

Scottish Sanitary Survey Project



Restricted Sanitary Survey Report Forth Estuary: Pittenweem FF 073 November 2008

Draft Report Distribution – Forth Estuary: Pittenweem

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Table of Contents

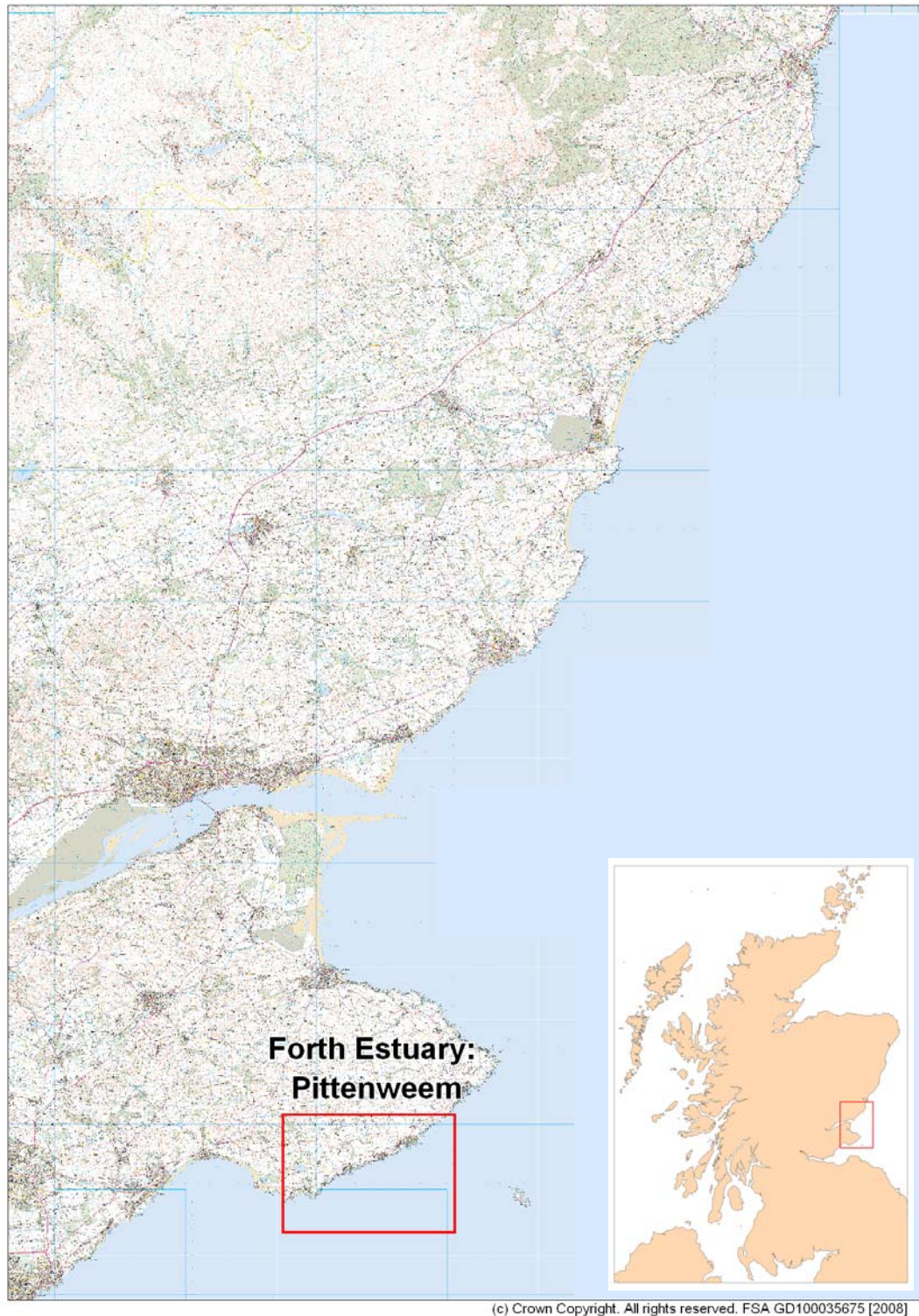
1.	Area Overview	1
1.1	Land Cover	2
1.2	Human Population	2
2.	Fishery	3
3.	Sewage Discharges	4
4.	Animals	8
4.1	Livestock	8
4.2	Wildlife	8
5.	Rainfall	10
5.1	Rainfall at Belliston	10
6.	River Flow	12
7.	Historical <i>E. coli</i> Monitoring Data	13
7.1	Validation	13
7.2	Summary of Sampling and Results by Species/ Monitoring Point	13
7.3	Temporal Pattern of Results	15
7.4	Geographical Pattern of Results	16
7.5	Shellfish Growing Waters Data	16
8.	Bathymetry and Hydrodynamics	21
8.1	Tidal Curve and Description	22
9.	Shoreline Survey Overview	25
10.	Overall Assessment	27
11.	Recommendations	30
12.	References	32
13.	List of Tables and Figures	33

Appendices

1. Summary Sampling Plan
2. Restricted Shoreline Survey Report
3. Statistical Data

1. Area Overview

The Forth Estuary Pittenweem site is located off the eastern coastline of Scotland (see Figure 1.1). Pittenweem is located on a stretch of coastline open to the North Sea. The production area is 6 km wide and 2.5 km long. The depth of the production area varies from 0 – 30 m.



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Figure 1.1 Location of Forth Estuary: Pittenweem

1.1 Land Cover

The land cover for the Pittenweem area is predominantly improved grassland with areas of arable farmland and horticulture. There are significant areas of urban development along the coastline at Anstruther, Pittenweem, St. Monans and Elie. These areas would be expected to contribute significant amounts of contaminated runoff after heavy rainfall.

1.2 Human Population

Figure 1.2 shows the census output areas that are directly adjacent to the Forth Estuary Pittenweem site. The settlements of Anstruther Wester, Pittenweem, St Monans and Elie lie on the production area coastline. Surrounding these settlements are additional census output areas with dispersed dwellings scattered throughout. Sewage discharges associated with these settlements would be expected to contribute to microbiological contamination at the shellfishery.

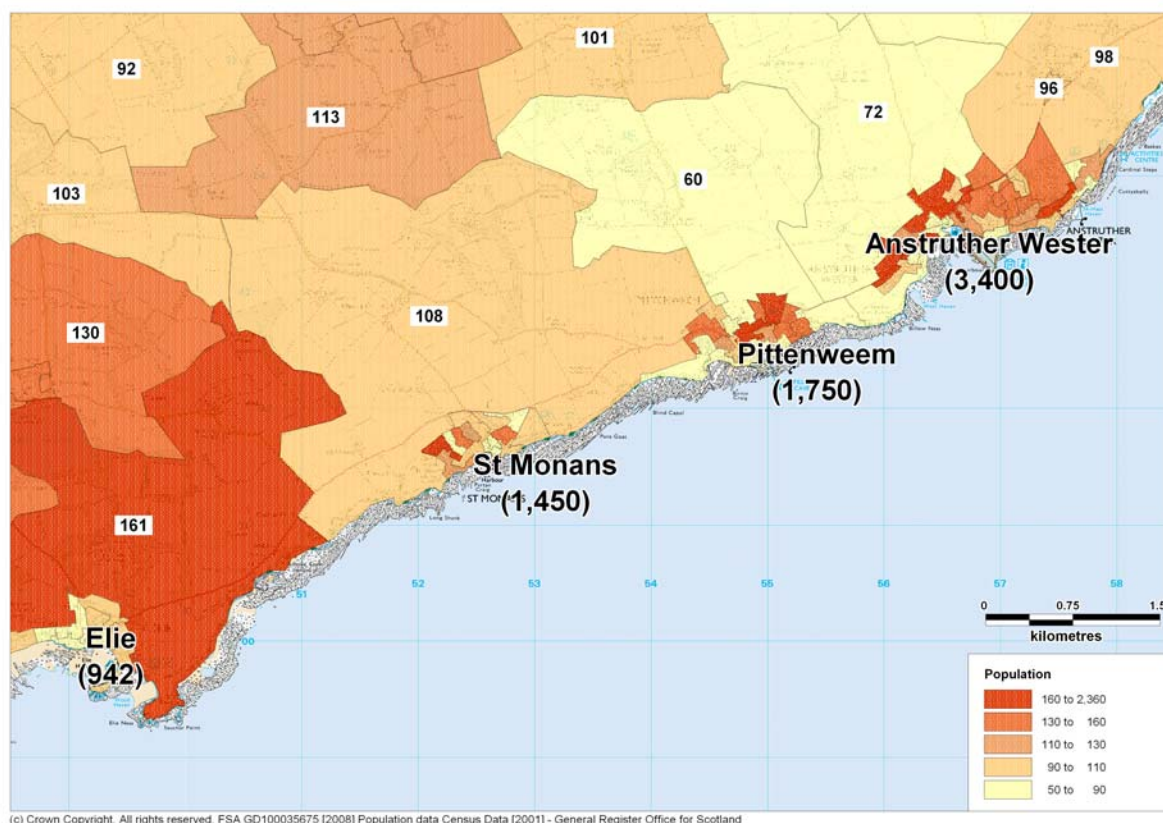


Figure 1.2 Human population of Forth Estuary: Pittenweem

2. Fishery

The fishery at Forth Estuary Pittenweem is comprised of a wild Surf clam (*Spisula solida*) bed within the Forth Estuary: Pittenweem site, (SIN FF 073 189 19).

The current production area boundaries are given as lines drawn between NO 5024 0000 and NO 5700 0000 and between NO 5700 0000 and NO 5700 0347 extending to MHWS.

There is currently no RMP assigned to this area. There is a designated shellfish growing water Fife Ness to Elie, which covers a 1.5km band along the coastline (see Figure 2.1).

The Surf clam beds are found within a section of the production area, as shown below in Figure 2.1. Harvesting of Surf clams takes place year round.

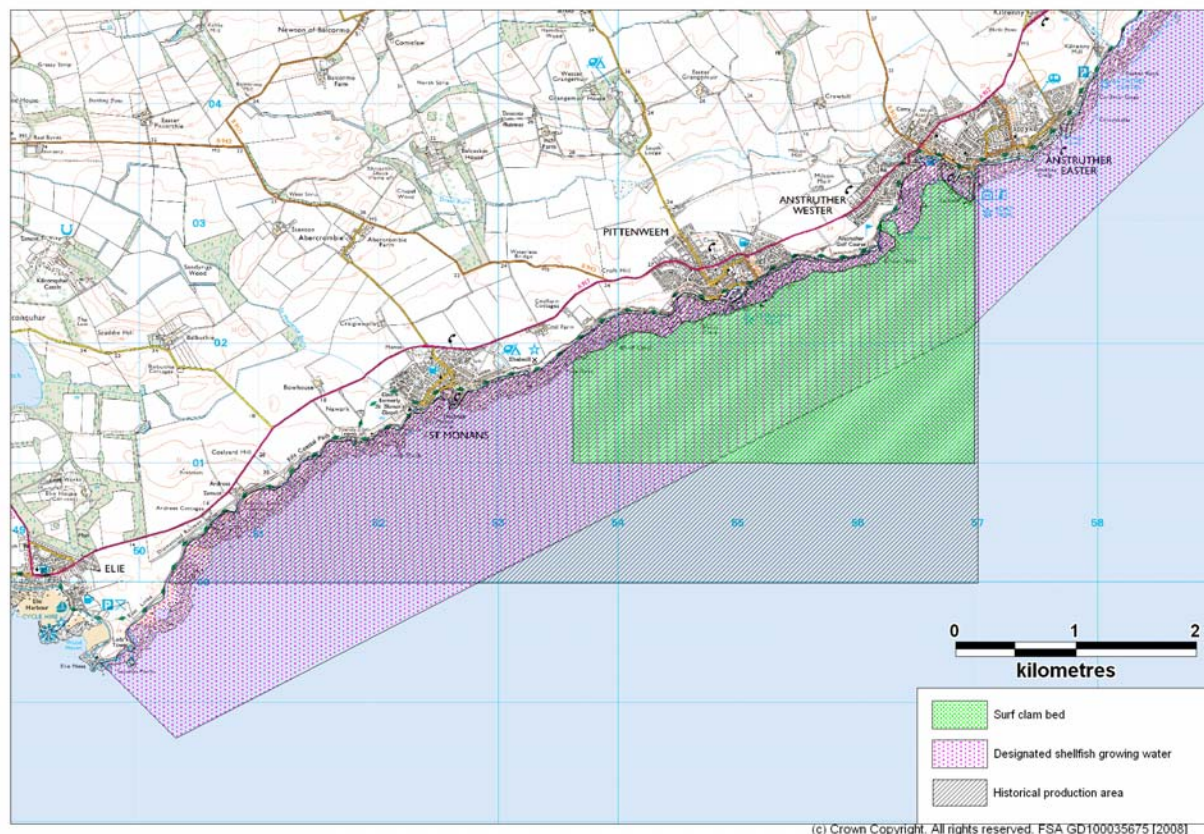


Figure 2.1 Forth Estuary Pittenweem Shellfish Bed

3. Sewage Discharges

Community septic tanks and sewage discharges were identified by Scottish Water for the area surrounding Forth Estuary: Pittenweem. They are detailed in Table 3.1 and mapped in Figure 3.1.

Table 3.1 Discharges identified by Scottish Water

Discharge Name	NGR of discharge	Discharge Type	Level of Treatment	Consented flow m3/day	Consented/ design pop
Arncroach STW & CSO	NO 5203 0437	Continuous	6mm screening	39	150
Anstruther Cornceres CSO	NO 5907 0390	Intermittent	5mm screening	1700	-
Skinfast Haven PS CSO & EO	NO 5768 0370	Intermittent	10mm screening	1301	-
Anstruther Esplanade PS3 CSO & EO	NO 5657 0333	Intermittent	12mm screening	740	2400
Bankwell Land PS2 CSO & EO	NO 5651 0311	Intermittent	5mm screening	209	700
Anstruther Billowness STW	NO 5650 0208	Continuous	-	2320	-
St Monans	NO 538 017	Continuous	6mm screening	1150	-

No sanitary or microbiological data were available for these discharges. The discharge for Anstruther Billowness STW and St. Monans both discharge within the area identified as the shellfish bed. Arncroach STW discharges to a tributary of Dreel Burn approximately 4.5 km upstream from where it joins the Firth of Forth just west of Anstruther Harbour.

There are numerous sewage discharge consents have been issued by SEPA for this area, many of them old and lacking detail. Twelve of the oldest permits lacked grid references and so were not included here. All but one of these discharged to Dreel Burn. Permits with grid references are listed in Table 3.2 and mapped in Figure 3.1.

