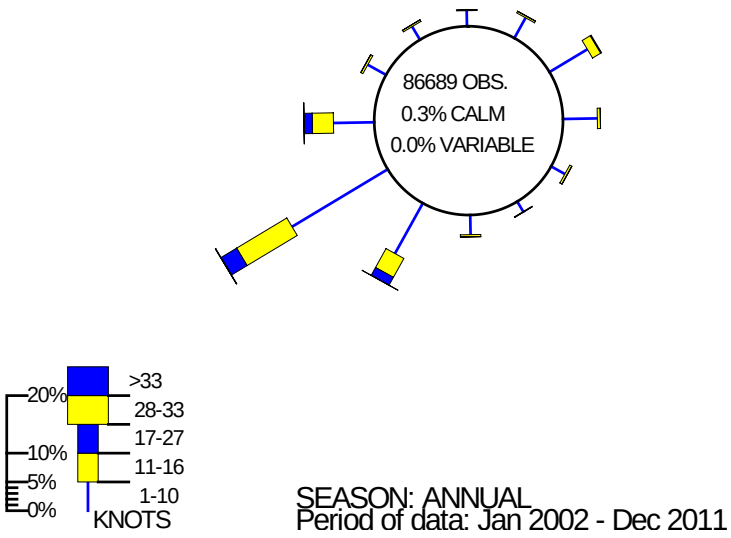


Figure 9.4 Annual wind rose for Edinburgh Gogarbank

Overall the predominant annual wind direction is WSW, along the axis of the firth. There was a greater prevalence of winds the NE from March to August. Winds were generally stronger in the winter months than in the summer months.

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 production area.

10. Classification Information

The Gullane area has received multiple fast track classifications for razors over the years and has been sampled for fast tracks every year since 2008. The classifications are summarized in Table 2.2 below:

Table 10.1 Fast track classifications for Gullane Point area

Production area	Site	SIN	Species	Classification	Dates
Gullane Sands	Aberlady Razors	EL-433-838-16	Razors	Provisional B	17 Jul 2008 to 16 Nov 2008
Gullane Bay	Gullane Bay Razors	EL-434-839-16	Razors	Provisional B	17 Jul 2008 to 16 Nov 2008
Gullane Sands	Aberlady Razors 3	EL-433-942-16	Razors	Provisional B	10 Nov 2009 to 10 Mar 2010
Gullane Bay	Gullane Bay Razors 2	EL-434-943-16	Razors	Provisional B	10 Nov 2009 to 10 Mar 2010
Gullane	Black Rocks Razors	FF-518-913-16	Razors	Provisional B	09 Aug 2010 to 08 Dec 2010
Gullane Point Fast Track	Gullane Point Fast Track	FF-555-1021-16	Razors	Provisional B	16 Apr 2011 to 15 Aug 2011

11. Historical *E. coli* Data

11.1 Validation of historical data

Results for all samples assigned against the eight fast track razor clam sites (Aberlady razors, Aberlady razors 2, Aberlady razors 3, Gullane Bay razors, Gullane Bay razors 2, Gullane Point Fast Track, Gullane Annual and Black Rock Razors) for the Gullane Point fast track production area for the period between 01/01/2008 to the 10/08/2013 were extracted from the FSAS database in August 2013 and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data. 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.

Two samples from Gullane Point Fast Track were recorded as rejected and have been omitted from the anaysis. All seven samples assigned to Aberlady 2 plotted on land 13 km south of the production area and were therefore omitted. Two samples from Gullane Point Fast Track site were also omitted from analysis, with one sample plotting >20 km south, on land of production area, and the other plotting within the bed of West Peffer Burn at the head of Aberlady Bay. The remaining 31 samples from six sites were analysed within 48 hours of collection. Six samples had *E. coli* results of <20 *E. coli* MPN/ 100 g.

11.2 Summary of microbiological results

Historical results are summarised by fast track area in Table 11.1 below.

Table 11.1 Historical fast track sampling and results at Gullane Point

Sampling Summary							
Production area	Gullane Bay		Gullane Sands		Gullane	Gullane Point Fast Track	Gullane Point
Site	Gullane Bay razors	Gullane Bay razors 2	Aberlady razors	Aberlady razors 3	Black Rock razors	Gullane Point Fast Track	Gullane Annual
Species	Razor clams						
SIN	EL-434-839-16	EL-434-943-16	EL-433-838-16	EL-433-942-16	FF-518-913-16	FF-555-1021-16	FF-601-1087-16
Location	Various	Various	Various	Various	Various	Various	Various
Total no of samples	3	4	2	5	5	7	5
No. 2008	3	-	2	-	-	-	-
No. 2009	-	3	-	4	-	-	-
No. 2010	-	1	-	1	5	-	-
No. 2011	-	-	-	-	-	4	-
No. 2012	-	-	-	-	-	-	5
No. 2013	-	-	-	-	-	3	-
Results Summary							
Minimum	40	20	<20	20	170	<20	<20
Maximum	220	790	<20	790	16000	3500	80
Median	90	280	<20	130	330	110	20
No. exceeding 230/100g	0	2	0	2	3	2	0
No. exceeding 1000/100g	0	0	0	0	2	1	0
No. exceeding 4600/100g	0	0	0	0	1	0	0
No. exceeding 18000/100g	0	0	0	0	0	0	0

Fast track sampling at Gullane has been carried out every year since 2008. The highest result was occurred in 2010 and was associated with the Black Rocks Razors fast track classification.

11.3 Overall geographical pattern of results

Sampling results are shown thematically mapped in Figure 11.1. Three samples from Gullane Annual were unverified and without national grid references (NGRs) and therefore are not shown on the map. Three samples from Gullane Point Fast Track were unverified but had associated NGRs and are included in Figure 11.1. Four samples shown on the map plotted outwith the boundary of the fast track production area. Of these, sample CEFAS_13/973 plotted near the head of Aberlady Bay. Although identified to the nearest 1 m, the location lies within 100 m of MHWS, within the channel of West Peffer Burn, and over 2km east of the fast track production area. As this location is likely to experience significantly reduced salinity, and the species of razor clam normally harvested in the UK (*Ensis ensis*, *Ensis siliqua* and *Ensis arcuatus*) are not thought to tolerate low salinities, the result has not been included in further analysis.

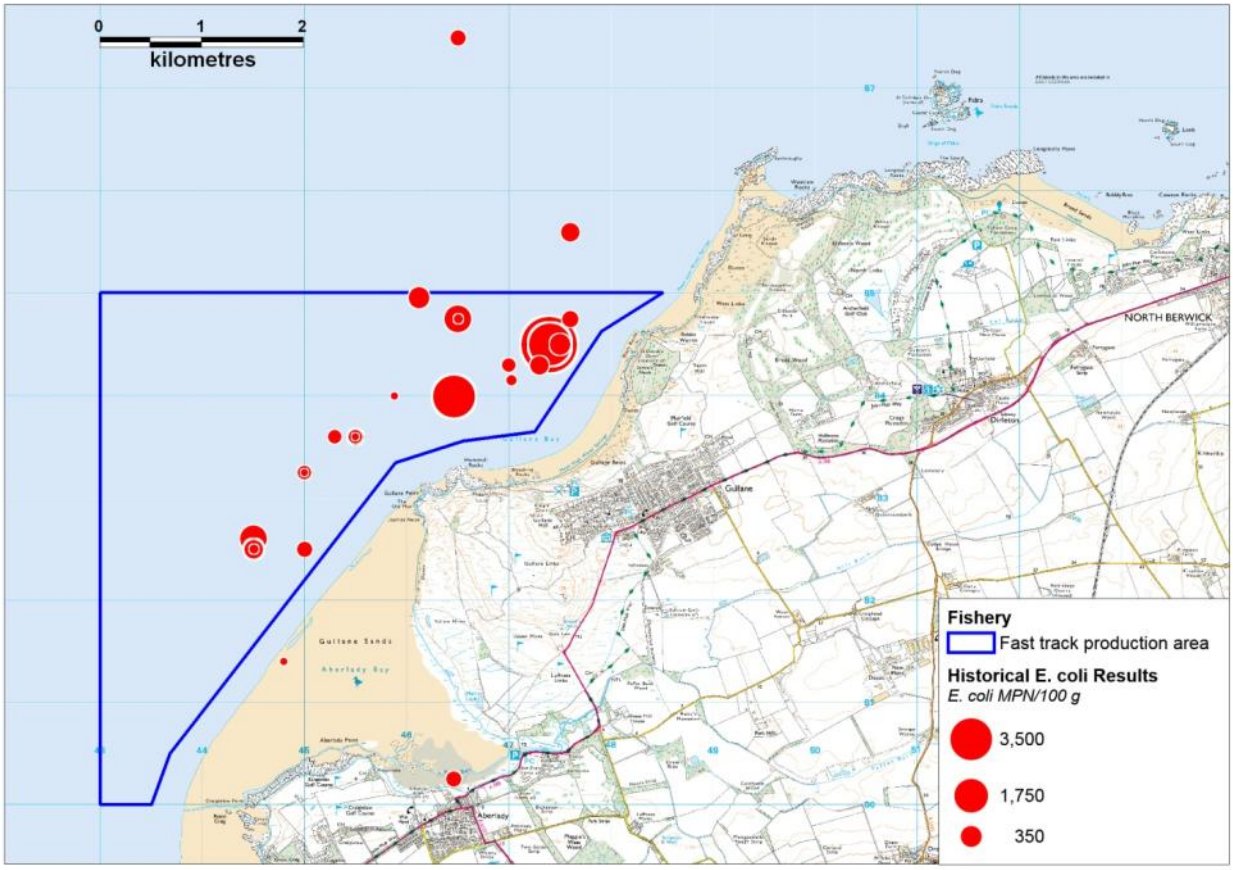


Figure 11.1 Map of Gullane Point razor clam sampling results

Higher results predominantly came from the northeast of the fast track production area, with the highest result of 16000 *E. coli* MPN/ 100 g taken near the NE extent of the production area. No samples have been taken from the southern or western extents of the production area.

11.4 Overall temporal pattern of results

Due to the low number of results recorded for each fast track application, data from each site have been combined to form one dataset for subsequent analysis. As sampling was 'lumpy', both temporally and geographically, subsequent environmental assessments have not been conducted. A scatterplot of razor clam *E. coli* results against date is presented in Figure 11.2. Jittering of data points was applied at 0.01 (x axis) and 0.001 (y axis) respectively.

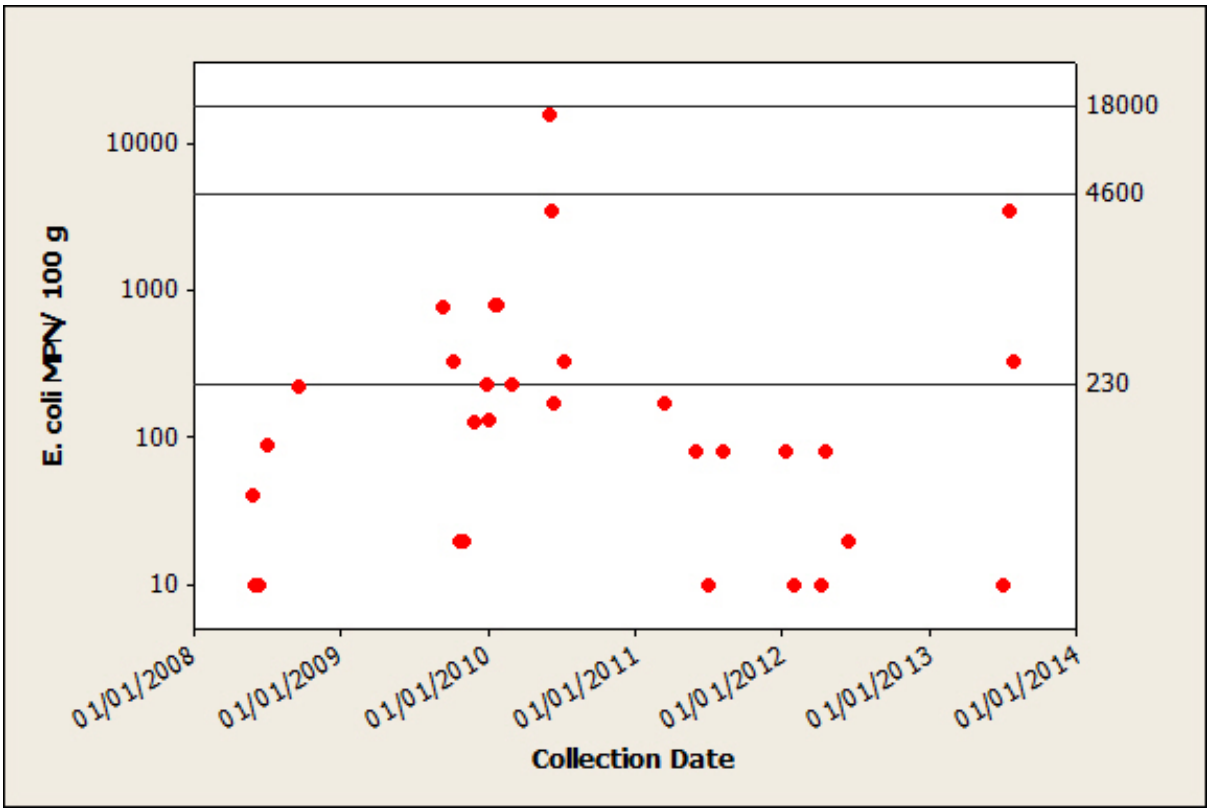


Figure 11.2 Scatterplot of razor clam *E. coli* results by date

11.5 Evaluation of results over >1000 *E. coli* MPN/ 100 g

Razor clam sampling results exceeding 1000 *E. coli* MPN/ 100 g are listed in Table 11.2.

