EC Regulation 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SANITARY SURVEY REPORT

Porthallow Cove (Cornwall)

2009

Cover photo: Porthallow Cove.

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STATEMENT OF USE: This report provides information from a study of the information available relevant to perform a sanitary survey of bivalve mollusc production areas in Porthallow Cove. Its primary purpose is to demonstrate compliance with the requirements for classification of bivalve mollusc production areas, as determined in EC Regulation 854/2004 laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption. The Centre for Environment, Fisheries & Aquaculture Science (Cefas) undertook this work on behalf of the Food Standards Agency (FSA).

DISSEMINATION STATUS: Food Standards Agency, Falmouth and Truro Port Health Authority, Cornwall Sea Fisheries, Environment Agency.

CONTENTS

1. INTRODUCTION

LEGISLATIVE REQUIREMENT

Filter feeding, bivalve molluscan shellfish (e.g. cockles, mussels) retain and accumulate a variety of microorganisms from their natural environments. Since filter feeding promotes retention and accumulation of these microorganisms, the microbiological safety of bivalves for human consumption depends heavily on the quality of the waters from which they are taken (Bell, 2006).

When consumed raw or lightly cooked, bivalves contaminated with pathogenic microorganisms may cause infectious diseases (e.g. Norovirus-associated gastroenteritis, Hepatitis A and Salmonellosis) in humans. Infectious disease outbreaks are more likely to occur in coastal areas, where bivalve mollusc production areas (BMPAs) are impacted by sources of microbiological contamination of human and /or animal origin.

In England and Wales, fish and shellfish constitute the fourth most reported food item causing infectious disease outbreaks in humans after poultry, red meat and desserts (Hughes *et al*., 2007).

The risk of contamination of bivalve molluscs with pathogens is assessed through the microbiological monitoring of bivalves. This assessment results in the classification of BMPAs, which determines the level of treatment (e.g. purification, relaying, cooking) required before human consumption of bivalves (Lee and Younger, 2002).

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

The Centre for Environment Fisheries & Aquaculture Science (Cefas) is performing sanitary surveys for new BMPAs in England and Wales, on behalf of the Food Standards Agency (FSA). The purposes of the sanitary surveys are to demonstrate compliance with the requirements stated in Annex II (Chapter II paragraph 6) of EC Regulation 854/2004, whereby ‘if the competent authority decides in principle to classify a production or relay area it must:

(a) make an inventory of the sources of pollution of human or animal origin likely to be a source of contamination for the production areas;

(b) examine the quantities of organic pollutants which are released during the different periods of the year, according to the seasonal variations of both

human and animal populations in the catchment area, rainfall readings, waste-water treatment, etc.;

(c) determine the characteristics of the circulation of pollutants by virtue of current patterns, bathymetry and the tidal regime in the production area; and

(d) establish a sampling programme of bivalve molluscs in the production area which is based on the examination of established data, and with a number of samples, a geographical distribution of the sampling points and a sampling frequency which must ensure that the results of the analysis are as representative as possible for the area considered.'

EC Regulation 854/2004 also specifies the use of *Escherichia coli* as an indicator of microbiological contamination in bivalves. This bacterium is present in animal and human faeces in large numbers and is therefore indicative of contamination of faecal origin.

In addition to better targeting the location of RMPs and frequency of sampling for microbiological monitoring, it is believed that the sanitary survey may serve to help to target future water quality improvements and better analyse their effects on BMPAs. Improved monitoring should lead to improved detection of pollution events and identification of the likely sources of pollution. Remedial action may then be possible either through funding of improvements in point sources of contamination or as a result of changes in land management practices.

This sanitary survey was prompted by an application for microbiological monitoring and classification of rope grown mussels (*Mytilus* spp.) at sites in the north and south of Porthallow Cove. The assessment is supported by published relevant information for the adjacent hydrological catchments and the Porthallow Cove coastal area together with new information obtained from a shoreline survey performed in the vicinity of the two proposed new sites (submerged longline operations) and a bacteriological survey of microbiological variation between the sites. In addition, statistical analysis of historical data from the bathing waters monitoring programme and rainfall data was undertaken. The sampling plan presents information on the recommended location of a monitoring point and sampling frequency for a new harvesting area for *Mytilus* spp. and recommends boundaries for the overall production area.