Table 3.2 Discharge consents issued by SEPA

Reference No.	NGR	Discharge Type	Level of Treatment	Popn	DWF	Description
CAR/R/1018582	NO 5630 0368	Continuous	Septic Tank	5	-	
CAR/L/1001063	NO 538 017	Continuous	screened sewage	-	1150000 l/day	St Monans STW
CAR/L/1001256	NO 5542 0250	Continuous	screened sewage	900	249 m3/day	Sewage Pumping Station
CAR/L/1001330	NO 5626 0275	Continuous	screened sewage	-	2320 m3/day	Anstruther Billowness Sewage Treatment Works
CAR/L/1001068	NO 5651 0311	CSO/EO	screened sewage	700	209 m3/day	Bankwell Land PS2 CSO & EO
WPC/E/6660	NO 5768 0370	EO	screened sewage	-	1301 m3/day	Skinfast Haven PS
CAR/R/1010884	NO 5790 0886	Soakaway	septic tank	10		Muirhead Farm, Crail
CAR/R/1019049	NO 5245 0549	Continuous	septic tank	6		Farm House, Easter Kellie
CAR/R/1019769	NO 5173 0449	Soakaway	septic tank	10		3 and 4 Balcormo Farm Cottages
R 6434	NO 5542 0250	CSO/EO	12mm screen		249 m3/day	Storm overflow from pumping station 1 to Billowness STW
R 6436	NO 5657 0333	CSO/EO	12mm screen	2400	740 m3/day	Storm overflow from pumping station 3 to Billowness STW
R 6437	NO 5650 0208	Continuous	5mm screen		2320 m3/day	Billowness STW
CAR/R/1013538	NO 5283 0818	Soakaway	septic tank	10		1&2 Cottages, Lochty Farm

Reference No.	NGR	Discharge Type	Level of Treatment	Popn	DWF	Description
CAR/R/1014109	NO 4637 0360	Continuous	package plant	6		Plot 4, Charleton Estate
CAR/R/1015577	NO 5428 0652	Soakaway	septic tank	7		Filter House, Balmonth
CAR/R/1017318	NO 4863 0358	Continuous	package plant	5		Balcarres Mill Coach House
CAR/R/1021009	NO 5111 0635	Soakaway	septic tank	13		Gillingshill House
CAR/R/1021010	NO 5115 0635	Soakaway	septic tank	5		The Barracks at Gillinshill
CAR/R/1021274	NO 5978 0912	Soakaway	septic tank	6		Ragfield House, Crail
CAR/R/1021365	NO 5466 0501	Continuous	package plant	15		Falside Farm, Cheese Production Unit and Café
CAR/R/1022263	NO 5635 0699	Continuous	package plant	10		Proposed House, Muiredge
CAR/R/1024127	NO 5754 0695	Soakaway	septic tank	5		11 East Pitcorthie
CAR/R/1025984	NO 5455 0317	Continuous	package plant	5		49 Charles Street
CAR/R/1024132	NO 5374 0184	Soakaway	septic tank	5		1 Pathead Cottage
CAR/R/1028316	NO 5448 0308	Soakaway	septic tank	6		51 Charles Street
CAR/R/1028476	NO 4465 0640	Soakaway	septic tank	8		Wester Lathallan
CAR/R/1013537	NO 5282 0817	Soakaway	septic tank	5		Holly Cottage, Lochty Farm
CAR/R/1013529	NO 5269 0847	Soakaway	septic tank	5		Nether Lochty Cottage
CAR/R/1013530	NO 5249 0805	Soakaway	septic tank	5		Lochty Farm House
CAR/R/1013532	NO 4978 0723	Soakaway	septic tank	5		North Baldutho Farmhouse
N 502	NO 538 051	Continuous	septic tank		1500 l/day	House at Ovenstone Crossroads
N 468	NO 542 040	Continuous	septic tank		1400 l/day	Coachhouse, Grangemuir Estate
E 379	NO 5194 0506	Continuous	septic tank		1.5 m3/day	Kellie Castle Farmhouse
E 379	NO 5195 0510	Continuous	septic tank		700 gal/day	Kellie Castle Farm and Cottages
138	NO 542 034	Continuous	septic tank		100 l/day	Pittenweem Refuse Transfer Station
E 265	NO 531 051	Continuous	septic tank		3000 l/day	Ovenstone Farm, Pittenweem
N 647	NO 547 022	CSO/EO	screened sewage			Pumping Station at West Shore Pittenweem

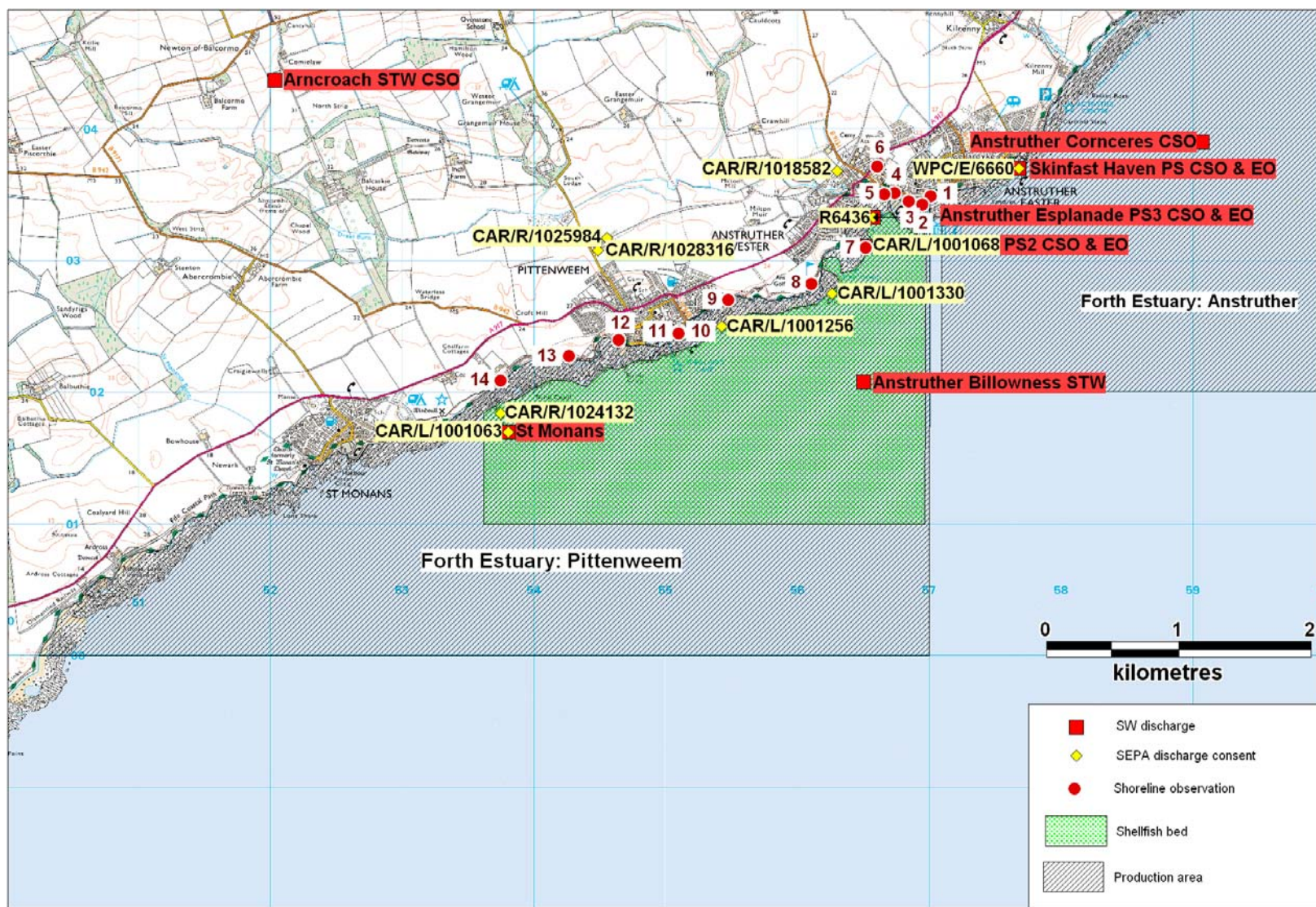
Septic tanks and outfall pipes were also observed during the shoreline survey and these are listed in Table 3.3. Their locations have been included in the mapped discharges in Figure 3.1. Further details can be found in the shoreline survey report in the appendix.

Table 3.3 Observations of potential sewage discharges

No.	Date	NGR	Description of potential sewage discharge
1	29/09/2008	NO 57010 03496	Outfall pipe and evidence of sewage
2	29/09/2008	NO 56951 03432	Outfall pipe
3	29/09/2008	NO 56848 03454	Outfall pipe
4	29/09/2008	NO 56736 03518	Outfall pipe below public toilets
5	29/09/2008	NO 56661 03508	Outfall pipe
6	29/09/2008	NO 56607 03721	Outfall pipe
7	29/09/2008	NO 56517 03102	New outfall pipe
8	29/09/2008	NO 56105 02831	Sewage pumping station, old outfall pipe
9	29/09/2008	NO 55475 02705	Outfall pipe (110mm internal diameter), strong odour of sewage, pipe leaking
10	29/09/2008	NO 55104 02469	Outfall pipe with seepage
11	29/09/2008	NO 55100 02452	Outfall pipe and inspection cover
12	29/09/2008	NO 54641 02404	Pipeline believed to be an overflow for a mid line pumping station
13	29/09/2008	NO 54266 02282	Outfall pipe (150mm internal diameter)
14	29/09/2008	NO 53747 02095	St Monans pumping station

All of the noted discharges along the Pittenweem coastline are sufficiently close to the shellfish bed to adversely impact water quality in and around the fishery. The greatest impact would be at the eastern end of the fishery, where the larger of the two sewage outfalls is located as well as the CSO/EOs from the pumping stations. Several of these discharges flow into Dreel Burn which would then affect the part of the fishery nearest Anstruther Harbour, where the burn discharges into the Firth of Forth.

Additional discharges of sewage are likely from the marina in Anstruther Harbour, where pleasure boats are used as weekend accommodation during the summer months.



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Figure 3.1 Sewage discharges at Forth Estuary Pittenweem

4. Animals

4.1 Livestock

No livestock were observed during the shoreline survey. However, there is a pig farm situated 30 metres from the shoreline of Cellardyke (see Figure 4.1). Slurry is spread on arable fields in the area, though no information is available regarding location, timing or amount.

4.2 Wildlife

The Firth of Forth is an important site for migratory birds. The Isle of May (see Figure 4.1) lies 8 km east off the Anstruther coast. During the height of the breeding season, over 200,000 seabirds of 12 species nest on the island, including Puffins, Black-legged Kittiwakes, Razorbills, Guillemots, Shags, Terns and Eider duck (Hemsley, 2008). During the shoreline survey there was an estimated 120 gulls, 10 cormorants and 20 eider ducks present along the Pittenweem shoreline (see Figure 4.1).

The Isle of May is also host to one of largest breeding groups of grey seals (*Halichoerus grypus*) in the British Isles, with 5.1% of the UK seal population resident on this island during the autumn (Scottish Natural Heritage, 1994). From September to February there were an estimated 1,950 seal pups with a total population of 5,900 in 1994.

The seasonal seal and migratory bird populations on the Isle of May, whilst producing a significant amount of faecal material, are likely to be too distant to significantly impact the shellfish bed. However, the animals feeding or foraging from the island on or near the shellfish bed may contribute more to the bacterial contamination of the shellfish.

The amount 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).

Any impacts to the fishery from wildlife sources are likely to be masked by impacts from sewage outfalls.

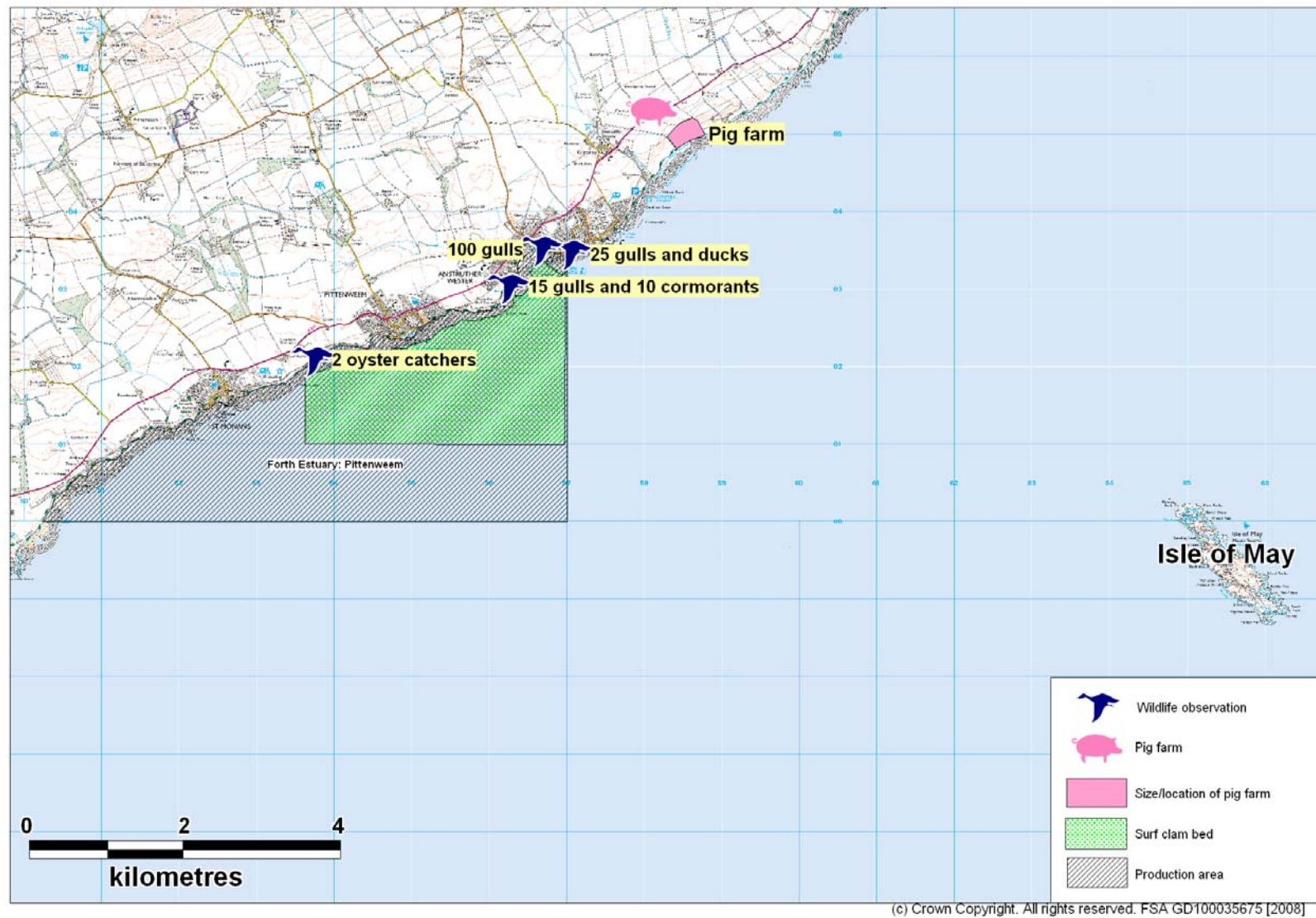


Figure 4.1 Wildlife observations during the shoreline survey and location of the pig farm at Pittenweem

5. Rainfall

The nearest weather station is located at Belliston, approximately 4.8 km northwest of the production area. Rainfall data was supplied for the period 01/01/03 to 31/12/07 (total daily rainfall in mm). For this period of 1826 days, daily rainfall records were complete. It is likely that the rainfall experienced at Belliston is very similar to that experienced at the production area due to their close proximity.