Table 11.2 Gullane Point razor clam historical *E. coli* results >1000 *E. coli* MPN/100 g

Site	Collection Date	*E. coli* (MPN/100g)	Location
Black Rocks Razors	03/05/2010	16000	NT 4740 8450
Black Rocks Razors	10/05/2010	3500	NT 4740 8450
Gullane Point Fast Track	23/07/2013	3500	NT 4646 8399 *

* Sample location unverified

Two high results were both attributed to the same NGR at the northern end of the fishery, one week apart. The third, from July 2013, was reported from a location approximately 1 km SW of the other two.

11.6 Summary and conclusions

Due to the intermittent nature of the fast track sampling regime, and the variation in fast track area over time, it was not possible to undertake a detailed analysis of historical monitoring results from this area. Although most results were low, 3 of 31 results exceeded 1000 *E. coli* MPN/100 g, suggesting that the area is periodically subject to significant levels of faecal contamination. However, two of these results were reported against the same location (to 10 metre accuracy) and related to roughly the same period in time and therefore may reflect a single, extended contamination event.

12. Designated Waters Data

Shellfish Growing Waters

The razor clam fishery at Gullane Point does not lie within a designated shellfish growing water.

Bathing Waters

Gullane Bay is a designated EU bathing water. The designated bathing water extends along the beach west of Gullane, from Hummell Rocks to Black Rocks. It was originally designated in 1987 (SEPA, 2010). The monitoring point is situated at the centre of the intertidal sands at Gullane Bay (i.e. northwest of Gullane Point). The compliance history since 2007 is shown in Table 12.1. Compliance in these years has been assessed against the stricter EU bathing waters directive (Directive 2006/7/EC), with CG signifying compliance with the guideline standards (95%-ile value of <100 faecal coliforms per 100 ml over 4 years monitoring data). The bathing water profile produced by SEPA identified that there are no significant sources of faecal contamination to the bathing waters.

Table 12.1. Compliance history at Gullane designated bathing water

Year	2007	2008	2009	2010	2011	2012
Compliance	CG[1]	CG	CG	CG	CG	NF[2]

Notes: [1]Compliant with both mandatory and guideline values
[2]Insufficiently sampled

13. Bathymetry and Hydrodynamics

13.1 Introduction

13.1.1 The Study Area

Gullane Point is a headland situated on the southern shore of the Firth of Forth in East Lothian on the east coast of Scotland. Gullane Point is located approximately 20 km east of the City of Edinburgh. There are two main settlements near Gullane Point which are of a relatively small size. Gullane town lies to the northeast with Aberlady to the southwest. The shoreline surrounding the area is sandy and shallow containing extensive intertidal sand flats at Gullane Sands which is contained within Aberlady Bay. The extent of the study area is shown in Figure 13.1.

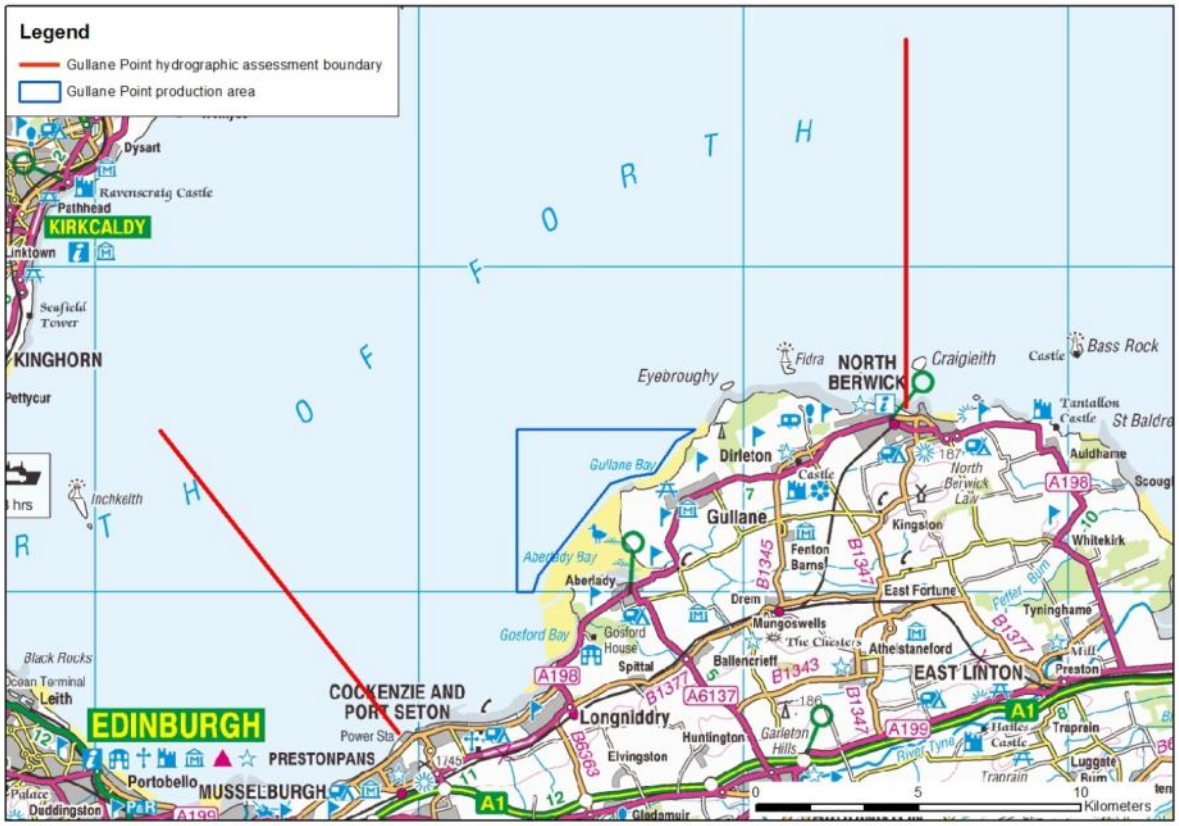


Figure 13.1 Extent of hydrographic study area

Coordinates for middle of hydrographic assessment area for Gullane Point:

56° 5.68’ N 002° 53.71’ W

NT 44400 89477

13.2 Bathymetry and Hydrodynamics

13.2.1 Bathymetry

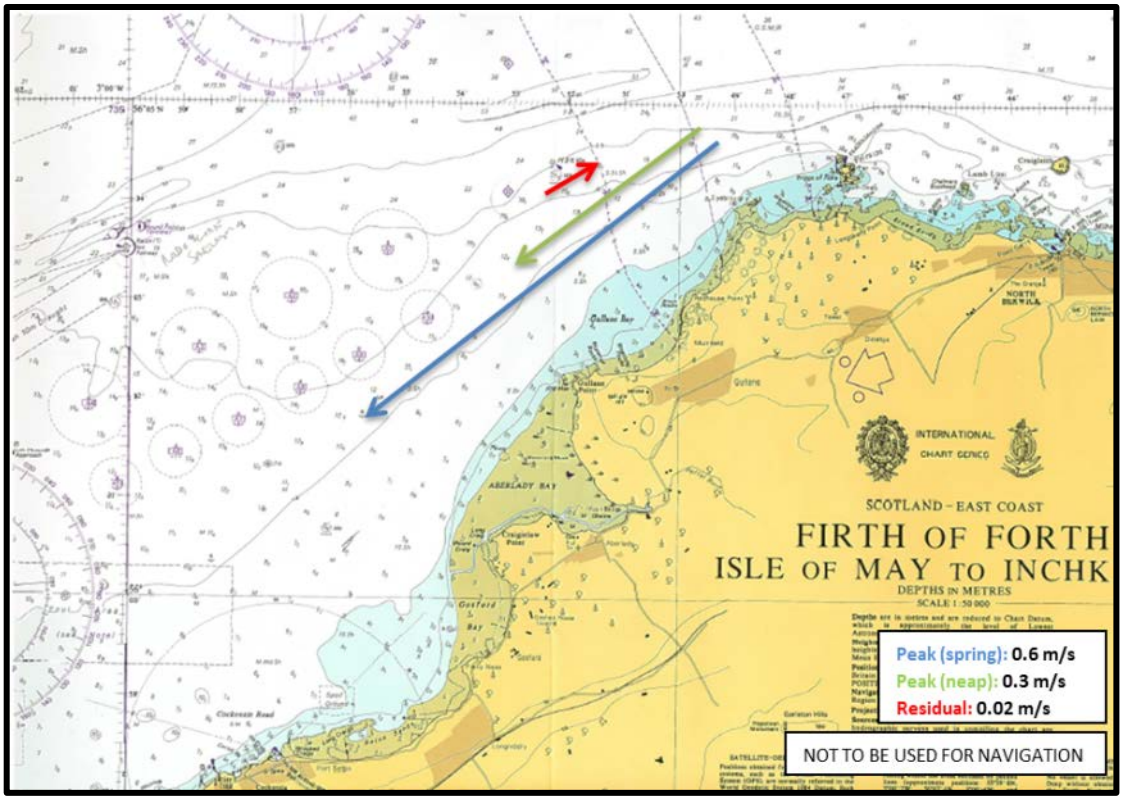


Figure 13.2 Admiralty chart (734) extract for Gullane Bay. Note that the length of the peak flow arrows approximately equate with the transport distance during the flood or ebb phases of the tide.

The Forth (the Estuary and Firth) as a whole has a length of approximately 100 km extending westwards from the North Sea and eventually narrows to a width of around 2.5 km at the far point of the estuary at Stirling (Neill & Elliott, 2004). The Forth is about 50 km in length, roughly vee-shaped and extends from the Queensferry rail and road bridges in the west towards to the Isle of May in the east until it ends at the opening to the North Sea.

Figure 13.2 shows the bathymetry of the Forth around the study area. The main entrance of the Firth of Forth faces NE, around 30 km wide (Balls & Topping, 1987) and connects directly to the North Sea. The exchange between the two areas is free with only the Isle of May being a relatively insignificant obstacle. There are several small islands dotted around the southern shore of the Firth near North Berwick including Bass Rock, Craigleith, Lamb Island and Fidra. Within the assessment boundary, depths are typically around 25 - 45 m with a maximum depth charted as 59 m approximately 4 km north of Fidra. There are extensive sand flats around the southern shores of the Firth especially at Aberlady Bay and Gosford Bay. The shoreline around the study area is a generally

fairly gentle gradient from inland to offshore areas with the exception of a few sites around North Berwick.