SITE DESCRIPTION

Porthallow is a small village in Cornwall, on the east coast of the Lizard Peninsula, situated at the mouth of Porthallow stream (Figure 1.1). The area is largely agricultural, almost entirely undeveloped, with no heavy Industry (Figure 1.2). There is a small resident population, which increases during the main holiday season due to tourism. The two proposed mussel aquaculture longline sites are situated approximately 0.5km offshore from the coast in Porthallow Cove (Figure 1.1). The proposed harvesting area lies within the Fal and Helford Special Area of Conservation (SAC), which is predominantly designated due to marine features.

Figure 1.1 Location of proposed rope grown mussel harvesting areas in Porthallow Cove.

Figure 1.2 Location of Porthallow Cove.

Google Earth ™ mapping service, 2009.

2. PROPOSED SHELLFISHERY

Porthallow Cove has not previously been classified for the production and harvesting of bivalve molluscs. Cornish Mussels plan to harvest rope-grown farmed mussels (*Mytilus* spp.*)* (Figure 2.1) at two new sites in Porthallow Cove: Porthallow North and Porthallow South (Figure 1.1). Porthallow North site covers approximately 1.0km^2 and Porthallow South site covers approximately 0.4km^2. Lines will be orientated approximately east-west at both sites. Divers will be employed when positioning the anchorage to avoid damaging sensitive habitats such as underwater reefs. A 300m wide navigable channel will separate the two sites to allow access to the beach (Steve Kestin, pers. com.).

***Figure 2.1 Rope*-grown *Mytilus* spp.**

N.B. the rope-grown mussel operation shown in the above Image is not at Porthallow but is given for illustration purposes.

Figure 2.2 Porthallow Cove, looking north-east from where Porthallow Stream enters the Bay.

Permission to establish a new shellfish farm has been granted by the Crown Estate. Initially three longlines will be established in March 2009, located at Porthallow North site. In 2010, an additional two lines are to be set up at the South site. The harvester intends to monitor the trial lines for a period of 12 months before expanding the operation. The maximum number of lines proposed in the longer term is 10 double-headed lines at the North site and five double-headed lines at the South site. Local spat fall is considered to be sufficient for the farm's requirement, using natural spat collection on the new ropes. However, if it proves necessary, seed mussel from King Harry Passage (Falmouth) will be used, but no intermediate site for growing-on will be needed.

It is anticipated that the production cycle will be approximately 18 months, with one restocking operation at approximately 6 months, during the autumn of the first year of settlement. Harvesting will take place using an hydraulic arm from a vessel. Harvesting is expected to take place year-round and there are no restrictions on the operation on stock conservation grounds. Production is anticipated to be in the region of 50 tonnes per annum.

Falmouth Port Health is the Local Enforcement Authority for the purposes of food hygiene monitoring.