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 wastewater treatment plant overflows (e.g. Mallin et al, 2001; Lee & Morgan, 2003). This is likely to be especially significant at Pittenweem due to its proximity to a number of discharges.

5.1 Rainfall at Belliston

As the rainfall records from Belliston are complete, total annual rainfall and mean monthly rainfall can be calculated, and are presented in Figures 5.1 and 5.2.

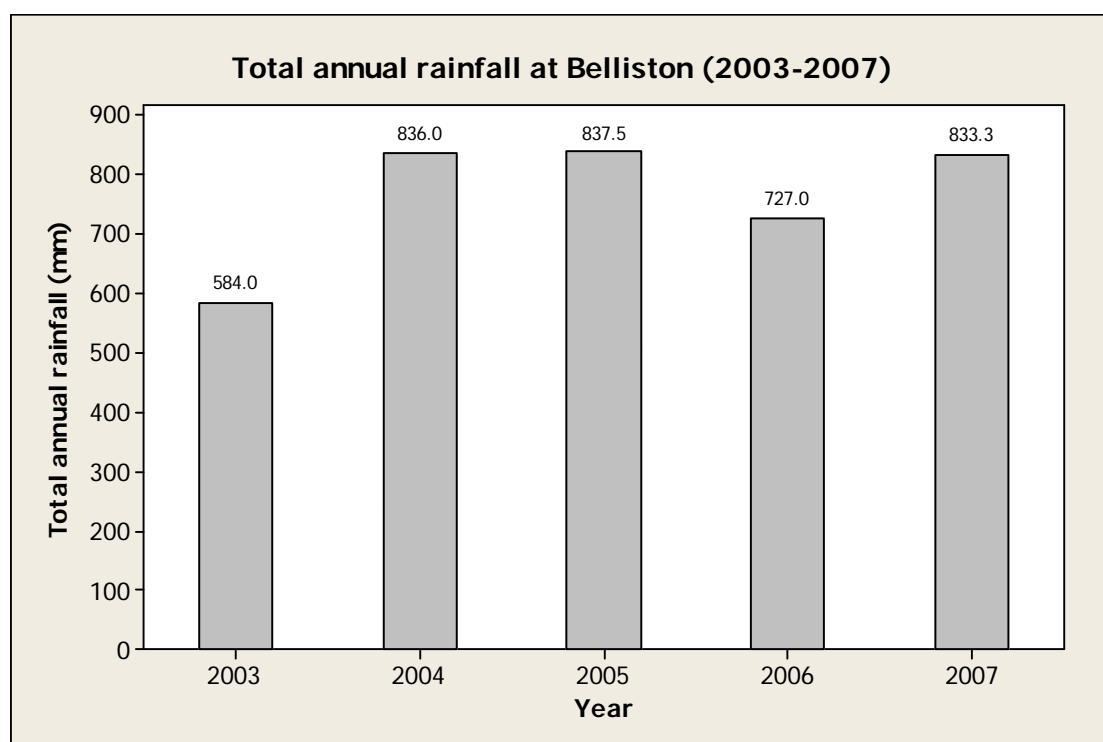


Figure 5.1 Total annual rainfall at Belliston 2003 – 2007

Rainfall totals were substantially lower in 2003 than in the other years and 2006 was also drier than 2004, 2005 or 2007.

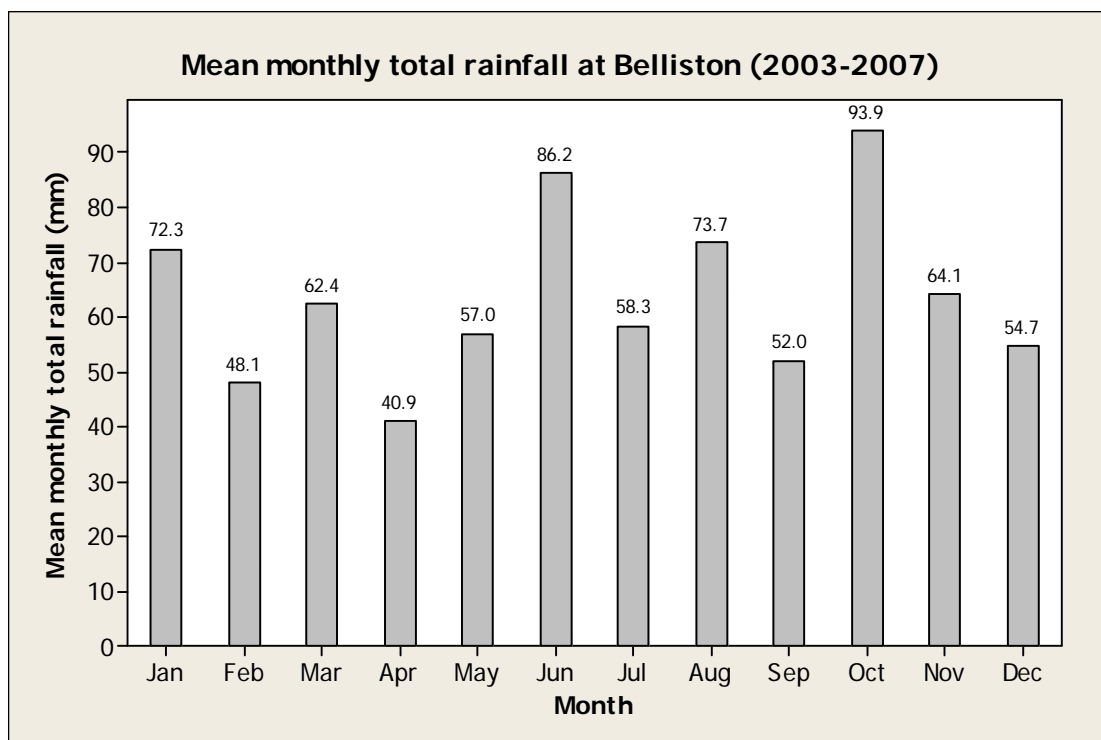


Figure 5.2 Mean total monthly rainfall at Belliston 2003 – 2007

The wettest months were October and June and the driest February and April. For the period considered here (2003 – 2007), 43% of the days experienced no rainfall and 53% of days experienced rainfall of 1mm or less.

The mean monthly rainfall amounts for the period do not appear to exhibit a seasonal pattern, with half the months showing an increase in rainfall over the previous month and the other half showing a decrease.

The largest increase in rainfall occurred in October, which represented an 81% increase over September's mean total. A further large increase (51%) was observed between May and June, after which rainfall levels remained relatively elevated through August.

It could be anticipated that water quality at the fishery would be particularly negatively affected by rainfall runoff during June and October, but also impacted throughout the summer months.

6. River Flow

There are no significant rivers or river gauging stations in the vicinity of Pittenweem.

During the shoreline survey only one burn was recorded discharging into the Pittenweem production area (see Figure 6.1). Dreel Burn was sampled during the shoreline survey. This represented the only significant freshwater input into the Pittenweem shellfish bed.

Table 6.1 River flow and loading – Pittenweem

No	Grid Ref	Description	Width (m)	Depth (m)	Measured Flow (m/s)	Flow in m3/day	<i>E. coli</i> (cfu/100ml)	Loading (<i>E. coli</i> per m3)
1	NO 5655903491	Dreel Burn	4.0	.128	0.478	21145	30000	6.3×10^{12}

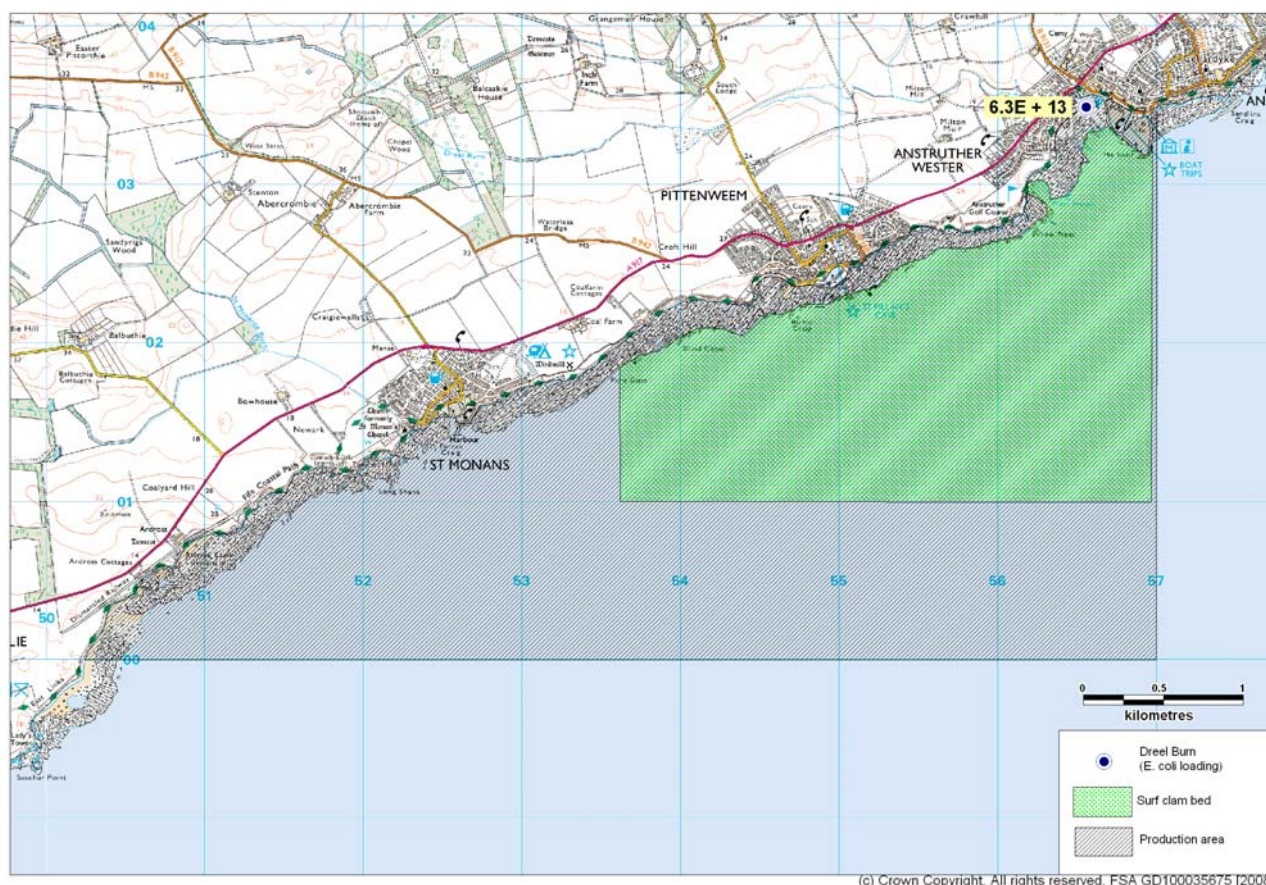


Figure 6.1 Location of the Dreel Burn at Pittenweem

A water sample from Dreel Burn resulted in 30,000 cfu *E. coli*/100 ml, indicating a significant level of faecal contamination. The calculated *E. coli* loading per day is also high and is based on the flow and dimension observed during the shoreline survey only. Dreel Burn should therefore be considered to be a significant source of faecal contamination to the shellfish bed and should be considered in the sampling plan.

7. Historical *E. coli* Monitoring Data

7.1 Validation

The *E. coli* results of all the shellfish samples taken from Forth Estuary: Pittenweem and Forth Estuary: Anstruther, an adjacent area also fished for the same species, from the beginning of sampling in 2001 up to the end of 2008 were extracted from the database and validated according to the criteria described in the standard protocol for validation of historical *E. coli* data.

For Forth Estuary: Pittenweem, four periwinkle samples were also submitted, but these were not considered in the following analysis. All samples taken from Forth Estuary: Pittenweem in 2008 had a reported sampling location at Anstruther Harbour, which was presumably their point of landing rather than their point of capture, but these samples were included in the analysis nevertheless. Two samples reported from Forth Estuary: Pittenweem had reported sampling locations within Forth Estuary: Anstruther, but these were used in the analysis nevertheless. The name of this production area was changed from Forth Estuary: Pittenweem (FF073) to Pittenweem: Billow Ness (FF 395) at the start of 2008, but it will be referred to as Forth Estuary: Pittenweem throughout this section for clarity.

For Forth Estuary: Anstruther, one razor sample was also submitted, but this was not considered in the following analysis. One sample had no reported sampling location and was excluded from the analysis. Two samples plotted more than 100m away from the sea, and were excluded from the analysis. Two samples had reported results of <20, and these were assigned a nominal value of 10 for statistical evaluation and graphical presentation.

No samples were rejected on the basis of sampling date discrepancies.

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

7.2 Summary of sampling and results by species/monitoring point

A summary of the number of samples and the *E. coli* results is presented in Table 7.1, and a boxplot of *E. coli* result by area is presented in Figure 7.1.

Table 7.1 Summary of historical results from Forth Estuary: Pittenweem and Forth Estuary: Anstruther.