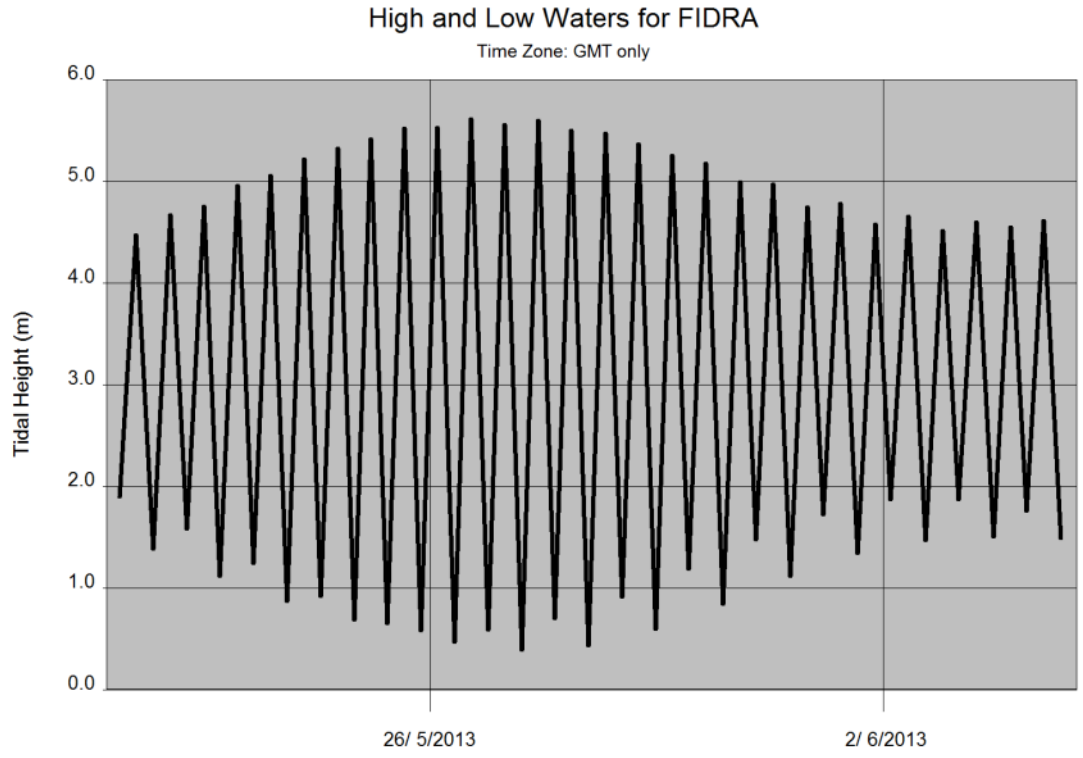
Within the study area the 10 m contour runs from between 1.5 km offshore at the east of the site and gradually increasing to 4 km at Gosford Bay towards the west of the study area.

13.2.2 Tides

The study area, in the outer Firth, has the typical semi-diurnal tidal characteristic. Data on tidal information is given from charted information.

Within the Forth Estuary the tides are more complex with a double high and double low water effect (Elliot & Clarke, 1998). The prevailing flows are predominantly tidal and the input of freshwater has a comparatively low influence on the overall flow characteristics. The bathymetry within the estuary causes stronger flood tides to the north of the estuary and stronger ebb currents towards the south.

Standard tidal data for the nearest area to Gullane Point is Fidra and these are given below. The spring/neap cycle of tidal height around the time of the survey (28th May 2013) is shown in Figure 13.3 (N.B. Although Cockenzie is closer to Gullane Point, Fidra is used due to there being no low water data for Cockenzie):



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

Figure 13.3 Two week tidal curve for Fidra

Tidal Heights (from Admiralty Chart 734) for Fidra:

Mean High Water Springs = 5.4 m
Mean Low Water Springs = 0.8 m
Mean High Water Neaps = 4.2 m
Mean Low Water Neaps = 2.0 m

Tidal Ranges averaged:

Mean Spring Range = 4.6 m
Mean Neap Range = 2.2 m

13.2.3 Tidal Streams/Currents

Meaningful current data to determine long term mean flows are difficult to obtain in this area because (i) the currents are relatively small, (ii) long instrument deployments are difficult due to the operational challenges associated with an area having significant shipping movements and (iii) the size of the Firth of Forth makes it costly to cover the area (Dyke, 1987). No consistent information exists on time-dependent circulation.

For the Firth of Forth as a whole, the maximum tidal currents recorded are 0.5 m/s with residual and wind-induced currents at the surface reaching around 0.05 m/s or less (Elliot & Clarke, 1998) with residuals probably less than 1 cm/s (Dyke, 1987).

There is a tidal diamond opposite Gullane Bay, approximately 4 km offshore from which the following statements are derived. However it should be remembered that data at tidal diamonds may only be relatively crude indications of flow characteristics derived from short current records (e.g. Bell and Carlin, 1998).

The flow is aligned parallel to the coast in the directions of 060°/240°. The flood tide flows generally southwest (SW) and the ebb flows northeast (NE). The tidal flow is typically rectilinear (back and forth) rather than elliptical suggesting it is constrained by the coastline. The maximum rates are 1.1 knots (0.6 m/s) at Springs and 0.6 knots (0.3 m/s) at Neaps, shown in Figure 13.2. There will be variations to these values across the assessment area in the vicinity of bays and headlands.

A residual flow in the study area has been estimated using the tidal diamond data. The tidal diamond provides a drift rate and direction for each hour of the tide. By summing the vectors for both spring flow and neap flow it is possible to calculate the residual flow, or net flow, over a tidal cycle. At neaps the residual flow is negligible (probably less than 300 m of net transport to the NE), at springs the residual flow amounts to a displacement of 1 km to the NE over the tidal cycle giving a residual current speed of approximately 0.02 m/s.

Further information on the circulation in the study area was extracted from published literature. The general circulation of coastal flow in the outer Firth is described by Dyke (1987) which shows a residual outflow along the southern shore and a residual inflow

along the central axis. This illustrates the classical concept of circulation in the Firth of Forth with landward net motion in the north side and seaward net motion on the south side (Lindsay, et al., 1996). Wind is the main driver of surface currents in the Firth of Forth but sub-surface and near-bed currents are less affected by this (Dyke, 1987). These interpretations are borne out by the tidal diamond analysis.

13.2.4 River/Freshwater Inflow

The Forth sits within a 4655 km^3 drainage basin (Elliot & Clarke, 1998). Whilst quantitative data for this specific study area are sparse, the mean annual rainfall for the estuary as a whole is roughly 700 mm (Lindsay, et al., 1996). The significant river discharges into the estuary are the Forth and Teith rivers which combine to give an input of 5.4 x 10^6 m^3/day and also the waters of Leith with an input of 2.2 x 10^6 m^3/day (Balls and Topping, 1987).

Even within the estuary, tidal movement is reported to dominate the flow, with freshwater influence being a relatively small component, reported to be 0.33% of the tidal flux at springs and 1.65% at neaps (Jacobs Arup on behalf of Transport Scotland, 2009). Freshwater discharge is not considered to have a significant impact on the hydrodynamics.

The outer Firth salinity is considered to be fully marine (Augley *et al*, 2007) and virtually homogeneous (Dyke, 1987) with characteristic salinity values around 34 psu compared to the inner Firth which is typically 30 – 33 psu. Any freshwater outflow will tend to follow the south shore for most of the year giving slightly lower salinity values (~0.5) than the north (Jacobs Arup on behalf of Transport Scotland, 2009; Balls & Topping, 1987)

The relatively low fresh water influence in the Firth of Forth, and the strongly marine nature of the water means that it is more like a coastal embayment than an estuary. A defined fresher surface layer can be present intermittently, usually in February and March when river flow is usually at its strongest (Dyke, 1987). However, the exposed nature of the site and minimal freshwater influence will generally give a well-mixed water column.

On a smaller scale, there is only one freshwater input into the specific assessment area which is from West Peffer Burn in Luffness and it enters the Firth of Forth from Aberlady Bay. This burn has a mean flow of 0.14 m^3/s (Jacobs Arup on behalf of Transport Scotland, 2009)

13.2.5 Meteorology

The Firth of Forth is a topographic embayment that faces towards the east. This east-facing aspect means that the area experiences a change of climatic variables along the west-east axis and also a variation in the orientation of principal weather systems and airflows between the adjoining hills and open water surface. This leads to different climatic conditions in both the estuary and the firth (Harrison, 1987).

Rainfall data for Belliston, roughly 19 km north of the fishery in the study area, are available for the period between January 2007 and August 2012. The year that had the most rainfall was 2011 and the least rainfall occurred in 2007.

There was variation in the amount of daily rainfall from year to year but a maximum of 60 mm/d occurred in 2009 and generally high rainfall values (>30 mm/d) were seen in all years. The highest daily rainfall values occurred throughout the summer and winter seasons where rainfall increased from June to August and November to February. The driest weather occurred from March to May. Rainfall levels of above 30 mm/d were common in all months with the exception of the winter months, i.e. December, January and February. For the duration of the data set, daily rainfall of below 1 mm occurred 62% of the time and daily rainfall of above 10 mm occurred 6% of the time.

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

There is predominantly (over 50%) western airflow in the winter (Harrison, 1987) and corresponding summer data show not only a predominant westerly airflow but also north-easterly and easterly airflows (over 35%), explained by the proximity of the North Sea and the development of sea breezes (Lindsay, et al., 1996).

Data about wind conditions were collected from Gogarbank in Edinburgh which is situated 37 km west south west of Gullane and spanned a time frame from January 2002 to December 2011. The main overall annual wind direction in this area is WSW and travels along the axis of the firth. During the summer months, wind from the ENE was also present. The strength of winds was greater in the winter months compared to the summer months but there was little variation in dominant directions throughout the year.

Older data from the period 1971 to 1980 in the Turnhouse area (4 km inland) states that, in winter, for 75% of the time wind directions were west, southwest and east. In the summer, there was principally western airflows over 50% of the time but also present were northeasterly and easterly flows over 35% of the time which are thought to originate from the development of sea-breezes over the coast of the North Sea (Harrison, 1987).

13.2.6 Model Assessment

Due to the paucity of data for this location and the unconstrained nature of the study area, it was not considered appropriate to set up a box model run for the outer Firth.

An extensive modelling study was conducted for the Forth (Jacobs Arup on behalf of Transport Scotland, 2009), but the model domain was concentrated on the inner Firth and the Estuary. The study area for this assessment was not included within the model. However, some elements of the model have been used to establish some of the broad characteristics of the Firth of Forth and are reported above.

13.3 Hydrographic Assessment

13.3.1 Surface flow

The site and the information from the literature indicate that freshwater is likely to be rather minimal in its impact. Indeed, the outer Firth of Forth can be viewed as having more marine characteristics than that of an estuary because the hydrography is more greatly influenced by the North Sea rather than freshwater discharge from the land. Although the greater influence of freshwater is found to the south and there is a small burn discharging into the study area, this is regarded as a rather weak and seasonal influence.

It is clear that flows in this site are tidally dominated and estuarine effects are minimal.

Maximum surface flow rates offshore are 0.6 m/s (springs) and 0.3 m/s (neaps) with likelihood of significant variation of speed in the vicinity of headlands. Corresponding transport over a tidal phase (ebb or flood) are estimated to be around 8 km (springs) and 4 km (neaps). The residual flow has been estimated to be up to 1 km to the NE during spring tides.

The dominance of the westerly winds is likely to enhance the residual flow to the NE and may even be the primary cause. The wind will also tend to enhance vertical mixing, though it has been reported that these waters are typically homogeneous which suggests effective vertical mixing conditions.

There are no direct measures of dispersion in the Firth, however, one might anticipate shear in the currents flowing along the shore, setting up a dispersive environment.

13.3.2 Exchange Properties

Due to the close proximity to the North Sea, and the dominance of the tidal flow, the outer Firth of Forth has a relatively short flushing time (Anderson & Read, 1974) of order a few days. It is expected that the study site will be a moderately-well flushed system throughout most of the year with surface contaminants being dispersed in the residual flow.