Sampling Summary		
Production area	Forth Estuary Anstruther	Forth Estuary: Pittenweem (Pittenweem: Billow Ness in 2008)
Species	Surf Clams	Surf Clams
SIN	FF 068	FF 073 (FF 395 in 2008)
Location	All locations	All locations
Total no of samples	50	25
No. 2001	10	0
No. 2002	4	0
No. 2003	12	4
No. 2004	3	10
No. 2005	7	3
No. 2006	3	7
No. 2007	11	1
No. 2008	6	6
Results Summary		
Minimum	<20	20
Maximum	9100	3500
Median	220	310
Geometric mean	262	263
90 percentile	2050	1300
95 percentile	2675	2950
No. exceeding 230/100g	27 (54%)	17 (68%)
No. exceeding 1000/100g	8 (16%)	6 (24%)
No. exceeding 4600/100g	2 (4%)	0 (0%)
No. exceeding 18000/100g	0 (0%)	0 (0%)

The inclusion of results for Forth Estuary: Anstruther permits the inclusion of 50 more samples and therefore a more robust analysis of what is essentially the same clam bed. Table 7.1 and Figure 7.1 indicate that the ranges and levels of contamination found in surf clams in the two areas are almost identical. A simple T-Test comparison confirms there is no significant difference in mean result between the production areas (T-Test, $T=-0.02$, $p=0.987$, Appendix 3). This suggests that the two production areas may be combined at some time in the future to reduce the associated sampling burden without significantly affecting the classification of either. However, it should be noted that, although the *E. coli* levels are currently similar, the areas are impacted by different contamination sources and therefore this situation may change with time.

The highest levels of contamination were found in samples taken within the Pittenweem area on 7 June 2006. Six samples were collected at various locations on the shellfish bed on this date in order to satisfy fast track classification sampling requirements.

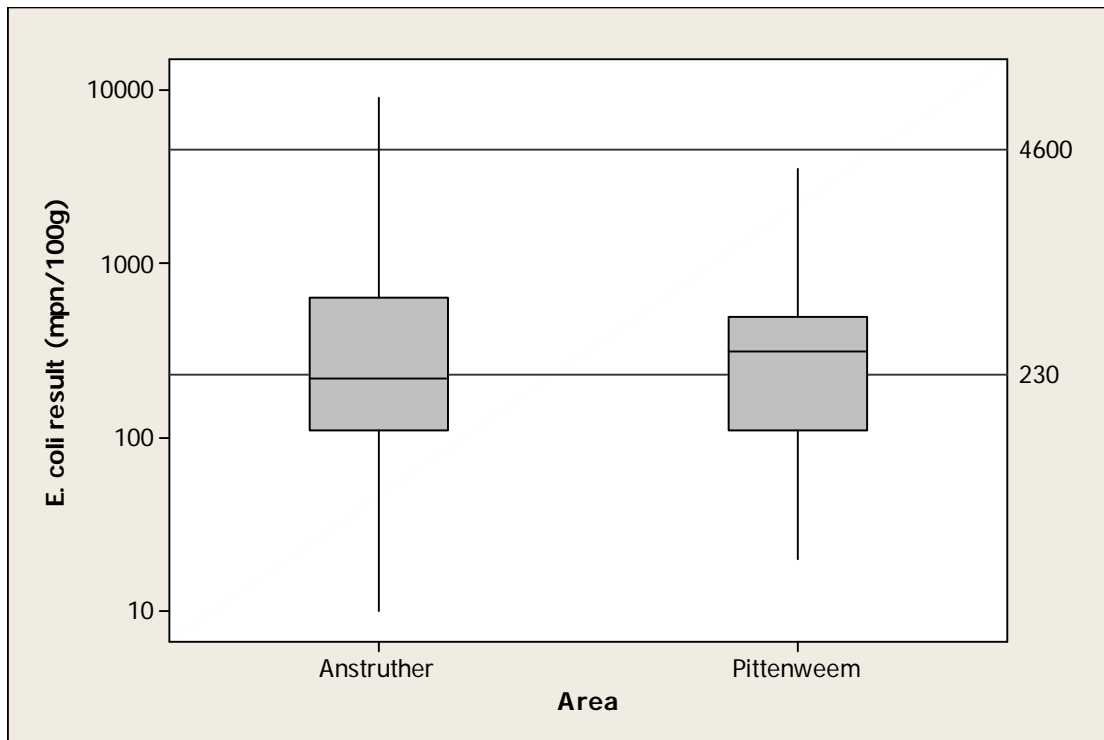


Figure 7.1. Boxplot of *E. coli* result by area

7.3 Temporal pattern of results

Figure 7.2 presents a scatterplot of the individual results against date for all surf clam samples taken from Forth Estuary: Pittenweem and Forth Estuary: Anstruther.

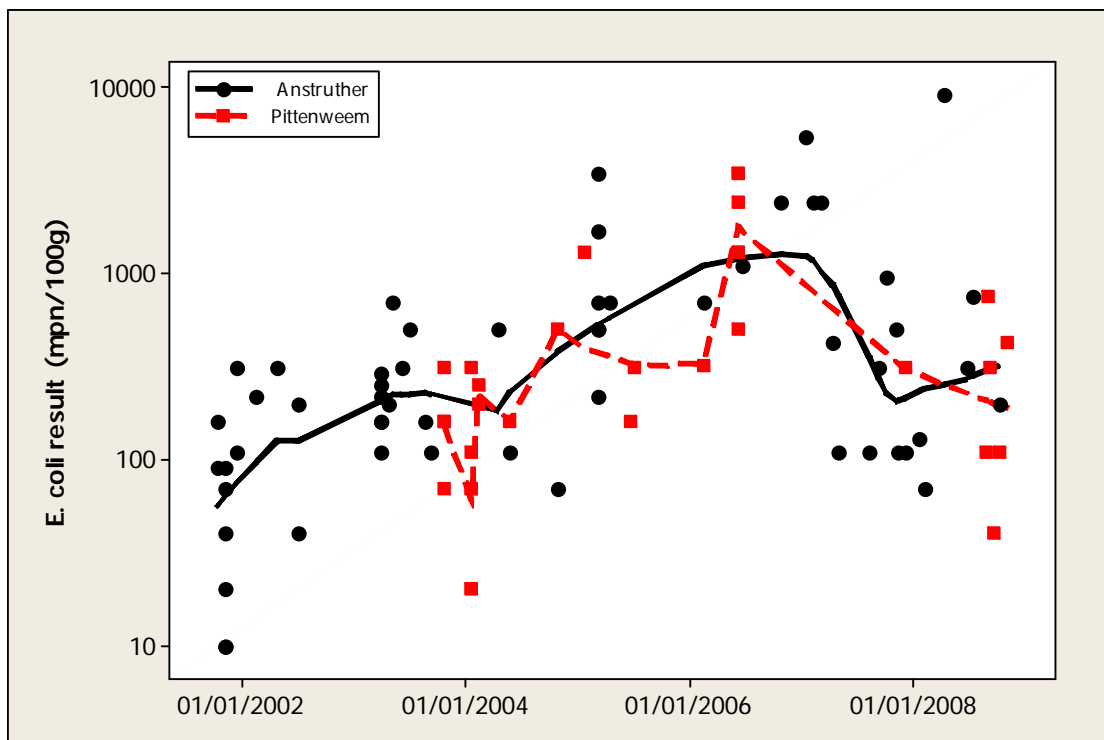


Figure 7.2 Scatterplot of Log *E. coli* result (mpn/100g) for Surf Clams vs collection date by site with loess smoother

Overall, during the course of the sampling history results appear to have deteriorated to the end of 2006, and possibly improved slightly since. On some occasions multiple samples have been taken on the same date from different locations.

7.4 Geographical pattern of results

Figure 7.3 (overleaf) shows a thematic map with the *E. coli* results plotted at the sampling locations of surf clams at Forth Estuary: Pittenweem and Forth Estuary: Anstruther. The map gives the impression that the highest *E. coli* results occurred closer to the shore, and closer to the main discharges. Also worthy of note is that sampling was more intensive in an area just to the ENE of Anstruther, possibly indicating higher densities of clams and hence greater fishing effort here.

7.5 Shellfish Growing Waters data

The area considered in this report is also a designated Shellfish Growing Water which was designated in 1998. The growing water encompasses a strip of coastal water between approximately 0.5 and 1.5 km in width from Fife Ness to Elie. Its extent is shown in Figure 7.4. There are three listed monitoring points, one at Ardross, one at Caipie, and one at Crail.

The monitoring requires the following testing:

- Annually for metals and organohalogens in shore mussels
- Quarterly for faecal coliforms in shore mussels

Monitoring results for faecal coliforms in shore mussels from 1999 to the end of 2005 have been provided by SEPA. No samples were taken in 2006 or 2007. These results are presented in Table 7.2.

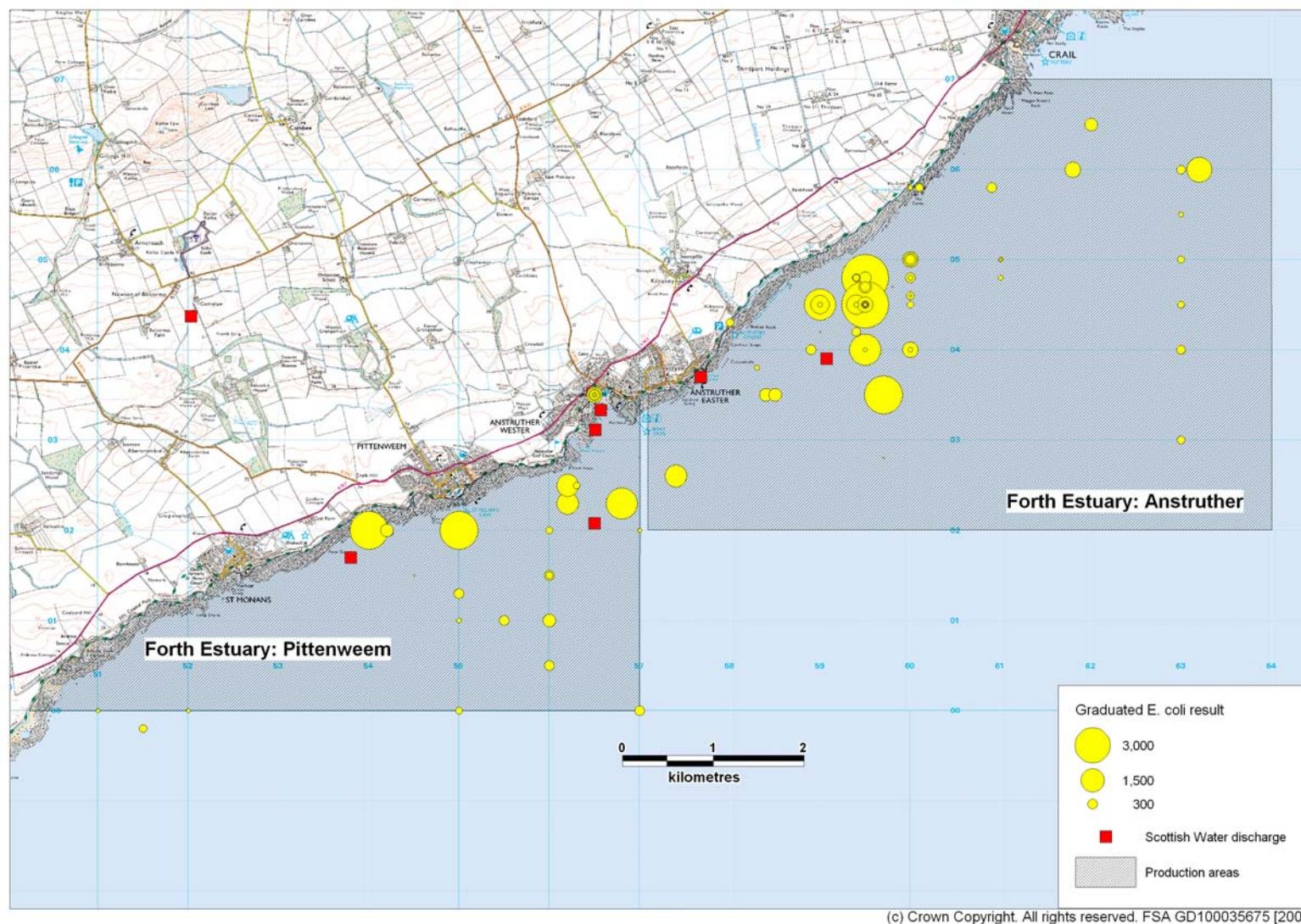


Figure 7.3 *E. coli* result (mpn/100g) by sampling location for Surf clams at Pittenweem and Anstruther

Table 7.2. SEPA Faecal coliform results (faecal coliforms/100g) for shore mussels

	Site	Fifeness - Elie:Caiplic	Fifeness - Elie:Ardross
	OS Grid Ref.	NO 592 052	NO 509 006
1999	Q4	500	1300
2000	Q1	70	500
	Q2	500	405
	Q3	110	1700
	Q4	180	10050
2001	Q1	FMD*	1245
	Q2	FMD*	235
	Q3	250	310
	Q4	360	265
2002	Q1	90	165
	Q2	80	110
	Q3	45	13050
	Q4	125	625
2003	Q1	180	1400
	Q2	55	1850
	Q3	160	475
	Q4	3000	505
2004	Q1	190	265
	Q2	125	500
	Q3	180	3500
	Q4	155	265
2005	Q1	405	125
	Q2	200	165
	Q3	9100	100
	Q4	120	750

*Site inaccessible due to Foot and Mouth disease

At Caiplic, the geometric mean result of all shore mussel samples was 213 faecal coliforms / 100g. Results ranged from 45 to 9100 faecal coliforms/100g. There was no significant difference in results between the quarters (one-way ANOVA, $p=0.666$, Appendix 3).

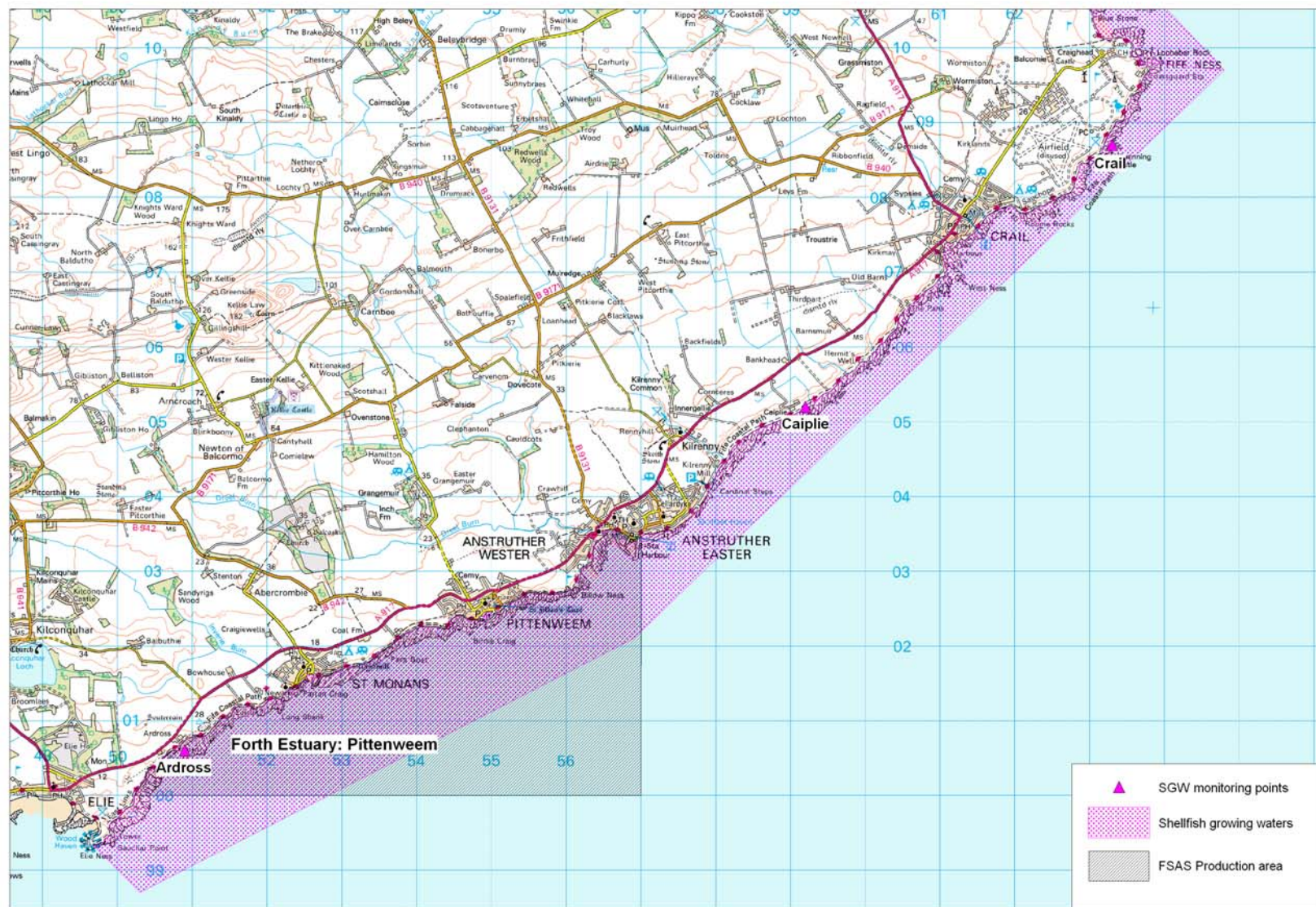
At Ardross, the geometric mean result of all shore mussel samples was 590 faecal coliforms / 100g. Results ranged from 100 to 13050 faecal coliforms/100g. There was no significant difference in results between the quarters (one-way ANOVA, $p=0.410$, Appendix 3).

Mean results were significantly higher at Ardross (paired T-test, $T=-2.35$, $p=0.028$). No samples were taken from the Crail monitoring point.

Levels of faecal coliforms are usually closely correlated to levels of *E. coli* often at a ratio of approximately 1:1. The ratio depends on a number of factors, such as environmental conditions and the source of contamination and as a consequence the results presented in Table 7.2 are not directly comparable with other shellfish testing results presented in this report. Differences in habitat and physiology between shore mussels and surf clams

further complicate possible comparisons between these results and those obtained during classification sampling.

Results for the physical and chemical parameters monitored by SEPA are not presented in this report.



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Figure 7.4 Map showing relevant part of the Designated Shellfish Growing water and monitoring points

8. Bathymetry and Hydrodynamics

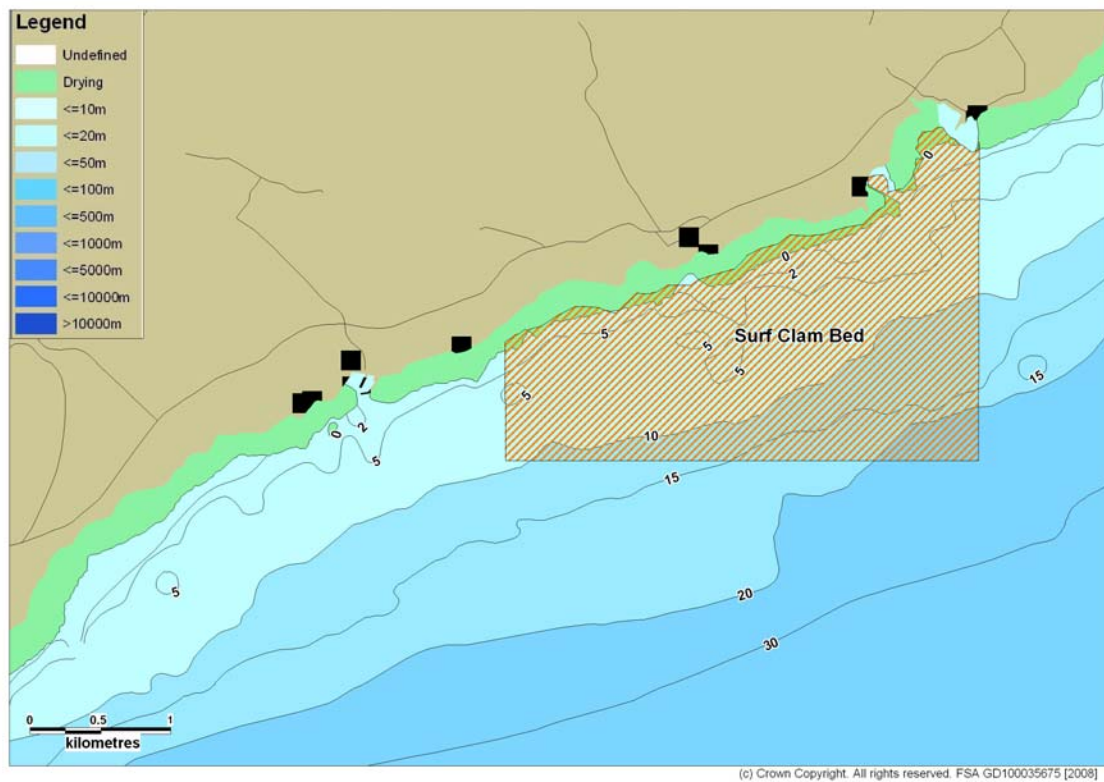


Figure 8.1 Forth Estuary Pittenweem Bathymetry

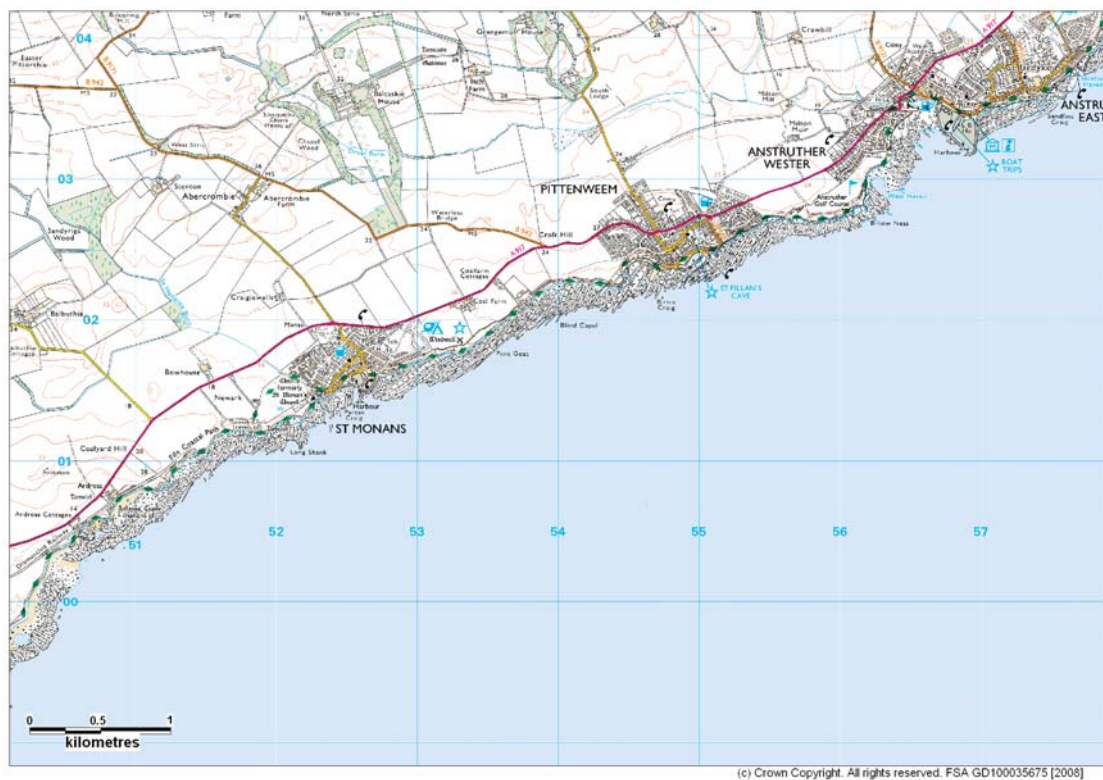


Figure 8.2 Forth Estuary Pittenweem

The bathymetry chart above shows that the depth steadily increases with distance from the shoreline at Pittenweem. The surf clam bed, as illustrated in Figure 8.1, is located almost completely within the 20 metre depth curve.

8.1 Tidal curve and description

The two tidal curves below are for the port of Anstruther Easter, the nearest secondary harmonic port– they have been output from UKHO TotalTide. The first is for seven days beginning 00.00 GMT on 24th September 2008. The second is for seven days beginning 00.00 GMT on 1st October 2008. Together they show the predicted tidal heights over high/low water for a full neap/spring tidal cycle.

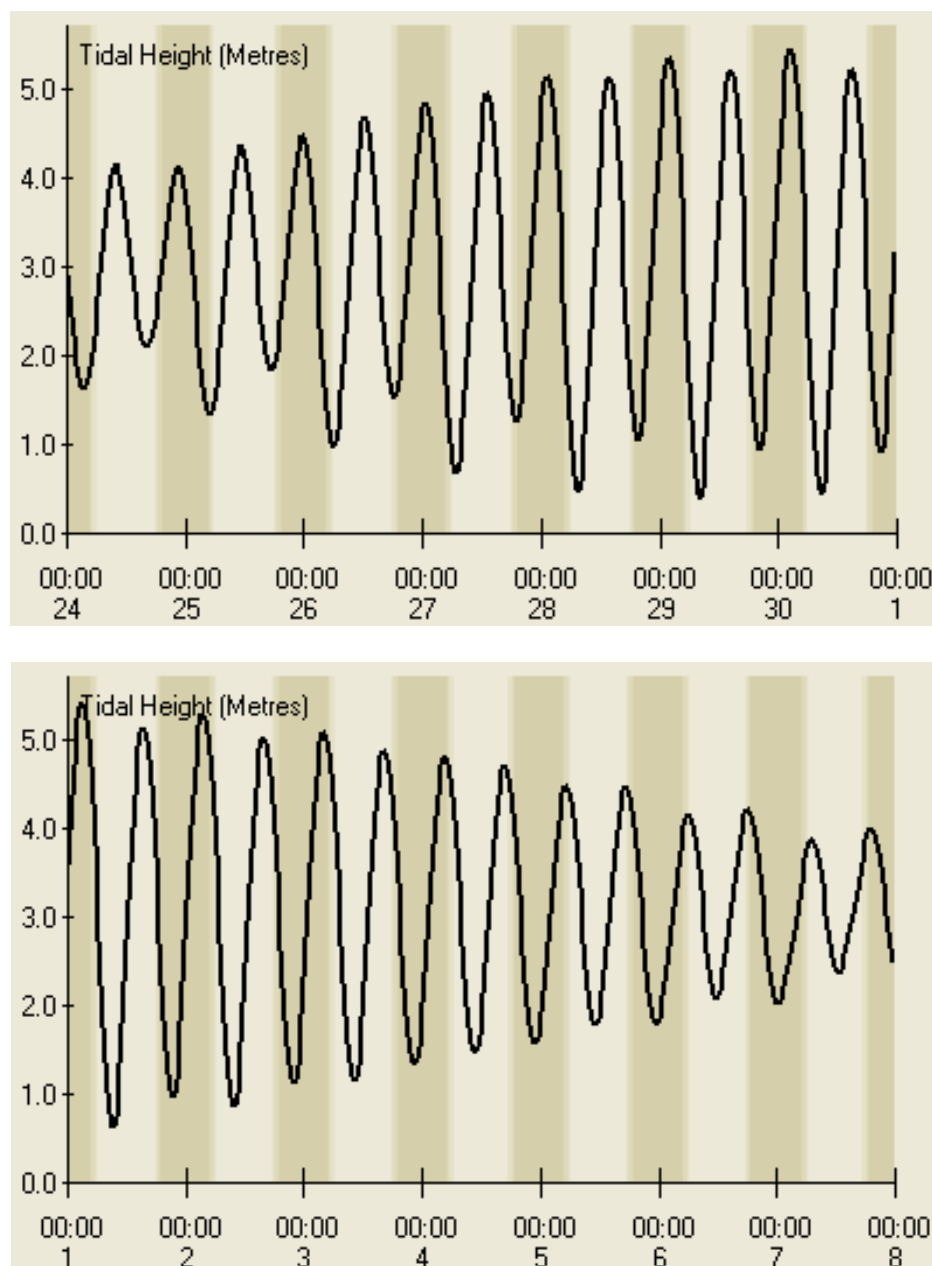


Figure 8.3 Tidal curves for Anstruther Easter

The following is the UKHO summary description for Anstruther Easter:

The tide type is Semi-Diurnal.

MHWS	5.3 m
MHWN	4.2 m
MLWN	2.0 m
MLWS	0.8 m

Predicted heights are in metres above chart datum. The tidal range at spring tide is therefore approximately 4.5 m and at neap tide 2.2 m.

Currents

The nearest tidal diamond (SN022A) was located offshore to the south of Anstruther, about 1 km to the south west of the south western extremity of the production area. This is likely to provide a good representation of tidal flow patterns within the production area, although they may be slightly weaker in the shallower water nearer the coast.

Table 8.1 Tidal diamond information for SN022A

Time	Direction	Spring rate	Neap Rate
-06h	061°	0.2 kn	0.1 kn
-05h	241°	0.2 kn	0.1 kn
-04h	232°	0.7 kn	0.4 kn
-03h	236°	0.9 kn	0.4 kn
-02h	250°	0.8 kn	0.4 kn
-01h	255°	0.5 kn	0.3 kn
HW	231°	0.3 kn	0.2 kn
+01h	066°	0.1 kn	0.1 kn
+02h	050°	0.5 kn	0.3 kn
+03h	055°	0.8 kn	0.4 kn
+04h	058°	0.8 kn	0.4 kn
+05h	067°	0.6 kn	0.3 kn
+06h	066°	0.4 kn	0.2 kn

The tidal diamond indicates a bidirectional flow pattern along the shore, with water moving in a south westerly direction on the flood, and a north easterly direction on the ebb. Peak rates of flow are 0.9 knots on spring tides, and 0.4 knots on neap tides. Flows are slightly stronger on the flooding tide. Figures 8.4 and 8.5 present predicted maximum tidal flows and direction on the ebb and flood tide respectively on the 22/08/2009, when the largest tides of the year are predicted.