There are few current meter data series available for the Firth and there is a lack of long term hydrographic data coverage for this area, particularly data sets with seasonal resolution. However, the site is relatively simple and the records that do exist substantiate simple circulation schemes proposed in the literature. Therefore the confidence level of this assessment is MEDIUM.

14. Shoreline Survey Overview

The shoreline survey at Gullane Point was conducted between the 28th and 30th May 2013. Significant rainfall was noted during the 24 hours prior to survey. Little rain fell throughout the survey days, except for on the first day of surveying. Temperatures varied between 7.2-8^{o}C, with wind speed also varying between 3km/h (28th and 30th) to 13.5 km/h on the 29th May.

The fishery consists of wild razor clam beds which are harvested using scuba diving equipment. The fishery is new and not yet assigned, therefore limited information was available from the local authority sampling officer and the harvesters on the fishery. No samples were obtained during the survey, due to difficulties in contacting the harvester.

The shoreline survey team were unable to reach the end of the Gullane WWTW outfall, which lies >1 km offshore. Sanitary towels were seen washed up on the shoreline at the head of Aberlady Bay, suggesting recent CSO operation. An outfall to sea at Kilspindie golf club was observed to be discharging raw sewage onto the shore, and a sample taken from the outflow returned a result of 2.3 x 10^6 *E. coli* cfu/100 ml. A further outfall from the Green Craig Hotel was seen, and a sample taken from the effluent returned a result of 1.0 x 10^5 *E. coli* cfu/100 ml. Public toilets at a small car park near the footbridge over the West Peffer Burn at Aberlady Bay Nature Reserve were also noted, as well as those at the larger car park at Gullane Bents. However, no pipes or discharges were observed from these.

The area was reported to be popular with dog walkers and horse riders, and to have a large number of visitors in summer. One caravan park was found to the southeast of Aberlady village. No mooring sites or piers were observed during the survey. Leith port lies west of the survey area and a number of boats (containers ships, fishing boats and smaller speed boats/ribs) were noted at sea during the survey.

Water samples were taken from West Peffer Burn, which flows across the mudflats at low tide, and from a smaller tributary adjacent to it. The smaller tributary was not flowing, however. Both watercourses flow through areas of rough grassland with tall vegetation at their banks. The sample result from West Peffer Burn (1800 *E. coli* MPN/100) indicated moderate faecal contamination at the time of sampling.

No farms were observed in the area immediately adjacent to the shoreline.

Many birds were observed during the survey, including crows, gulls, mallard ducks and rafts of eider ducks were spotted on the shore and at sea. Aberlady Bay Local Nature Reserve had an area cordoned off with signage advising walkers to keep out of the nesting area. Four deer were also seen inland along the north side of Aberlady Bay.

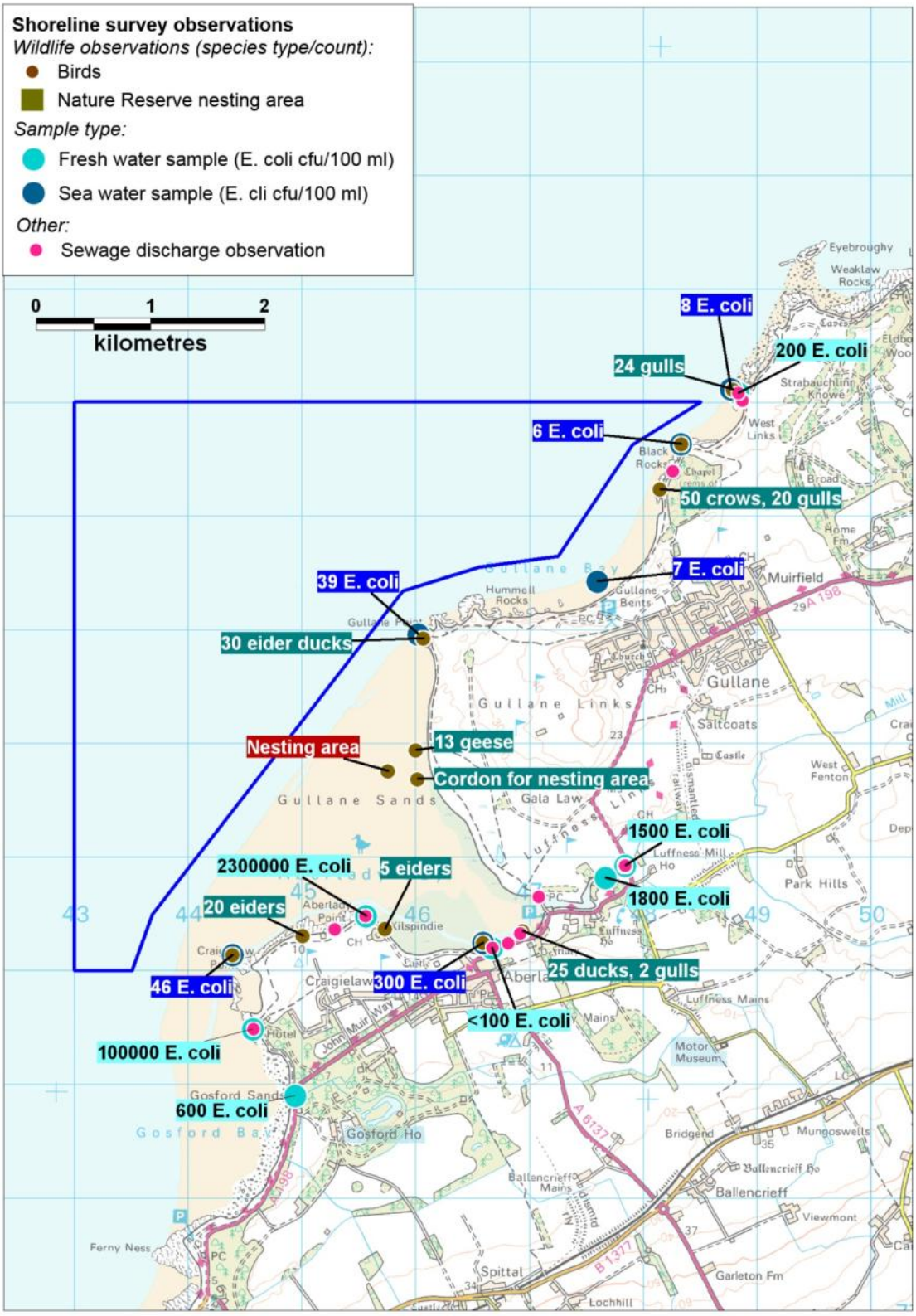


Figure 14.1 Map of shoreline survey observations at Gullane Point

15. Overall Assessment

Human sewage impacts

Gullane WWTW discharges primary treated sewage effluent off Gullane Sands, within the standard track application area boundary. An associated CSO discharges approximately 500 m SE of the main outfall, and is also within the production area boundary. Various CSOs and or EOs are situated around Gullane, the majority of which discharge to West Peffer Burn, which flows into the head of Aberlady Bay and along the south shore of the bay toward the southern extent of the production area. Further sewage discharges are located away from the application area.

West Peffer Burn also receives discharges of treated sewage (either secondary or septic tank) from a number of private properties and one private STW. Therefore this burn is likely to represent a significant pathway for the transport of sewage to the sea around the southeastern extent of the production area. A SEPA report noted West Peffer Burn as suffering from decreased flow due to agricultural extraction and therefore flows during dry weather may lead to higher sewage contamination levels due to poorer dilution during these times.

Two private septic discharges were observed discharging to sea during the shoreline survey. One of these, from the Kilspindie Golf Club, appeared to be malfunctioning and was discharging raw sewage onto the shoreline. This was located along the south shore of the mouth of Aberlady Bay, near the West Peffer Burn channel.

Continuous and intermittent discharges from Gullane WWTW are likely to impact water quality in the central southeastern part of the application area, however how this affects shellfish at the seabed will depend on the assessed movement of contaminants.

As the shellfish are subtidal, and sewage effluent would be buoyant in comparison to the surrounding seawater, impact on water quality may be higher at the surface than at the seabed near discharges. However, particulate matter fine enough to pass through 5-7mm screens would still be expected to eventually sink to the seabed where it could become resuspended by disturbance to the seabed, e.g. through storms.

Discharges from the CSO at the northern end of the fishery would be most likely to impact water quality in the near vicinity.

Agricultural impacts

Inland areas around the bay are largely agricultural, with the majority of land used for arable agriculture rather than animal production. West Peffer Burn was identified by SEPA as being significantly impacted by both agricultural source diffuse pollution and by water abstracting, resulting in poor water flow and bad ecological status of the burn. Although freshwater input to the fishery is low, this burn is the most significant

watercourse discharging to the fishery. The loading of faecal indicator bacteria from agricultural run-off to the burn is not known and will depend on the proportion of fields applying slurry or sludge as fertiliser as well as the number and location of livestock with access to the burn or its tributaries.

The more significant impact may be through the reduced flow in the burn, which would provide less dilution for septic tank and sewage discharges to the burn.

Overall, agricultural-source faecal contamination to the fishery is likely to be moderate particularly around Aberlady Bay and the mouth of West Peffer Burn at the southern end of the fishery.

Wildlife impacts

The area around Gullane Sands and Aberlady Bay host very large populations of seabirds, waterfowl and shore birds. The largest recorded populations are present around and just beyond the northeastern end of the application area. These are likely to contribute to background levels of faecal contamination, and may post a significant source when large numbers of birds deposit droppings on the intertidal sand and mud, which could be washed over the shellfish bed on the subsequent dropping tide.

Seasonal variation

Seasonal variation is expected in human population, with peak numbers present during the traditional summer holiday months of July and August, however due to its proximity to Edinburgh the area is likely to receive an influx of visitors through a much greater extent of the year.

Seasonal variation is also expected in bird populations, with large populations of waterfowl and waders present during autumn and winter throughout the area but particularly across the northern side of Aberlady Bay and extending northeastward beyond the application area. The bird population is likely to be lowest during the summer.

Rainfall appears to be higher in winter and summer and lower in spring and autumn. Although increases in run-off might be expected during the wetter months, extreme rainfall events during the drier months may have a disproportionate impact on water quality as contaminants will have built up on land during dry periods and therefore a first flush effect may be more pronounced. Reduced flows in West Peffer Burn would also be expected to reduce the amount of dilution available to discharges flowing into the burn during dry periods when extraction for agricultural use is highest.

Although CSOs would operate whenever extreme rainfall events caused high flows through the sewerage system, this might be expected to happen more frequently during

summer and winter when there is more rain generally. However, extreme rainfall events can occur in any month and therefore CSOs may operate at any time of year.

The historical monitoring results were not evenly spread over time, and therefore it was not possible to assess any seasonal variation in results.

Rivers and streams

There is relatively little freshwater inflow to the fishery area. The most significant watercourse is the West Peffer Burn, which receives septic tank effluent, treated sewage, combined sewer overflows and both urban and agricultural run-off. It discharges to the head of Aberlady Bay, following the southern shore of the bay at low tide.

At the time of shoreline survey, the burn was found to be carrying a relatively high *E. coli* loading and the flow was also high, presumably due to rainfall the day before. The water sample result of 1500 *E. coli*/100 ml suggested significant faecal contamination, though it is not possible to identify the relative contributions from point and diffuse sources within the catchment.

It is likely that contamination from this watercourse will contribute significantly to contamination levels along the southeastern side of Aberlady Sands.

Movement of contaminants

The hydrographical assessment in Section 13 identified that the bathymetry of the fishery is relatively shallow, particularly along the southern half. Maximum tidal flows off Gullane Bay were predicted to be 1.1 kts at spring tides, with flow moving back and forth along the axis of the firth as the tide ebbs and floods. Maximum transport over a tidal cycle would be expected to be up to 8 km during spring tides and 4 km during neap tides. Contaminants arising from the Gullane WWTW continuous discharge may be expected to impact well beyond the location of the outfall.

There is a residual flow toward the NE along the south side of the Firth of Forth, and therefore there may be a tendency for overall movement toward the NE over multiple tidal cycles. Westerly winds will tend to enhance this flow to the NE. As effective vertical mixing is predicted, contaminants will most likely be well mixed throughout the water column and therefore available for uptake by bivalves at the seabed.