Figure 8.4 Maximum ebb tide flow and direction on a large spring tide at SN022A (from Admiralty TotalTide)



Figure 8.5 Maximum flood tide flow and direction on a large spring tide at SN022A (from Admiralty TotalTide)

During the ebb and flood, it is likely that a counter current will be present close to the coast for at least part of the tide. Tidal currents are likely to be slower over the shellfish bed as depths are shallow and interaction with the seabed more pronounced.

Conclusions regarding effect on impacting sources

Due to the tidal range and the open nature of the coastline at Pittenweem, pollution entering the production area from local sources is predicted to move slightly away from the shore and then along the shoreline with the tide. Prevailing winds may enhance transport by driving a surface current along the shoreline.

Without modelling, it is not possible to predict the tidal excursion of effluent discharges or other contaminants entering the area.

9. Shoreline Survey Overview

A restricted shoreline survey of the Pittenweem area was undertaken by staff from Fife Council and FSA Scotland on 29 September 2008.

A number of sewage outfall pipes and septic tanks were recorded during the survey and sewage related debris was observed along the shoreline. Locals reported that sewage appears on beaches in the area, especially after heavy rain.

Land use was reported as arable agriculture outside the towns, with slurry application carried out at various times during the year. A pig farm was identified to the east of the production area and a 9 hole golf course was noted along the shoreline west of Anstruther.

There were 140 berths available in Anstruther Harbour for small pleasure boats. It was reported that these are used during the summer season by weekend sailors who also use them as overnight accommodation. No pump out facilities were available in Anstruther harbour

Approximately 40 fishing boats were found to be operating from Pittenweem Harbour, according to the harbour master. Commercial shipping was observed approximately 2 km offshore. The tourist ferry that runs between Anstruther and the Isle of May from May to September is licensed to carry 100 passengers and has no sewage holding facility.

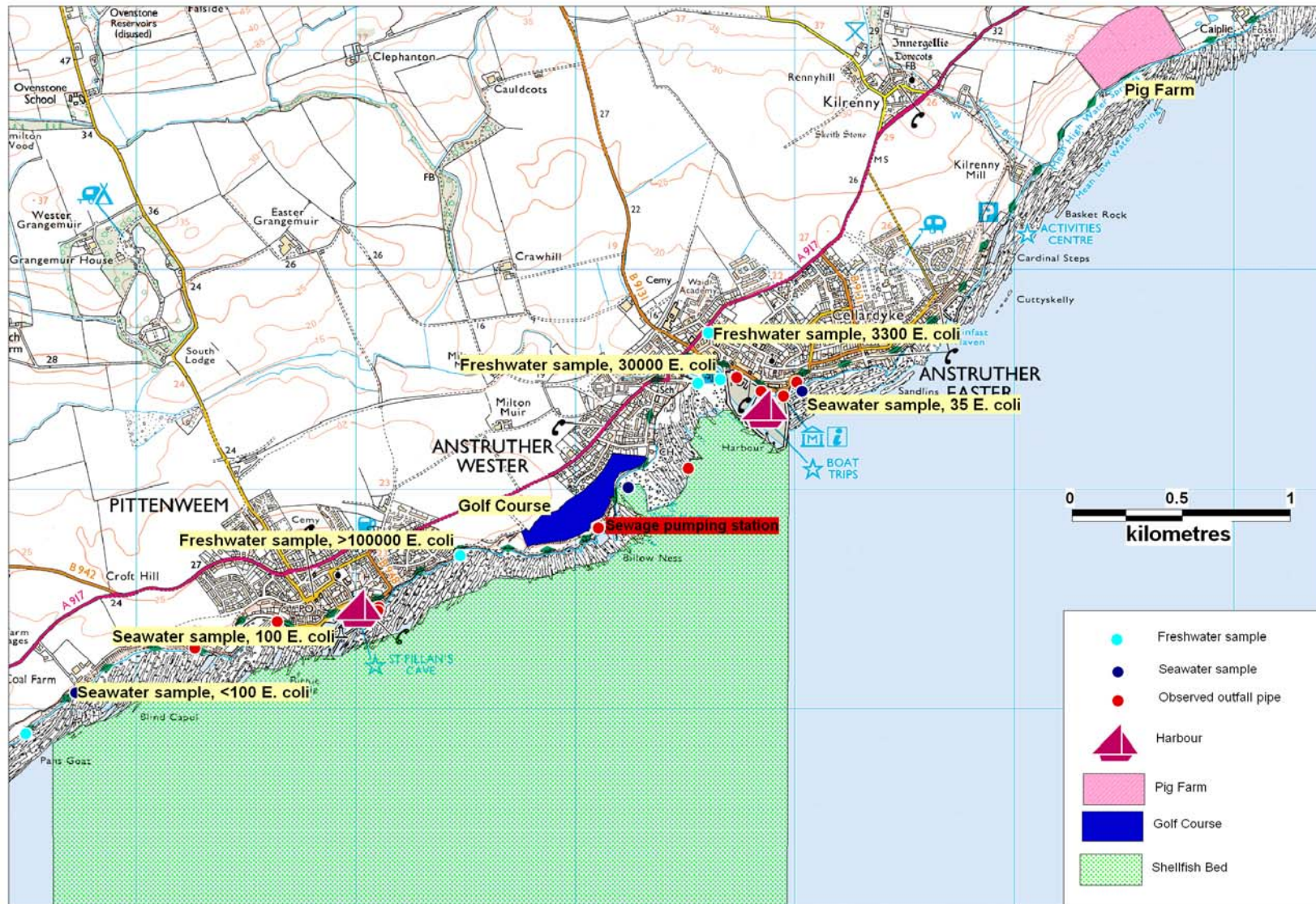
Approximately 150 seabirds were observed during the shoreline survey, the majority of which were gulls.

Both freshwater and seawater samples were collected from around the survey area. Dreel burn was found to be heavily contaminated, as were most of the discharges sampled. Seawater sample results ranged from 7 to 100 *E. coli* cfu/100ml with highest result seen at Pittenweem Harbour. Freshwater sample results ranged from <100 to >100000 *E. coli* cfu/100ml, the most contaminated of which were taken from discharge pipes between Pittenweem and Anstruther.

Figure 9.1 shows the relative locations of the most significant findings. Where the bacterial concentration is labelled, scientific notation is written in digital format as this is the only format recognised by the mapping software. So, where normal scientific notation for 1000 is 1×10^3 , in this case it would be written as 1E+3.

In summary, identified sources of most significant contamination are:

- Dreel burn at the eastern end of the shellfish bed
- Sewage and septic tank outfall pipes
- Heavy boat traffic from Pittenweem and Anstruther harbours
- Potential runoff from any slurry or sludge application to golf course greens or other agricultural land.



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Figure 9.1 Summary of shoreline observations

10. Overall Assessment

Human sewage inputs

Three large settlements are directly adjacent to the shellfish bed. St Monan's at the western end has a population of 1,450, Pittenweem in the centre has a population of 1,750 and Anstruther Wester at the eastern end has a population of 3,400 (2001 census). Two major sewage treatment works in the area discharge screened, untreated sewage into the production area. St. Monan's STW, on the western end of the shellfish bed, discharges a lower volume than does Billowness STW which is located nearer Anstruther and further offshore.

There are a number of discharges carried via Dreel Burn, including screened sewage from Arncroach STW. A further sewage discharge lies to the northeast within the Forth Estuary: Anstruther production area.

The locations of these relative to historical sampling results can be seen in Figure 7.3. Sampling results appear to be highest to the northeast of each discharge which is consistent with a generally northeast tidal drift.

Agricultural inputs

The land surrounding the settlements along the Pittenweem coastline is primarily used for arable agriculture. No livestock were observed during the shoreline survey and livestock density is thought to be relatively low overall. There is a pig farm situated 30 metres from the shoreline of Cellardyke. This could affect eastern end of the shellfish bed on a rising tide.

Slurry application is carried out on the surrounding fields and this could be considered a significant source of contamination to the shellfish bed. However, the location, frequency and timing of application would be unpredictable and so this could not be considered in establishing a sampling plan.

Wildlife inputs

Wildlife such as cetaceans, water birds and seals are likely to be resident in or visit the area, but not in large numbers. During the shoreline survey 150 gulls and half a dozen ducks, cormorants and oyster catchers were observed. There is a grey seal (*Halichoerus grypus*) colony (approximately 5,900 seals in 1994) resident in the autumn and winter on the Isle of May, 5 miles off shore to the shellfish bed. The Isle of May is also resident to 200,000 migratory birds in spring and summer. Overall, the wildlife impacts to the shellfish bed at Pittenweem are likely to be localized, minor and unpredictable and will therefore not be explicitly taken into account in determining the sampling plan.

Seasonal variation

The historical monitoring dataset was analysed and a scatter plot showed there are no patterns in seasonal variation. As little is known about the livestock husbandry of the area, it was not possible to assess seasonal variation in livestock numbers.

There is likely to be an increase in human population during the spring and summer months when tourists and birdwatchers stay in the area. While the fishing fleet and commercial ships will be active year round, pleasure boat traffic is likely to be seasonal with activity highest in summer.

Rivers and streams

Dreel Burn discharges approximately 0.18 km north of the shellfish bed. A water sample taken during the shoreline survey contained a high concentration of *E. coli* (30,000 *E. coli* cfu/100ml). Flow measurements taken on the day showed an overall loading of 6.3×10^{13} *E. coli* per day. The sewage discharge at Arncroach discharges to this burn, as well as an indeterminate number of smaller dwellings and farms, making this a significant source of faecal contamination to the shellfishery.

In addition to streams, fresh water discharges from six outfall pipes were also sampled and varied from <100 to >100,000 *E. coli* cfu/100ml. The highest *E. coli* sample was taken from a leaking outfall pipe adjacent to the centre of the shellfish bed. The second highest *E. coli* result (16,000 *E. coli* cfu/100ml) was taken from an outfall pipe adjacent to the stream mentioned above. It is therefore likely that the stream and the outfall pipes that input into the Pittenweem shellfish bed will have a relatively high effect on the bacterial contamination of the shellfish.

Rainfall

Rainfall patterns at Belliston (the nearest rainfall station) show that rainfall in the area is sporadic with no overall pattern. It would therefore be difficult to predict when an increase in rainfall would wash a flush of bacteria from the surrounding land into the production area.

Analysis of results

Historic shellfish hygiene monitoring results for Surf clams are available from 2004 to present, with samples collected from locations scattered throughout the Pittenweem and Anstruther production areas. Results varied greatly, ranging from 20 to 3500 *E. coli* (mpn/100g). There was an apparent trend to lower results further from the shoreline.

Seawater samples were taken from four points along the shore with results ranging from 7 to 100 *E. coli* cfu/100ml, consistent with an equivalent Class B standard. Freshwater samples taken from watercourses and discharges showed highly contaminated water entering the production area.

The highest levels of contamination were found in samples taken on 7 June 2006. Rainfall recorded at Belliston for the week prior showed that this date fell 7 days into a period of dry weather, so this could not be related to rainfall.

As noted in the previous sections the level of contamination and calculated bacterial loading for the single stream discharging into the far eastern end of the Pittenweem shellfish bed is fairly high.

Summary

Factors of particular relevance to the sampling plan are as follows:

- Outfalls from St. Monan's and Anstruther Billowness STW on the shellfish bed.
- Contamination levels in the Dreel Burn, which discharges into the eastern end of the shellfish bed.
- Potential contamination from heavy boat traffic in and around Pittenweem and Anstruther harbours and the Firth of Forth (commercial shipping area), with no pump out facilities available.
- Potential for overflows at sewage pumping stations.

11. Recommendations

Historically, small areas of the clam bed have been given fast track classifications as required and samples have been submitted from areas outside the identified clam bed. A series of samples taken in 2003 and 2004 describe a logical outer boundary for identifying a production area. However, it is apparent that contamination levels within and just outside Anstruther Harbour may be higher than on other parts of the fishery. As this is within the area of the identified clam bed, it is recommended that this area be excluded from the production area.

It is recommended that the production area be established as the area bounded by lines drawn between NO 5619 0300 and NO 5700 0300 and between NO 5700 0300 and NO 5700 0000 and between NO 5700 0000 and NO 5024 0000 extending to MHWS and specifically excluding the harbours at St. Monans and Pittenweem.

There are two large sewage discharges located on the identified shellfish bed, and samples obtained from areas to the northeast of these discharges have been more contaminated than those from other areas.

While the highest levels of contamination were found in two samples taken on the western end of the shellfish bed, these were collected on the same date and so may not be indicative of higher overall levels of contamination in that area.

It was recommended that an RMP with a 250 m tolerance zone (NO 5656 0212) be placed to the northeast of the Anstruther Billowness discharge, south of Anstruther Harbour. This location was proposed for a number of reasons:

- It lies near the larger of the two sewage discharges on the shellfish bed.
- It lies nearer potential overflows at the sewage pumping stations in and around Anstruther.
- A larger number of samples have come from here than from other areas of the shellfish bed, indicating the area is routinely productive.
- It is nearer to the mouth of Dreel Burn.
- It is near to Anstruther Harbour, so even if boats are dredging further out on the bed it will be a convenient location to dredge for a sample on the way back to harbour making compliance more likely.

However, after receiving feedback from Fife Council and harvesters, Food Standards Agency Scotland indicated that the use of a single RMP with 250m tolerance would not adequately accommodate the needs of the fishery. It was noted that the clam bed lies in an area of shifting sands and that the concentration of harvestable stock may move around considerably over even a short span of time.

Therefore, after consideration of alternative methods of monitoring that would be both practical and scientifically valid, a representative monitoring zone was determined to be the most workable solution.

It is recommended that this zone be established between the two sewage outfalls on the shellfish bed and is described as the area bounded by lines drawn between NO 5374 0188 to NO 5373 0160 to NO 5676 0206 to NO 5669 0234. The location of the zone relative to the shellfish bed and production area is illustrated in Figure 11.1. Due to the size of the zone and the fact that it was developed as an accommodation rather than a primary choice for monitoring, it is recommended that no sampling tolerance be allowed. All samples submitted for classification monitoring must therefore be dredged from wholly within the RMZ. The midpoint of the dredge should be reported on the sampling form as the location of sample.

Sampling should be undertaken monthly as the fishery is active year round and the full area has not held a continuous classification for sufficient time to warrant a stability analysis.

The spatial effects of monitoring using the RMZ should be examined in a point in the future when the sanitary survey is reviewed.

The locations of the recommended production area and RMP can be found in Figure 11.1.

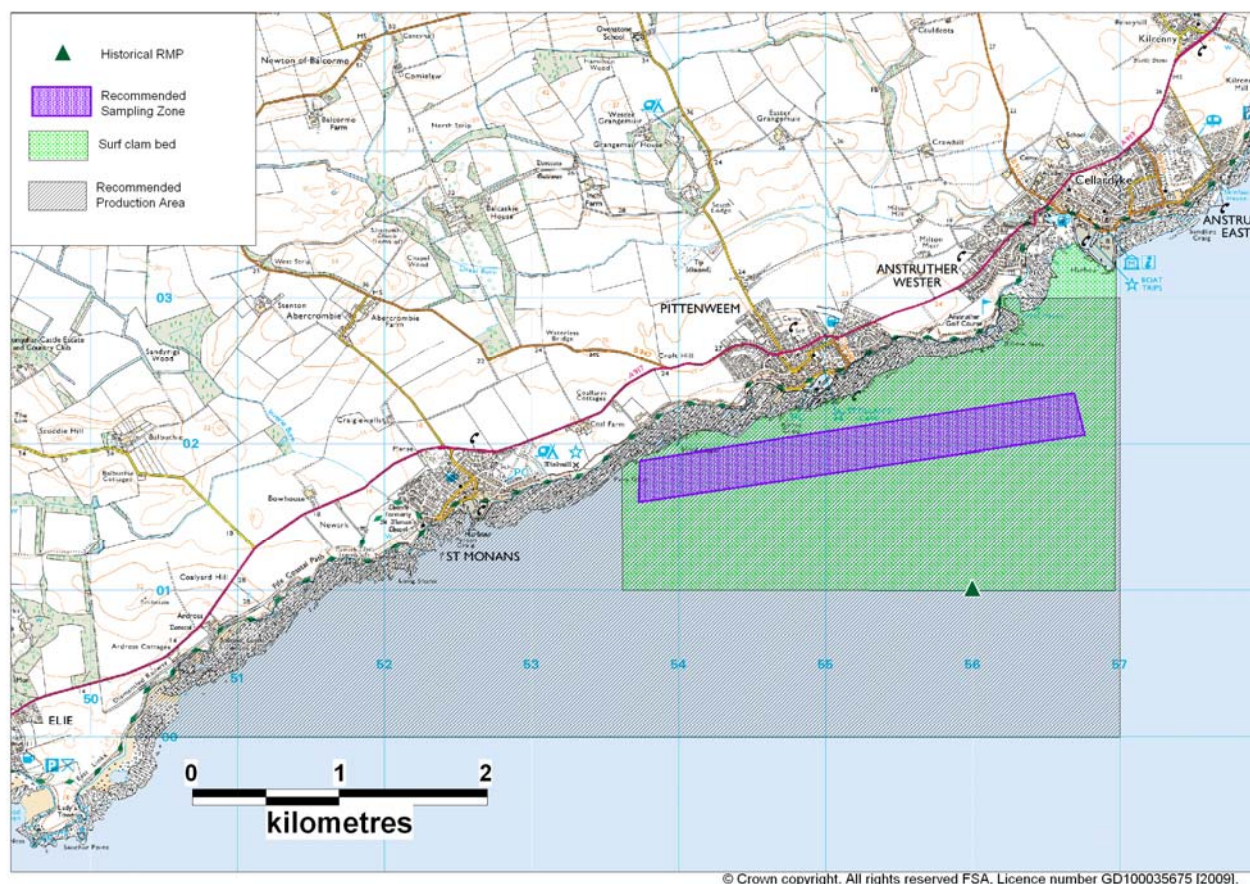


Figure 11.1 Map of Forth Estuary: Pittenweem recommendations

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13. List of Figures and Tables

Table 2.1	Forth Estuary: Pittenweem shellfish bed	3
Table 3.1	Discharges identified by Scottish Water	4
Table 3.2	Discharge consents held by SEPA	4
Table 3.3	Observations of potential sewage discharges	6
Table 6.1	River flow and loading – Pittenweem	12
Table 7.1	Summary historical results from Pittenweem	14
Table 7.2	SEPA Faecal coliform results for shore mussels	18
Table 8.1	Maximum flood tide flow and direction on a large spring tide at SN022A	23
Figure 1.1	Location of Forth Estuary: Pittenweem	1
Figure 1.2	Human population of Forth Estuary: Pittenweem	2
Figure 2.1	Forth Estuary: Pittenweem shellfish bed	3
Figure 3.1	Sewage discharges at Forth Estuary: Pittenweem	7
Figure 4.1	Wildlife observations during the shoreline survey and location of the pig farm at Pittenweem	9
Figure 5.1	Total annual rainfall at Belliston 2003 – 2007	10
Figure 5.2	Mean total monthly rainfall at Belliston 2003 – 2007	11
Figure 6.1	Location of the Dreel Burn at Pittenweem	12
Figure 7.1	Box Plot of <i>E. coli</i> result by area	15
Figure 7.2	Scatterplot of Log <i>E. coli</i> result for surf clams vs. collection date by site	15
Figure 7.3	<i>E. coli</i> result (mpn/100g) by sampling location for surf clams at Pittenweem	17
Figure 7.4	Shellfish Growing Water and monitoring points	20
Figure 8.1	Forth Estuary: Pittenweem bathymetry	21
Figure 8.2	Forth Estuary: Pittenweem	21
Figure 8.3	Tidal curves for Anstruther Easter	22
Figure 8.4	Maximum ebb tide flow and direction on a large spring tide at SN022A	24
Figure 8.5	Maximum flood tide flow and direction on a large spring tide at SN022A	24
Figure 9.1	Summary of shoreline observations	26
Figure 11.1	Pittenweem recommendations	31

Appendices

1. **Sampling Plan**
2. **Statistical Data**
3. **Shoreline Survey Report**

Appendix1: Sampling Plan for Forth Estuary: Pittenweem

PRODUC-TION AREA	SITE NAME	SIN	SPECIES	TYPE OF FISH-ERY	NGR OF RMP	EAST	NORTH	TOLER-ANCE (M)	DEPTH (M)	METHOD OF SAMPLING	FREQ OF SAMPLING	LOCAL AUTHORITY	AUTHORISED SAMPLER(S)	LOCAL AUTHORITY LIAISON OFFICER
Forth Estuary: Pittenweem	Pittenweem	FF 073	Surf Clams	Wild Harvest	RMZ as described below			0	Na	Dredge	Monthly	Fife Council	Nan Knight Alistair Little Ronnie Vaughan	John Lecyn

- Samples shall be dredged from an area bounded by lines drawn between NO 5374 0188 to NO 5373 0160 to NO 5676 0206 to NO 5669 0234.
- The entire sampling dredge must be completed within this zone as no sampling tolerance is allowed.
- The midpoint of the dredge should be recorded as the sampling location on the sample submission form.

Statistical Data

Minitab Output:

Descriptive Statistics: *E. coli* results (*E. coli* mpn/100g)

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
<i>E. coli</i>	28	0	721	183	968	20	160	310	1013	3500

Two-Sample T-Test and CI: for Log *E. coli* result by site

Two-sample T for Logresult

Site	N	Mean	StDev	SE Mean
Anstruther	56	2.419	0.609	0.081
Pittenweem	31	2.421	0.581	0.10

Difference = mu (Anstruther) - mu (Pittenweem)
Estimate for difference: -0.002
95% CI for difference: (-0.267, 0.262)
T-Test of difference = 0 (vs not =): T-Value = -0.02 P-Value = 0.987 DF = 64

ANOVA comparison of (log10) shellfish growing waters results by quarter, Ardross

Source	DF	SS	MS	F	P
Quarter Ardross	3	0.955	0.318	1.01	0.410
Error	21	6.644	0.316		
Total	24	7.599			

S = 0.5625 R-Sq = 12.57% R-Sq(adj) = 0.08%

Individual 95% CIs For Mean Based on Pooled StDev

Level	N	Mean	StDev
Q1	6	2.6130	0.4434
Q2	6	2.5339	0.4335
Q3	6	3.0097	0.7689
Q4	7	2.9053	0.5424

-----+-----+-----+-----+
(-----*-----)
(-----*-----)
(-----*-----)
(-----*-----)
-----+-----+-----+-----+
2.40 2.80 3.20 3.60

Pooled StDev = 0.5625

ANOVA comparison of (log10) shellfish growing waters results by quarter, Caiplie

Source	DF	SS	MS	F	P
Quarter Caiplie	3	0.469	0.156	0.53	0.666
Error	19	5.581	0.294		
Total	22	6.049			

S = 0.5420 R-Sq = 7.75% R-Sq(adj) = 0.00%

Individual 95% CIs For Mean Based on Pooled StDev

Level	N	Mean	StDev
Q1	5	2.1882	0.3004

---+-----+-----+-----+-----
(-----*-----)

Q2	5	2.1481	0.3727	(-----*-----)
Q3	6	2.4185	0.7968	(-----*-----)
Q4	7	2.4792	0.4983	(-----*-----)

				-----+-----+-----+-----
				1.75 2.10 2.45 2.80

Pooled StDev = 0.5420

**Paired T-Test comparison of (log10) shellfish growing waters results from
Caipie and Ardross (where both were sampled during the same quarter)**

Paired T for Logres Caipie paired - Logres Ardross paired

	N	Mean	StDev	SE Mean
Logres Caipie paired	23	2.328	0.524	0.109
Logres Ardross paired	23	2.774	0.577	0.120
Difference	23	-0.446	0.911	0.190

95% CI for mean difference: (-0.840, -0.052)

T-Test of mean difference = 0 (vs not = 0): T-Value = -2.35 P-Value = 0.028

Shoreline Survey Report



Forth Estuary: Pittenweem FF 073

Restricted Scottish Sanitary Survey Project



Shoreline Survey Report

Production. Area: Firth of Forth
Site Name: Pittenweem
SIN: FF 073 189 19
Species: Surf Clams (*Spisula solida*)
Harvester: Independent boats fishing this area
Local authority: Fife Council
Status: New application

Date Surveyed:	29/09/08	
Surveyed by:	John Lecyn	Fife Council
	Nan Knight	Fife Council
	Alistair Little	Fife Council
	Ronnie Vaughan	Fife Council
	Graham Ewen	Food Standards Agency
	Neil Leitch	Food Standards Agency

Existing RMP: N/A
Area Surveyed: See Figure 1.

Weather observations

Dry, partly cloudy with wind from the west increasing to force 7 in strength during the survey period. Seas calm initially but became increasingly rough during the survey period.

Site Observations

Fishery

The area is currently fished for surf clams (*Spisula solida*). Natural surf clam beds are found in sub tidal sandy beds between rocky outcrops. The surf clam beds are inaccessible other than by boat. The surf clams are harvested all year round.

Sewage/Faecal Sources

The area surveyed has three towns in the area. Two towns, Anstruther and Pittenweem are within the survey area. The town of Cellerdyke is joined to Anstruther but lies to the east and is just outside the survey area. The village of St. Monans lies to the west and just outside the survey area but close to the survey boundary. A number of sewage outfall pipes and septic tanks were recorded during the survey.

The tourist boat that crosses daily between Anstruther and the Isle of May (May to September) is licensed to carry 100 passengers and has no sewage holding facility.

There is no sewage pump out facility for vessels at Pittenweem Harbour.

Seasonal Population

Anstruther and Pittenweem have a significant number of holiday homes and second homes. There is a seasonal static caravan park in Anstruther that is open from Easter to October. Weekend sailors who rarely put to sea but will use the boat as sleeping accommodation also use the pleasure craft in Anstruther harbour. In June July and August there are a significant number of day trip visitors to Anstruther and Pittenweem.

Boats/Shipping

Anstruther has a harbour with fishing and pleasure boats and Pittenweem has an active fishing fleet. The Firth of Forth is also a commercial shipping area primarily for oil tankers headed for the Grangemouth oil refinery.

Anstruther harbour master advised that there are a maximum number of 140 berths for small pleasure craft in the harbour. These berths are primarily for small pleasure craft e.g. yachts. There are some small commercial fishing boats in this harbour. There is one tourist boat crossing daily (weather permitting) between Anstruther and the Isle of May between May and September.

Pittenweem harbour master advised that there are approximately 40 commercial fishing boats operating from the harbour. The fishing boats are small with few being over 10 metres in length. There are fuel and ice supplies in the harbour for use by the fishing vessels.

Land Use

Land use in the survey area is primarily arable. Muck spreading is carried out on the arable fields at various times of the year. To the east of Anstruther and Cellardyke there is a pig farm extending to some 30 metres from the shoreline. The pig farm lies just outside the survey area. There is a 9-hole golf course to the west of Anstruther that runs parallel to the shore towards Pittenweem.