Temporal and geographical patterns of sampling results

Sampling patterns were not consistent over time or location, resulting in a ‘lumpy’ distribution that made it difficult to identify any trends. Historical sampling results did show that the area is subject to periodically high levels of faecal contamination, with two of the highest results falling within a two-week period. The highest overall results came from the northeast end of the fishery. However, it is not clear whether this reflects a

single pollution event or whether results would have been more or less contaminated at other locations within the overall fishery area at the same time.

Results from samples taken near the sewage outfall were not particularly high (ranging from 20 to 790 *E. coli* MPN/100 g). Given that the residual flow of water in the area is northeastward, it is possible that the sewage effluent is carried in that direction as it rises toward the surface. Smaller particulate matter, to which bacteria such as *E. coli* may be attached, may therefore sink back to the seabed some distance from the outfall.

No samples were reported from the southern end of the production area, nearer the channel of West Peffer Burn. One result was reported from within the burn, near MHWS. It is not clear whether the reported location was accurate, as it is not a typical location for this bivalve species.

Conclusions

Overall, the razor clam fishery at Gullane is potentially subject to different contamination sources at its northern and southern extents. The northern end of the fishery is likely to be more heavily impacted by discharges from the Gullane WWPS and Gullane WWTW, and seabird and shorebird droppings from the nearby nesting areas. The southern end of the fishery is more likely to be impacted by contamination carried via Peffer Burn and any sewage discharges from further up the estuary.

As no samples have been taken to date from the southern end of the fishery, it is not possible to assess whether the scale of contamination differs from that at the northern end of the fishery.

16. Recommendations

It is recommended that the production area be split in two, to be called Gullane North and Gullane South, due to the absence of information contamination levels in shellfish from the southern end of the fishery area and the presence of potentially significant contamination sources there. It is also recommended that a monitoring zone approach be applied at both production areas to allow sufficient scope for provision of monthly samples.

Gullane Point North

Production area

It is recommended that the boundaries be extended include the bed areas identified by the harvester as well as areas previously sampled that lay outwith, but reasonably close to, the fishery area identified in the standard track application.

The recommended boundary for the Gullane Point North production area is therefore the area bounded by lines drawn from NT 4900 8600 to NT 4300 8600 to NT 4300 8250 to NT 4500 8150 to NT 4614 8308 to NT 4652 8319 to NT 4706 8316 and back to NT 4900 8600. This area does not exclude the outfall points from Gullane WWTW, as it to do so would require impractical and potentially unenforceable boundaries.

RMZ

It is recommended that a monitoring zone be established that includes the area between the Gullane WWTW final effluent outfall and the Gullane WWPS CSO, where highest results have been occurred in historical monitoring. The recommended RMZ is the area bounded by lines drawn from NT 4756 8474 to NT 4641 8413 to NT 4641 8380 to NT 4756 8439 and back to NT 4756 8474.

Tolerance

Not applicable due to monitoring zone approach.

Frequency

Due to gaps in historical data and the potential for some seasonal variation in contamination sources, monthly sampling is recommended.

Gullane Point South

Production area

It is recommended that the boundaries be drawn include the southernmost bed area identified by the harvester.

The recommended boundary for the Gullane Point South production area is therefore the area bounded by lines drawn from NT 4500 8150 to NT 4300 8250 to NT 4200 8000 to NT 4400 8000 and back to NT 4500 8150.

RMZ

It is recommended that a monitoring zone be established that includes the southeastern part of the shellfish bed identified by the harvester, which lies nearest the sources identified along the southern end of Aberlady Bay. The recommended RMZ is the area bounded by lines drawn from NT 4372 8112 to NT 4345 8132 to NT 4323 8043 to NT 4350 8023 and back to NT 4372 8112.

Tolerance

Not applicable due to monitoring zone approach.

Frequency

Due to gaps in historical data and the potential for some seasonal variation in contamination sources, monthly sampling is recommended.

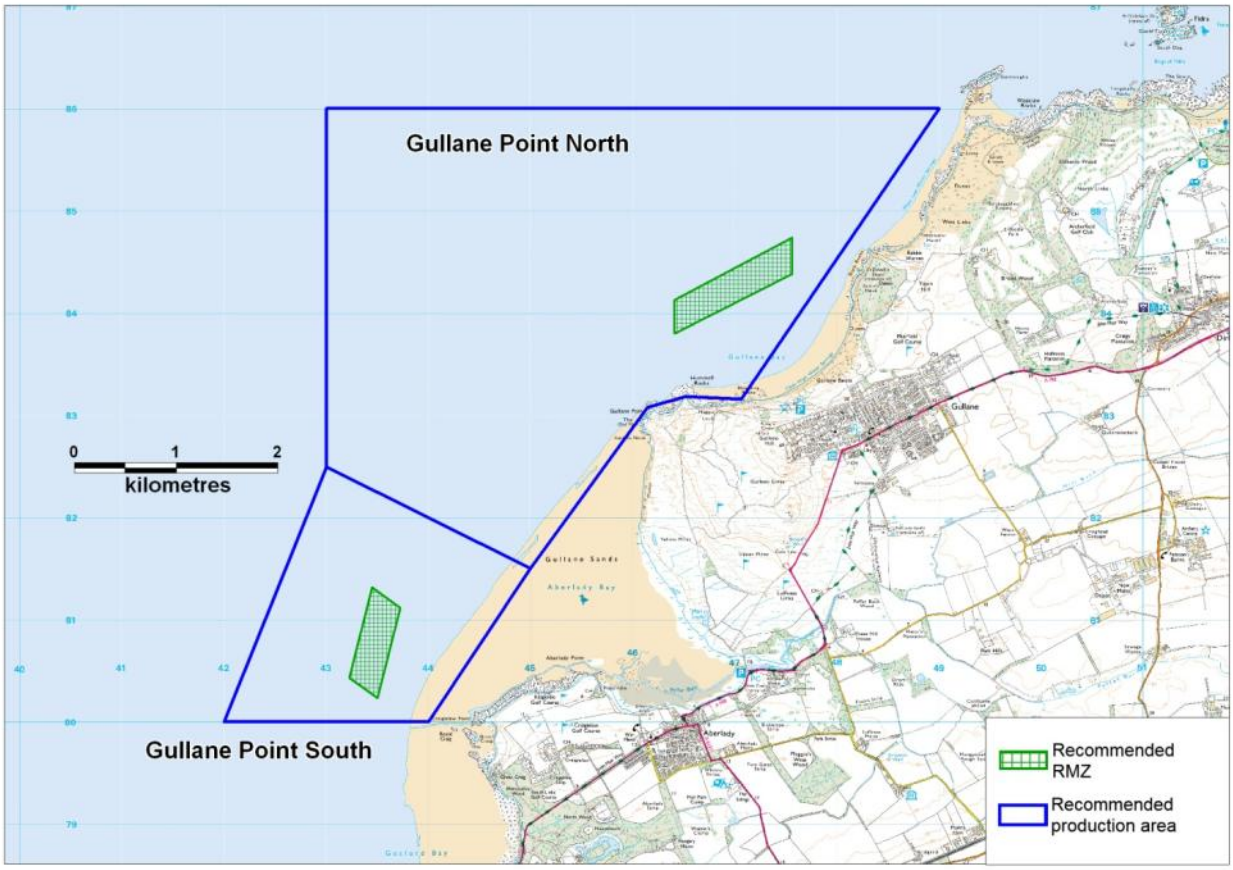


Figure 16.1 Map of recommendations at Gullane Sands

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18. List of Figures and Tables

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2. **Tables of Typical Faecal Bacteria Concentrations**
3. **Statistical Data**
4. **Hydrographic Section Glossary**
5. **Shoreline Survey Report**

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

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	1.7×10^{7} * (+)	1.4×10^{7}	2.0×10^{7}	282	2.8×10^{6} * (-)	2.3×10^{6}	3.2×10^{6}
Crude sewage discharges	252	1.7×10^{7} * (+)	1.4×10^{7}	2.0×10^{7}	79	3.5×10^{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	1.0×10^{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	3.3×10^{5} * (-)	2.9×10^{5}	3.7×10^{5}	184	5.0×10^{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	2.8×10^{5} * (-)	2.2×10^{5}	3.5×10^{5}	93	5.1×10^{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}		

comparing base- and high-flow GMs for each group and type.

Source: (Kay, et al., 2008)

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

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

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

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

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

Source: (Gauthier & Bedard, 1986)

References

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3. Statistical Data

Descriptive Statistics: E. coli MPN/ 100 g

```
Variable             N  N*  Mean  SE Mean  StDev  Minimum  Q1  Median   Q3
E. coli MPN/ 100 g  14   0  1484     1143   4276       10  18      80  255

Variable            Maximum
E. coli MPN/ 100 g    16000
```

One-way ANOVA: logec versus Season

```
Source  DF      SS     MS     F      P
Season   2   2.163  1.082  1.32  0.307
Error   11   9.039  0.822
Total   13  11.203

S = 0.9065   R-Sq = 19.31%   R-Sq(adj) = 4.64%


                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level  N    Mean   StDev  ---------+---------+---------+---------+
1      7  2.4495  1.0825                     (---------*--------)
2      5  1.7906  0.6326           (----------*-----------)
4      2  1.4515  0.6386  (----------------*-----------------)
                          ---------+---------+---------+---------+
                                 0.80      1.60      2.40      3.20

Pooled StDev = 0.9065


Grouping Information Using Tukey Method

Season  N    Mean  Grouping
1       7  2.4495  A
2       5  1.7906  A
4       2  1.4515  A

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 = 97.94%


Season = 1 subtracted from:

Season    Lower   Center   Upper     +---------+---------+---------+---------
2       -2.0926  -0.6589  0.7749           (---------*--------)
4       -2.9612  -0.9980  0.9653     (------------*------------)
                                    +---------+---------+---------+---------
                                  -3.0      -1.5       0.0       1.5


Season = 2 subtracted from:

Season    Lower   Center   Upper     +---------+---------+---------+---------
4       -2.3877  -0.3391  1.7096         (-------------*------------)
                                    +---------+---------+---------+---------
                                  -3.0      -1.5       0.0       1.5
```

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

Document Number	B0067_Shoreline 0012

Revision History

Revision	Changes	Date
A	Issue for internal review	17/06/2013
01	First issue to CEFAS	28/06/2013
02	Corrections as advised by CEFAS	07/08/2013

	Name & Position	Date
Author	Gail Twigg, Eilidh Cole	03/06/2013
Checked	Andrea Veszelovszki	15/07/2013
Approved	John Hausrath	07/08/2013

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

Shoreline Survey Report

Production area:	Gullane Point
Site name:	Gullane Annual
SIN:	FF-601-1087-16
Species:	Razor clam
Harvester:	Rab Maxwell
Local Authority:	Fife Council
Status:	New area
Date Surveyed:	27th-30th May 2013
Surveyed by:	Gail Twigg, Eilidh Cole
Existing RMP:	Not yet assigned
Area Surveyed:	Shoreline adjacent to West Links Golf Course, south towards Black Rocks, Hummell Rock and Gullane Point. Along Gullane Sands to Aberlady Bay, following the shoreline to finish where the John Muir Way meets Gosford Sands.

Weather

Significant rainfall 24 hours prior to survey. Constant, heavy rain on Monday 27th May, clearing up around 16.00 hrs.

Tuesday 28th May

At start of survey, cloud cover 98%; wind speed 3 km/h; temperature 7.2°C; very muggy; sea state calm. Slightly less cloud cover in afternoon with sunny periods. No rain apart for one 10 minute shower.

Wednesday 29th May

Cloud cover 100%; hazy out at sea; breezy, wind speed 13.5 km/h; temperature 8°C; could not see the sea as tide was too far out across extensive sand and mudflats. No rain.

Thursday 30th May

Cloud cover 98%; wind speed 3 km/h; temperature 7.4°C; very muggy; sea state calm.

Stakeholder engagement during the survey

Both the harvester and sampling officer were very helpful and cooperative during pre-survey arrangements. The sampling officer for the area, Mr Sandy Duncan, noted that he had not yet visited the fishery as it was newly established. Neither the sampling officer nor the harvester were available to attend site during the survey due to other commitments.

Fishery

The fishery in the area consists of wild razor clam beds which are collected using scuba diving equipment. Sampling locations would depend on where the harvester could collect sufficient samples/clams. The fishery is a new area and not yet assigned and therefore limited information was available from the local authority sampling officer. Mr Maxwell provided a hand drawn indication of the harvest areas for the razor clams (see Figure 1 below). During the survey very few razor shells were noted on the shore. Mr Maxwell also noted that there are scattered beds of mussels and a few small oyster beds in the area, but that these are of no commercial value or interest.

Shoreline Survey Plan – Gullane Point

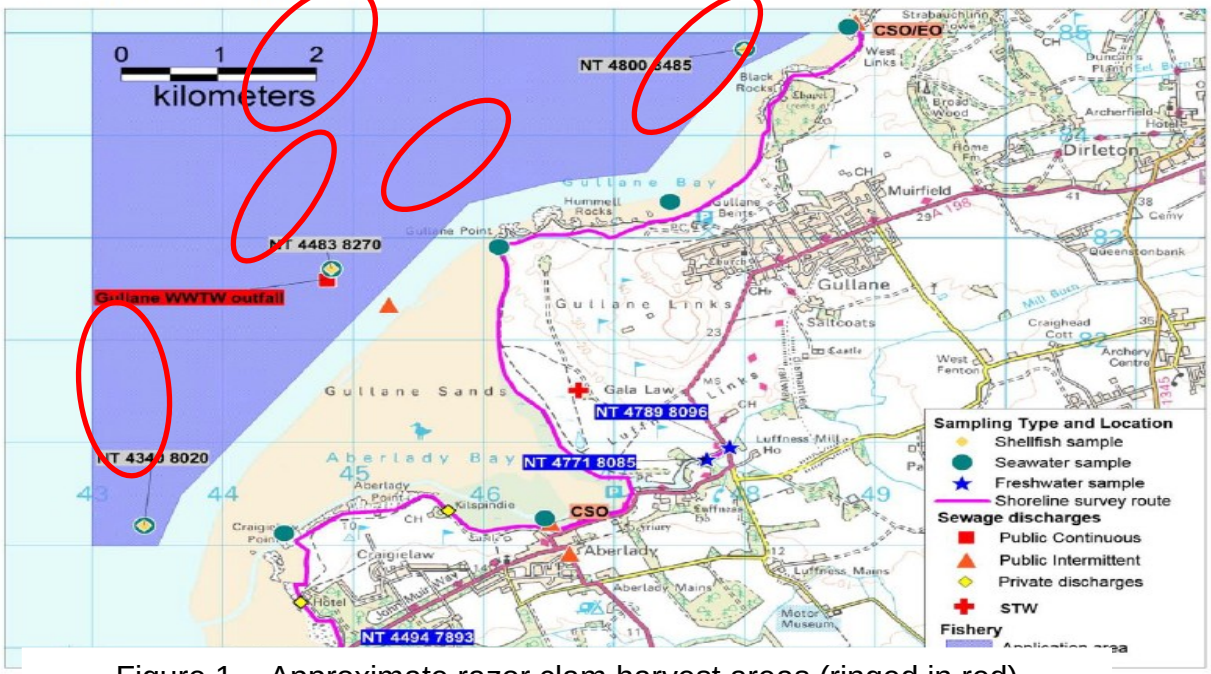

Figure 1 – Approximate razor clam harvest areas (ringed in red)

Sampling

Unfortunately we were unable to contact the harvester (Rab Maxwell) with regards to collecting samples prior to the survey. It was decided therefore to at least collect the proposed offshore seawater samples NT 4800 8485/NT 4483 8270/NT 4340 8020 and the WWTW outfall (NT 4540 8230) sample by alternate means. The boat 'Braveheart' out of North Berwick was chartered for sampling on Wednesday 29th May. Unfortunately the skipper, Dougie Ferguson, called this off at the last minute due to a forecasted 5m swells and he deemed the conditions unsafe for the rest of week.

In a further attempt to collect these offshore seawater samples, an additional sample was taken from the shore at high tide off the Black Rocks at the north east end of Gullane Bay (waypoint no. 42/43) as near to NT 4800 8485 as safety allowed. It was not possible to safely collect the other proposed seawater samples NT44838270 and NT43408020 due to very low tides and extensive mudflats which have very fast incoming tides.

Sewage Sources

Gullane Point is a headland on the southern shore of the Firth of Forth approximately 20 miles east of Edinburgh. Three relatively small villages lie close to the production area, Aberlady to the southwest, and Gullane and Dirleton to the northeast. There is public sewerage provision to the area. Private discharges to sea at Kilspindie Golf Club and Green Craig Hotel, Craigielaw were evident with raw sewage being discharged onto the shore. The main sewage outfall for the area, Gullane Waste Water Treatment Works (WWTW) outfall, lies over 1 km offshore. Unfortunately, due to weather conditions, no sample could be taken from outfall. There are public toilets at a small car park near the footbridge over the Peffer Burn at Aberlady Bay Nature Reserve and at the larger car park at Gullane Bents although no pipes or discharges were observed coming directly from these.

Seasonal Population

This part of East Lothian is very popular with visitors and locals for both day trips and extended holidays. Golfing is predominant in the area with many links courses and four of which were within the survey area alone. The John Muir Way, Aberlady Nature Reserve, the National Museum of Flight, Motor Museum and the Seabird Centre at North Berwick also attract visitors to the area. Gullane Bay is frequented with dog walkers and horse riders, both observed during the survey, and in the summer months is a very popular seaside destination.

There are no campsites or caravan parks in the immediate vicinity with the nearest caravan park 0.6 miles south east of Aberlady village. There are a number of B&B's and hotels in the small villages close to the production area however North Berwick which lies approximately 5 miles northeast has large numbers of B&B's, hotels and self-catering properties.

Boats/Shipping

There were no mooring sites or piers observed around Gullane Point during the survey. Leith port lies West of the survey area and a number of large ships were noted at the time of survey. These included large containers ships, fishing boats and smaller speed boats/ribs.

Farming and Land Use

No farms were observed in the area immediately adjacent to the shoreline. Further inland agriculture is the main land use.

Land Cover

Gullane Bay which sits at the northern end of the survey route consists of large sand flats and beach area with some rocky intertidal areas at the north and south of the bay. Behind this bay are dune systems, rough grassland, small plantations and large areas of links golf courses. Going southward past Gullane Point, Gullane Sands is a large bay with expansive mudflats exposed at low tide, incorporating Aberlady Bay Nature Reserve. The reserve covers an area of 582 hectares (1,439 acres), of which two-thirds falls below the high-tide mark and consists of bare sand and mudflats through to salt-marsh, dunes and dry grassland.

Watercourses

The Peffer Burn is the only major watercourse with a smaller water course joining it further downstream. Both these water courses flow through areas of rough grassland with tall vegetation at their banks. The Peffer Burn runs out across the mudflats at low tide.

Wildlife/Birds

Roe deer were spotted on several occasions. Many birds such as crows, gulls, mallard ducks and rafts of eider ducks were spotted on the shore and at sea. No seals were recorded on this survey.

Shoreline Survey Maps

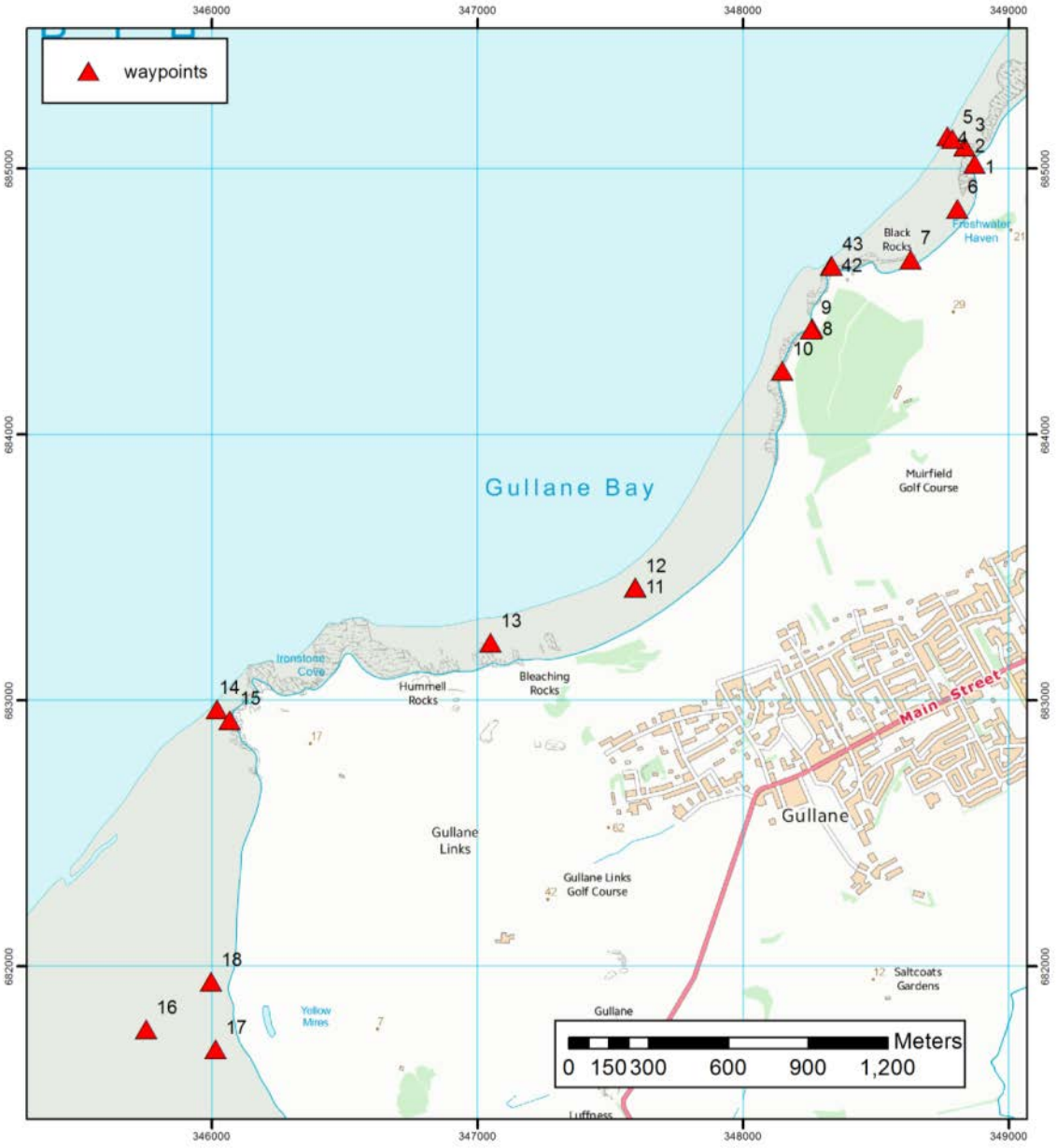

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Figure 2. Map of Gullane Point waypoints (upper section of survey route)