Wildlife/Birds

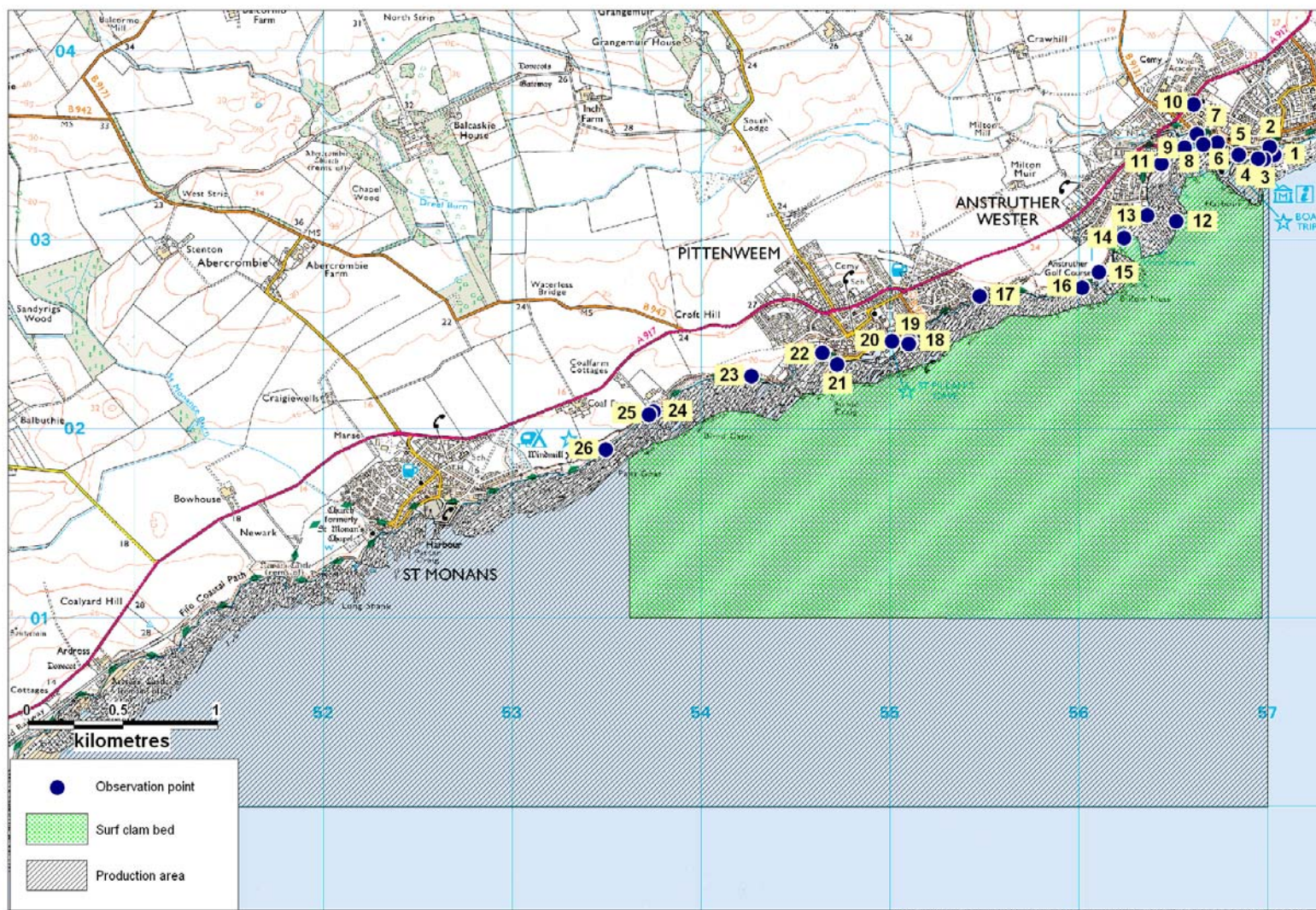
The Firth of Forth is an important site for migratory birds. The Isle of May lies 6 miles off the Anstruther coast and during the breeding season is host for several species of birds including Puffins, Terns, Eider duck and Kittiwakes. The Isle is also a breeding area for grey seals. During the shoreline survey there was an estimated 120 gulls, 10 cormorants and 20 eider ducks in the area.

Other comments

The Local Authority receives a number of complaints from residents in Anstruther and Pittenweem relating to sewage on the beaches especially after heavy rain. The complaints are investigated by the local authority but are often referred to Scottish Water who has responsibility to carry out their own investigations and resolve issues relating to faults in the sewerage system.

Observations can be found in Table 1.

Figure 1. Map of Shoreline Observations



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Table 1. Shoreline Observations

No.	Date	NGR	East	North	Associated photograph	Description
1	29/09/08	NO 57036 03454	357036	703454		Sample 1 seawater (Salinity 35ppt) Approx. 25 birds mixed gulls and ducks
2	29/09/08	NO 57010 03496	357010	703496	Figures 3 & 4	Evidence of outfall pipe and sewage
3	29/09/08	NO 56980 03430	356980	703430	Figure 5	Anstruther Harbour (east) Evidence of dog faeces on the beach
4	29/09/08	NO 56951 03432	356951	703432	Figures 6 & 7	Anstruther Harbour (west) a maximum of 140 pleasure and working boats. No sewage pump out facility in harbour. Outfall noted but inaccessible for safety reasons
5	29/09/08	NO 56848 03454	356848	703454	Figure 8	Second outfall into harbour. No evidence of sewage
6	29/09/08	NO 56736 03518	356736	703518	Figure 9	Outfalls below public toilets. No evidence of sewage.
7	29/09/08	NO 56625 03563	356625	703563	Figure 10	Evidence of incomplete screening at treatment works on shore
8	29/09/08	NO 56661 03508	356661	703508	Figure 11	Outfall pipe on shore. Flow rate estimated at 0.2 litres/ second (water sample 2). Estimated 100 gulls in close vicinity. Commercial shipping evident at approx. 2 Km offshore
9	29/09/08	NO 56559 03491	356559	703491	Figure 12	The Dreel Burn, manhole cover nearby Water sample 3 (Salinity 3ppt)
10	29/09/08	NO 56607 03721	356607	703721	Figure 13	Unknown outfall. Pipe diameter 52 cm (Water sample 9)
11	29/09/08	NO 56437 03407	356437	703407	Figure 14	Slipway with evidence of land runoff
12	29/09/08	NO 56517 03102	356517	703102	Figures 15 & 16	Unknown outlet (new construction) No flow or evidence of sewage. 300mm diameter
13	29/09/08	NO 56363 03132	356363	703132	Figure 17	Drainage holes in wall below golf course car park.
14	29/09/08	NO 56241 03014	356241	703014		Water sample 4 (Salinity 35ppt) Approx. 15 gulls and 10 cormorants or shags in area.
15	29/09/08	NO 56105 02831	356105	702831	Figures 18, 19 & 20	Sewage pumping station. General view of beach near pumping station. Old and inaccessible outfall line.
16	29/09/08	NO 56017 02750	356017	702750	Figure 21	Location of manhole possibly connected to unknown building on golf course.
17	29/09/08	NO 55475 02705	355475	702705	Figures 22, 23 & 24	Outfall pipe, 110mm in diameter, close to shore (Water sample 5) Also the location of a second outfall pipeline running out to sea. End of out fall underwater. This pipe had the strong odour of sewage from leaking joints in the pipe. Water sample 10 taken from leaking pipe. Evidence of live mussels in this area.

No.	Date	NGR	East	North	Associated photograph	Description
18	29/09/08	NO 55104 02469	355104	702469	Figure 25	Location of outfall with seepage. No evidence of sewage.
19	29/09/08	NO 55100 02452	355100	702452	Figures 26 & 27	Unknown pipeline. No obvious outfall due to incoming tide. Manhole associated with pipeline.
20	29/09/08	NO 55010 02468	355010	702468	Figure 28	Pittenweem Harbour and fishing fleet.
21	29/09/08	NO 54720 02344	354720	702344	Figure 29	Seawater sample (Water sample 6)
22	29/09/08	NO 54641 02404	354641	702404	Figures 30 & 31	Pipeline believed to be an overflow for a mid line pumping station that pumps sewage to the pumping station at either Anstruther 15) or St Monans pumping station. Note the evidence of backflow on the manhole above the pumps. Audible noises of flow and pumps below manhole.
23	29/09/08	NO 54266 02282	354266	702282	Figures 32 & 33	Outfall (Diameter 150 mm) 10 metres above shoreline with minimal flow.
24	29/09/08	NO 53747 02095	353747	702095	Figure 34	St Monans pumping station
25	29/09/08	NO 53723 02078	353723	702078	Figure 35	Water sample 7 near St Monans pumping station (Salinity 42ppt) 2 oystercatchers. Tide flooding
26	29/09/08	NO 53495 01892	353495	701892	Figures 36 & 37	Water outlet believed to be from a natural spring at Coal Farm. Not accessible for flow rate measurement. Brown deposit believed to be iron (Water sample 8)

Photos referenced in the table can be found attached as Figures 3 - 37.

Sampling

Water samples were collected at sites marked on the map (Figure 2). Bacteriology results follow in Table 2. On the day of the shoreline survey weather conditions were deemed unsafe to go out on the boat and collect shellfish samples. Therefore no shellfish samples were collected during the shoreline survey.

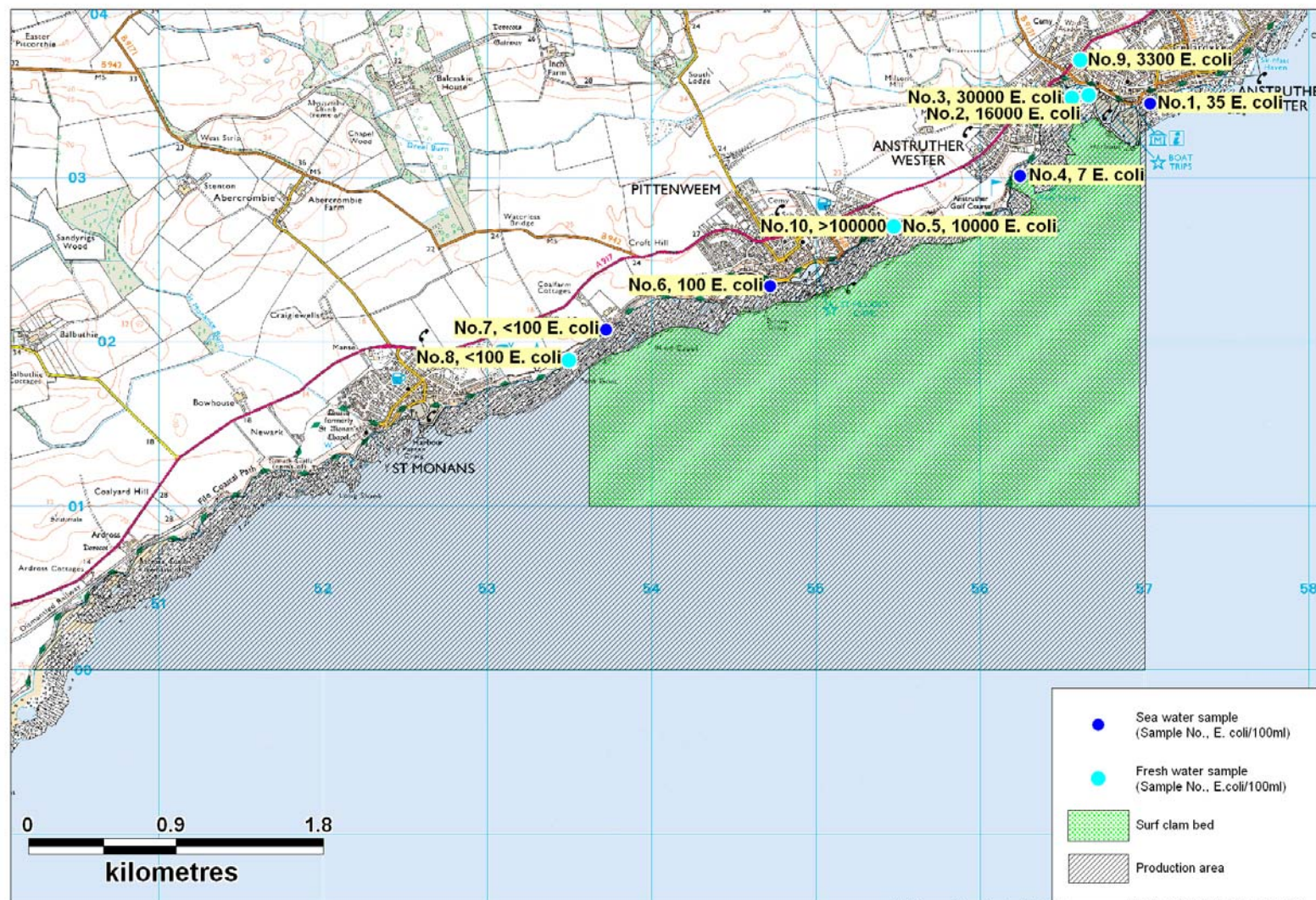
Seawater samples were tested for salinity using a hand held refractometer. These readings are recorded in Table 1 as salinity in parts per thousand (ppt).

Samples were also tested for salinity by the laboratory using a salinity meter under more controlled conditions. These results are shown in Table 2, given in units of grams salt per litre of water. This is equivalent to ppt.

Table 2. Water Sample Results

No.	Date	Grid Ref	Type	<i>E. coli</i> (cfu/100 ml)	Salinity (g/L)
1	29/09/2008	NO 57036 03454	Seawater	35	32.6
2	29/09/2008	NO 56661 03508	Freshwater	16000	-
3	29/09/2008	NO 56559 03491	Freshwater	30000	-
4	29/09/2008	NO 56241 03014	Seawater	7	33.0
5	29/09/2008	NO 55475 02705	Freshwater	10000	-
6	29/09/2008	NO 54720 02344	Seawater	100	32.1
7	29/09/2008	NO 53723 02078	Seawater	<100	35.1
8	29/09/2008	NO 53495 01892	Freshwater	<100	-
9	29/09/2008	NO 56607 03721	Freshwater	3300	-
10	29/09/2008	NO 55475 02705	Freshwater	>100000	-

Figure 3. Water sample results map



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Photographs



Figure 3. Outfall pipe



Figure 4. Evidence of sewage



Figure 5. Anstruther Harbour (East)



Figure 6. Anstruther Harbour (West)



Figure 7. Outfall pipe (Inaccessible)



Figure 8. Outfall pipe (Inaccessible)



Figure 9. Outfall pipe below public toilets



Figure 10. Evidence of incomplete screening at treatment works



Figure 11. Outfall pipe on shoreline (Water sample 2)



Figure 12. Drael Burn with manhole cover nearby (Water sample 3)



Figure 13. Unknown outfall (Water sample 9)



Figure 14. Slipway and evidence of runoff



Figure 15. Unknown outlet (new construction, no flow)



Figure 16. Unknown outfall (new construction, no flow)



Figure 17. Drainage holes in wall below golf course car park



Figure 18. Sewage pumping station



Figure 19. General view of beach near pumping station



Figure 20. Old and inaccessible outfall pipe



Figure 21. Manhole possibly connected to unknown building on golf course



Figure 22. Outfall pipe (Water sample 5)



Figure 23. Outfall pipe running into the sea. End of outfall under water



Figure 24. Outfall pipe (Figure 35) leaking, strong smell of sewage (Water sample 10 taken)



Figure 25. Location of outfall with seepage



Figure 26. Unknown pipeline, no obvious outfall due to incoming tide



Figure 27. Manhole cover associated with outfall pipe in Figure 38



Figure 28. Pittenweem Harbour and fishing fleet



Figure 29. Seawater sample 6



Figure 30. Pipeline believed to be overflow for a mid line pumping station that pumps sewage to the pumping station at Anstruther or St Monans



Figure 31. Manhole cover associated with overflow pipe in Figure 42



Figure 32. Location of outfall pipe



Figure 33. Outfall and seepage from Figure 44



Figure 34. St Monans pumping station



Figure 35. Location of seawater sample 7 near St Monans pumping station



Figure 36. Water outlet believed to be natural spring at Coal Farm (Water sample 8)



Figure 37. Brown deposit believed to be iron from Figure 48