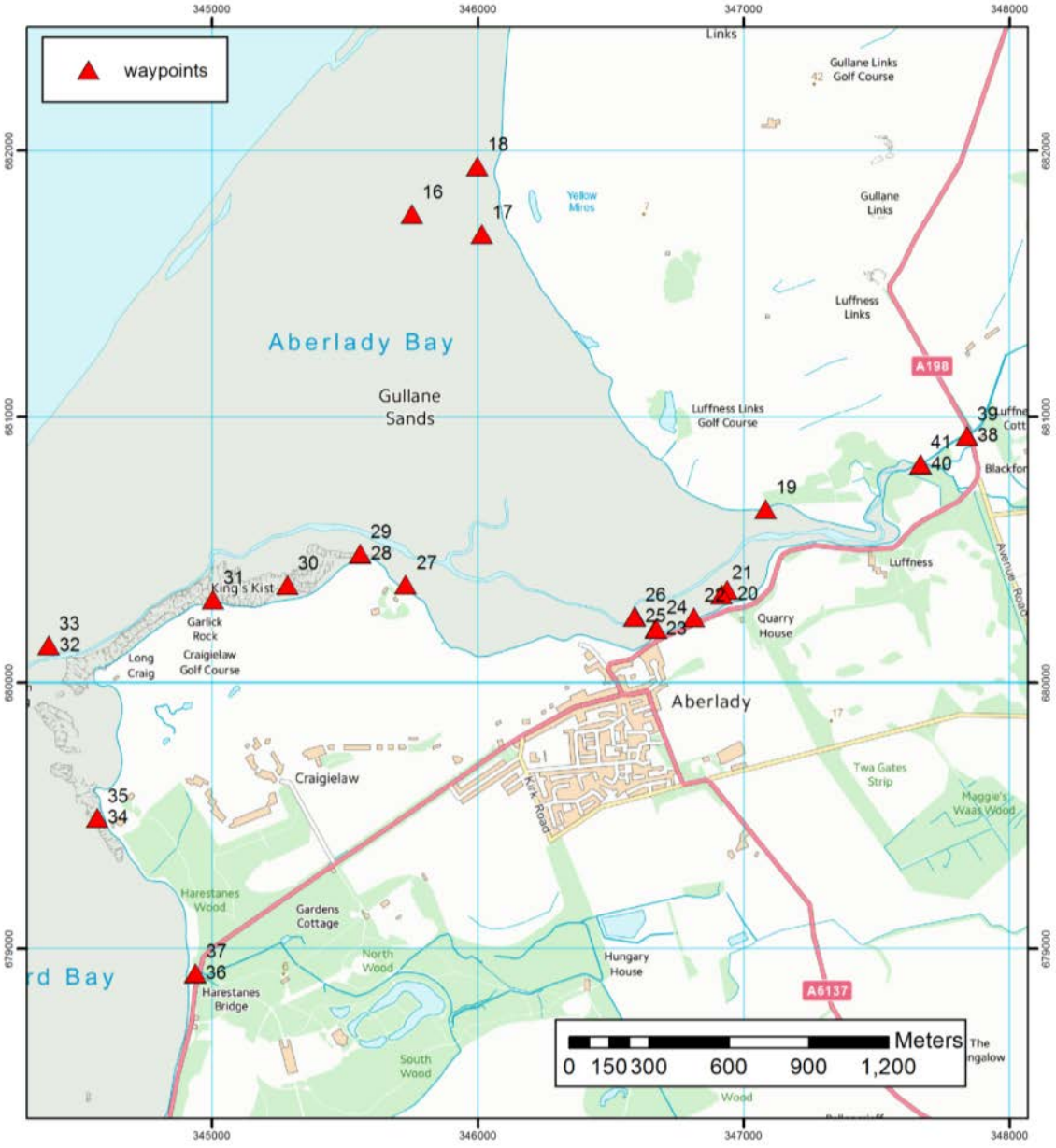

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Figure 3. Map of Gullane Point waypoints (lower section of survey route)

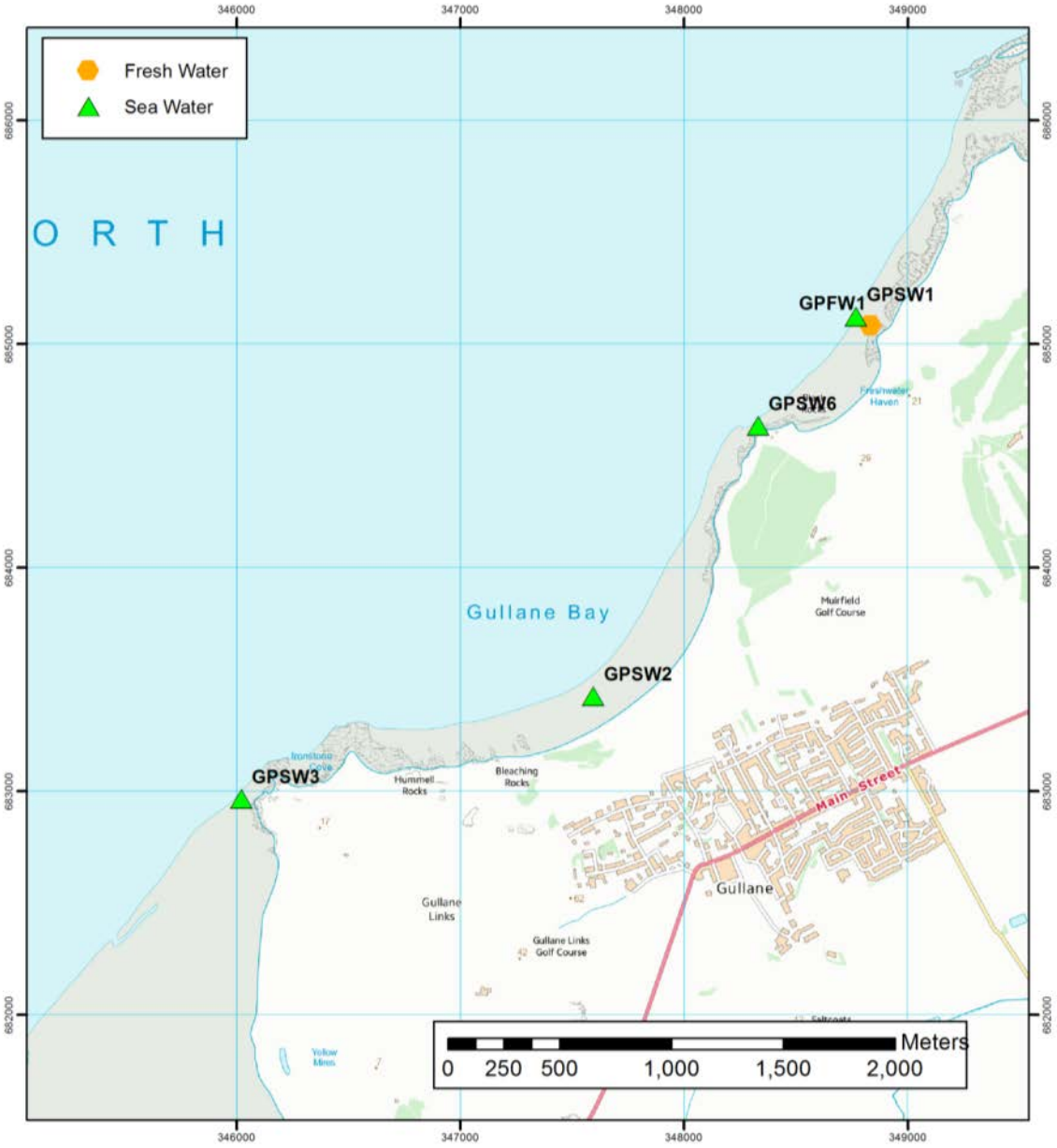

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Figure 4. Map of Gullane Point samples (upper section of survey route)

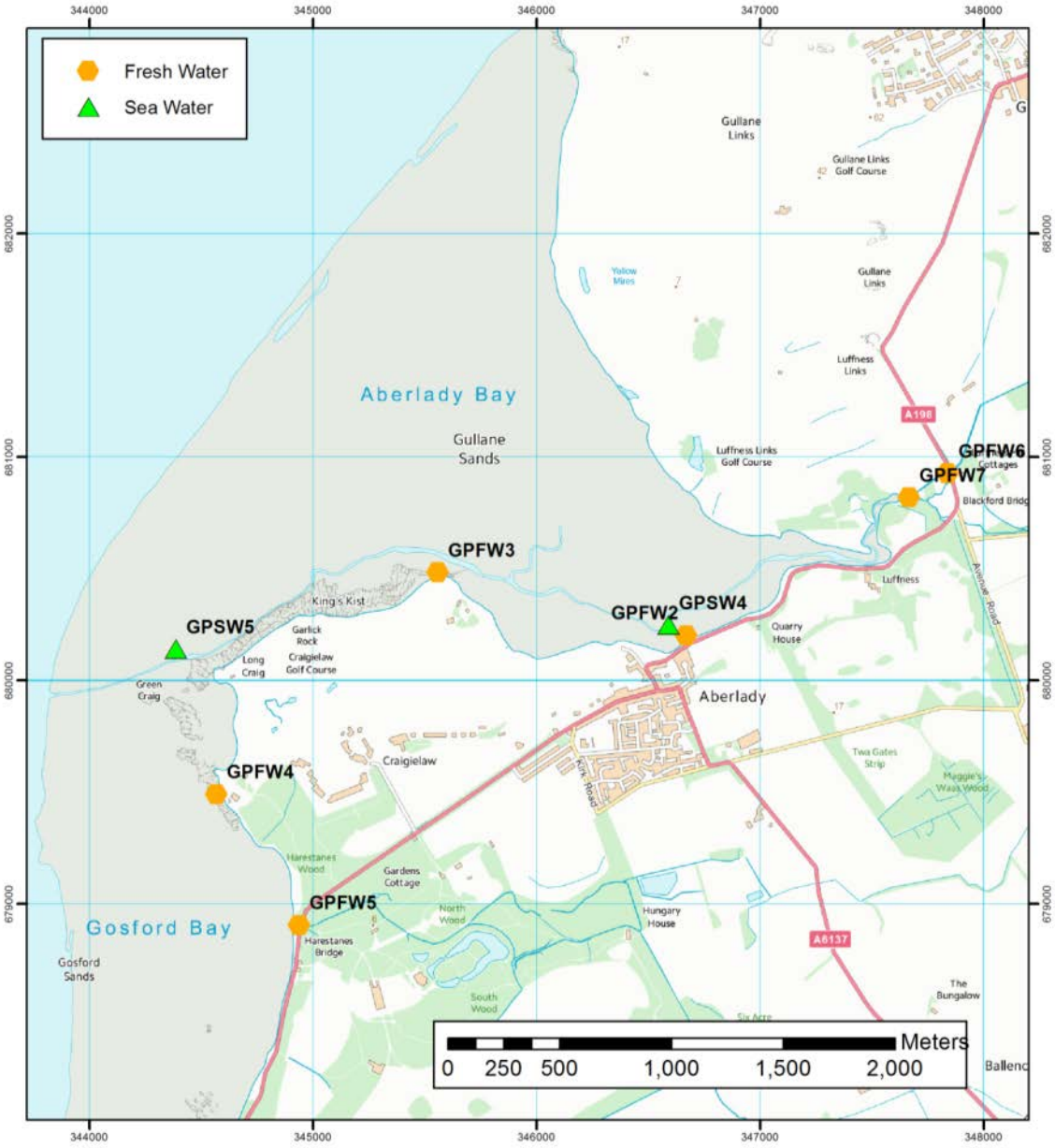

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Figure 5. Map of Gullane Point samples (lower section of survey route)

Table 1 Shoreline Observations

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
1	28/05/2013	10:10	NT 48873 85017	348873	685018	Fig 6		Start of survey northeast of Black Rocks on Gullane Bay. Rocky intertidal area with rough grass at top of the shore with golf links behind. Concrete pipe on shore with metal drain cover sitting above. No flow at time of survey but running water audible. Pipe Ø 38cm. Two carrion crows and 15 gulls on the shore.
2	28/05/2013	10:27	NT 48834 85083	348835	685083		GPFW1	Planned FW sample taken. Associated with waypoint 3.
3	28/05/2013	10:29	NT 48834 85082	348835	685083			Concrete double-headed outflow pipe running down the intertidal. Pipe Ø 10 cm; Depth 2cm; Flow 100 ml/s.
4	28/05/2013	10:37	NT 48770 85121	348771	685122	Fig 7	GPSW1	Planned SW sample taken. Associated with waypoint 5.
5	28/05/2013	10:38	NT 48788 85111	348789	685112	Fig 7		Sample taken down shore of waypoint 3 outflow pipe. 24 gulls noted on the sea.
6	28/05/2013	10:49	NT 48807 84849	348807	684849			Small boat noted at a distance out at sea, travelling fairly fast.
7	28/05/2013	10:57	NT 48631 84658	348631	684658			Mats of green algae on the shore. *Ulva Enteromorpha* species.
8	28/05/2013	11:10	NT 48261 84399	348261	684399			Metal pipe in rock situated at the top of the shore on the border between rough grass area and sandy beach. Pipe Ø 10 cm; Depth 1cm; Flow 1L per 7 sec. No sample taken.
9	28/05/2013	11:11	NT 48257 84394	348257	684395			Metal pipe in rock situated at the top of the shore on the border between rough grass area and sandy beach. Pipe Ø 10 cm; Depth 1cm; Flow 1L per 6 sec. No sample taken. Waypoint pipes 8 and 9 are situated approx. 5 metres apart. Above the rough grass is a small plantation area with golf links beyond.
10	28/05/2013	11:21	NT 48148 84238	348149	684239	Fig 8		Approximately 50 carrion crows and 20 gulls along the shoreline. Gullane Bay at this point in survey seems to be busy with beach activities, dog walkers, horse riding and people walking the coastal path.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
11	28/05/2013	11:47	NT 47595 83424	347596	683424		GPSW2	Planned SW sample taken. Associated with waypoint 12.
12	28/05/2013	11:47	NT 47595 83423	347595	683424			Sample taken down shore at low tide. Large area of sandy beach exposed. Extensive sand dunes and rough grassland (Gullane Bents) run parallel to the shore. Car park behind dunes. Approximately 40 houses sit on the hill above and behind the shore.
13	28/05/2013	12:01	NT 47049 83216	347050	683217			Two large pieces of broken concrete pipe partly buried in the sand.
14	28/05/2013	12:33	NT 46020 82964	346021	682965		GPSW3	Planned SW sample taken. Associated with waypoint 15.
15	28/05/2013	12:35	NT 46068 82924	346068	682925			Sample taken down shore of sandy beach. Rocky outcrop at east end of the shore marks the start of Gullane Sands incorporating Aberlady Bay. Thirty Eider ducks on the sea. Cormorant on rocks. Large boat in the distance.
16	28/05/2013	13:17	NT 45753 81761	345753	681761	Fig 9		Aberlady Bay Local Nature Reserve with notice asking walkers to 'Please Keep Out' of nesting area. This resulted in a detour from the proposed shoreline survey route. Two large boats in the distance.
17	28/05/2013	13:30	NT 46015 81686	346016	681687	Fig 10		At this point the shoreline associated with a wildlife reserve was cordoned off with an electric fence, therefore keeping the surveyors inland of the shore and away from the planned shoreline route. Behind the shore salt-marsh and sand dunes cover a large area. Two Lapwings and 6 Skylarks visible however many more birds could be heard in the rough grass. Members of the public are asked to keep to the main footpaths via notices and fences and this was adhered to by the survey team. Three roe deer in the distance. End of first survey day.
18	29/05/2013	9:50	NT 45998 81941	345999	681941	Fig 11		Start of second survey day. Four geese with 9 young spotted. Two Stonechats, male and female. Can also hear the chatter of

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
								many birds in the grass and tress surrounding the bay. The tide was very far out exposing a vast expanse of mud flats and soft sand.
19	29/05/2013	10:26	NT 47083 80651	347083	680652	Fig 12		Footbridge over the Peffer Burn, where Peffer Burn meets shoreline at Aberlady Bay. There were public toilets at a small car park near the footbridge over the Peffer Burn at Aberlady Bay Nature Reserve although no pipes or discharges were observed coming directly from these. Large boat out at sea.
20	29/05/2013	10:53	NT 46938 80348	346939	680349			Twenty five Mallard ducks on water channel on mudflats. Two gulls.
21	29/05/2013	10:55	NT 46917 80331	346918	680331			Two sanitary towels washed up on shore.
22	29/05/2013	10:58	NT 46813 80245	346813	680245			Large brick and concrete drain with metal cover.
23	29/05/2013	11:04	NT 46670 80202	346670	680203		GPFW2	Freshwater sample taken. Associated with waypoint 24.
24	29/05/2013	11:04	NT 46671 80201	346671	680201			Two concrete pipes side by side, covered by metal bars. One is flowing, one is backed up with no flow. Both coming from under road. Diameter - 43 cm; Depth - 3 cm; Flow - 30 ml / 4 sec. Diameter of non-flowing pipe - 36 cm.
25	29/05/2013	11:19	NT 46591 80248	346591	680249	Fig 13	GPSW4	Planned seawater sample. Associated with waypoint 26.
26	29/05/2013	11:19	NT 46590 80247	346591	680248	Fig 13		Seawater sample taken from where burn joins shore. Ship noted far out to sea. The tide was very far out exposing a wide expanse of mudflats/very soft sand. Two geese, five seagulls and two mallards on the mudflats. Lots of cockle shells and oyster shells.
27	29/05/2013	11:47	NT 45729 80368	345730	680369			Concrete cover with house behind. One hare and five eider ducks.
28	29/05/2013	11:54	NT 45559 80483	345559	680484	Fig 14	GPFW3	Freshwater sample - contaminated. Associated with waypoint 29.

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
29	29/05/2013	11:55	NT 45557 80484	345558	680485	Fig 14		Metal pipe with a storm flap flowing heavily. Extremely bad smell. Raw sewage coming out of pipe. Golf course behind. Diameter - 17 cm; Depth - 2 cm; Flow - 30 ml / sec.
30	29/05/2013	12:08	NT 45285 80367	345286	680368			Metal pipe. No flow. Diameter - 18 cm; Pipe running from golf course onto shore. Drainage pipe behind, no flow. Four swallows.
31	29/05/2013	12:16	NT 45004 80311	345004	680312	Fig 15		Twenty eiders on shore. Same boat behind out to sea which had stayed in the same place all day.
32	29/05/2013	12:36	NT 44387 80140	344388	680140		GPSW5	Planned seawater sample. Associated with waypoint 33.
33	29/05/2013	12:37	NT 44386 80139	344387	680140			Seawater sample at Craigielaw Point. Two seagulls and one oyster catcher.
34	29/05/2013	13:08	NT 44568 79491	344569	679491		GPFW4	Contaminated freshwater sample. Associated with waypoint 35
35	29/05/2013	13:09	NT 44569 79491	344570	679491			Freshwater sample. Very bad smell. 'Milky' looking outflow from metal pipe. One house on shore behind. Diameter - 12 cm; depth - 1 cm; Flow - 30ml/ 5 seconds. There was a sudden increase in flow speed for approximately 30 seconds but unfortunately this could not be measured as the survey team were heading away from the pipe at the time.
36	29/05/2013	13:34	NT 44938 78905	344939	678905	Fig 16	GPFW5	Planned freshwater sample. Associated with waypoint 37.
37	29/05/2013	13:34	NT 44939 78905	344939	678906	Fig 16		Freshwater sample from small river running under road at south end of survey plan. Width - 2 m; Depth 1 - 10 cm; Flow 1 - 0.248 m/s; SD 1 - 0.004. Depth 2 - 12 cm; Flow 2 - 0.518 m/s; SD 2 - 0.007.
38	29/05/2013	15:01	NT 47840 80926	347841	680927	Fig 17	GPFW6	Planned freshwater sample. Associated with waypoint 39.
39	29/05/2013	15:01	NT 47840 80927	347840	680927	Fig 17		Freshwater sample taken at Peffer Burn bridge next to road. Width - 2 m 55 cm. Depth 1 - 9 cm; Flow 1 - 0.820 m/s; SD 1 - 0.010. Depth 2 - 11 cm; Flow 2 - 0.774 m/s; SD 2 - 0.012. Three plastic pipes draining into Peffer Burn, sample was taken

No.	Date	Time	NGR	East	North	Associated photograph	Associated sample	Description
								downstream of these pipes. All pipes trickling. Diameters were 8 cm, 10 cm and 8 cm. One pheasant and one deer in field next to Peffer Burn. Three swallows flying.
40	29/05/2013	15:17	NT 47666 80819	347667	680819		GPFW7	Planned freshwater sample. Associated with waypoint 41.
41	29/05/2013	15:18	NT 47665 80820	347665	680821			Sample taken from where the smaller watercourse adjoins Peffer Burn. The banks of the river are too steep to access safely from both sides therefore only one measurement taken and an estimate of width. Est. width - 4 m; Depth - 69 cm; Flow - 0.012 m/s; SD - 0.005. The river at this point smelled stagnant and looked murky. Barely looks like it is flowing.
42	30/05/2013	10:14	NT 48332 84635	348333	684635	Fig 18	GPSW6	Seawater sample. Associated with waypoint 43.
43	30/05/2013	10:15	NT 48335 84633	348335	684634	Fig 18		Seawater sample taken as an extra sample from the shore at Black Rocks as boat access to this point was not possible. Two gulls on the sea.

Photographs referenced in the table can be found attached as Figures 6 – 18.

Sampling

Water samples were collected at sites marked on the map shown in Figures 4 and 5. Samples were transferred to Biotherm 10 boxes with ice packs and posted to Glasgow Scientific Services (GSS) for *E. coli* analysis. All samples were posted on the day of collection and all of them were received and analysed the following day. The sample temperatures on arrival to the laboratory ranged between 1.8 ˚C and 5.6 ˚C.

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

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

No shellfish samples were collected and no salinity profiles were taken during this survey due to unsafe weather conditions for boat use.

Table 2. Water Sample Results

No.	Date	Sample	Grid Ref	Type	E. coli (cfu/100ml)	Salinity (ppt)
1	28/05/2013	GPFW1	NT 48834 85083	Fresh Water	200	
2	28/05/2013	GPSW1	NT 48770 85121	Sea Water	8	35.05
3	28/05/2013	GPSW2	NT 47595 83424	Sea Water	7	35.05
4	28/05/2013	GPSW3	NT 46020 82964	Sea Water	39	34.33
5	29/05/2013	GPFW2	NT 46670 80202	Fresh Water	<100	
6	29/05/2013	GPSW4	NT 46591 80248	Sea Water	300	5.18
7	29/05/2013	GPFW3	NT 45559 80483	Fresh Water	2300000	
8	29/05/2013	GPSW5	NT 44387 80140	Sea Water	46	28.54
9	29/05/2013	GPFW4	NT 44568 79491	Fresh Water	100000	
10	29/05/2013	GPFW5	NT 44938 78905	Fresh Water	600	
11	29/05/2013	GPFW6	NT 47840 80926	Fresh Water	1500	
12	29/05/2013	GPFW7	NT 47666 80819	Fresh Water	1800	
13	30/05/2013	GPSW6	NT 48332 84635	Sea Water	6	35.41

Shoreline Survey Photographs

Figure 6. Concrete pipe on shore with metal drain cover sitting above. No flow at time of survey but running water audible. Associated with waypoint 1.

Figure 7. Sample taken down shore of waypoint 3 outflow pipe. Planned SW sample taken (GPSW1). Associated with waypoints 4 and 5.

Figure 8. Horse riders along the shore at the beach at Gullane Bay. Associated with waypoint 10.

Figure 9. Aberlady Bay Local Nature Reserve notice asking walkers to 'Please Keep Out' of nesting area along the shoreline. Associated with waypoint 16.

Figure 10. Electric fence cordoned off area at Aberlady Bay Nature Reserve. Associated with waypoint 17.

Figure 11. Expanse of mud flats and soft sand at Aberlady Bay. Associated with waypoint 18.

Figure 12. Where Peffer Burn meets the shoreline at Aberlady Bay. Associated with waypoint 19.

Figure 13. Planned seawater sample (GPSW4) taken from where burn joins shore. Large ship out at sea. Associated with waypoints 25 and 26.

Figure 14. Freshwater sample (GPFW3) taken from pipe with raw sewage. Associated with waypoints 28 and 29.

Figure 15. Twenty eider ducks on shore. Associated with waypoint 31.

Figure 16. Planned freshwater sample (GPFW5) from small river running under road at south end of survey plan. Associated with waypoints 36 and 37.

Figure 17. Freshwater sample taken (GPFW6) at Peffer Burn bridge next to road. Associated with waypoints 38 and 39.

Figure 18. Seawater sample (GPSW6) taken from the shore at Black Rocks. Associated with waypoints 42 and 43.