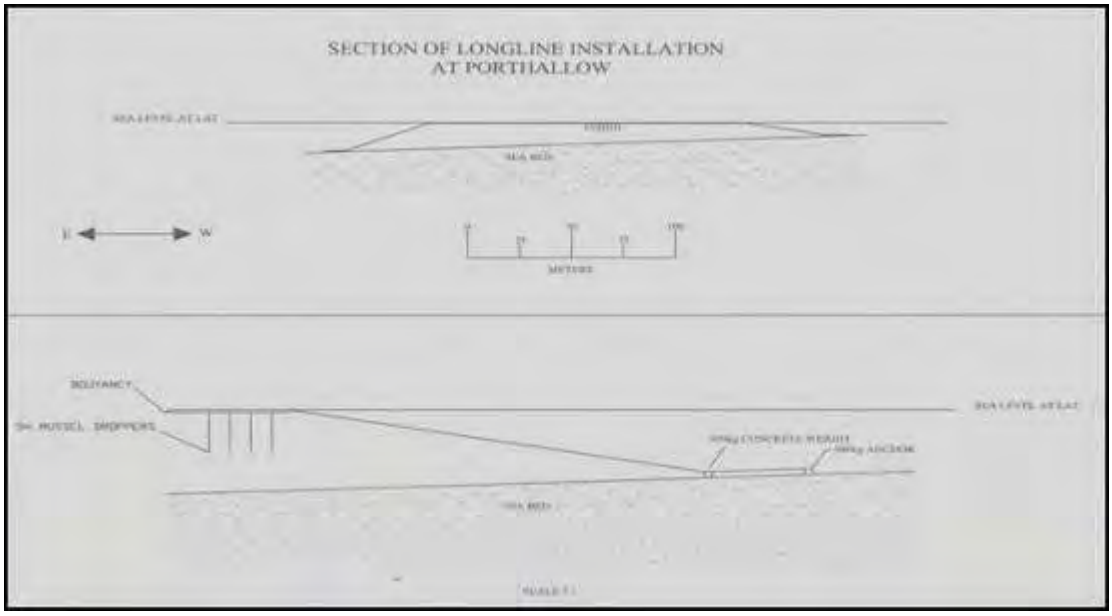

Figure 2.3 Diagram of proposed mussel longlines at Porthallow Cove.

3. OVERALL ASSESSMENT

AIM

This section presents an overall assessment of pollution sources on the microbiological contamination of rope-grown mussels in Porthallow Cove, as a result of a sanitary survey undertaken by Cefas on behalf of the Food Standards Agency. Its main purpose is to inform the sampling plan for the microbiological monitoring and classification of a bivalve mollusc production area (BMPA) at this location. The survey was prompted by an application for microbiological monitoring and classification of *Mytilus* spp. in Porthallow Cove.

SHELLFISHERIES

There are no existing established BMPAs at Porthallow Cove and therefore no historic microbiological data associated with shellfish for the area. The legislation[1] requires that the sampling plan must be as representative as possible and therefore a bacteriological survey[2], using bagged shellfish, has been undertaken in support of this sanitary survey to inform the location of the representative monitoring point (RMP) in the proposed sampling plan[3] for the production area.

POLLUTION SOURCES

Given the rural location of Porthallow, which has a small resident population[5], and the undeveloped nature of the wider hydrological catchment area, there are few sewage discharges in the locality[4]. However, the local population increases during the main holiday season due to tourism[5] and this will increase load to the sewage discharges accordingly. The main potential point sources of microbiological contamination in the Porthallow North and South BMPAs are the continuous effluent discharge from Porthallow sewage treatment works (STW) and the intermittent sewage discharge from Porthallow pumping station (PS)[4]. The sewage works continuous effluent discharge however is disinfected with ultraviolet (UV) light. Fortnightly monitoring data indicates it has a consistently low faecal coliform content (geometric mean=69CFU $100ml^{-1}$)[4] so this may only pose a significant impact in the event of a breakdown with the works operation. The intermittent discharge from the sewage pumping station (PS) in Porthallow is permitted to discharge both storm and emergency flows near the mouth of Porthallow Stream, approximately 500m southwest of the proposed mussel lines. There is no monitoring of this intermittent discharge and therefore no information on the frequency or volume of discharges from this location.

There are some un-sewered private dwellings in Porthallow village and further inland; as such these are small discharges and some discharge to soakaways.

[1] EC Regulation 854/2004
[2] Appendix XIV
[3] Section 4
[4] Appendix VII
[5] Appendix I

Collectively these are considered insignificant and whilst under certain conditions they may collectively contribute to background levels in the stream they are unlikely to impact upon the production area.

There are two discharges from the Cornish Sea Salt Company premises. One small ($0.8m^3$ day^{-1}) discharge is of secondary treated sewage effluent from the office and canteen, and the other is a larger ($358m^3$ day^{-1}) trade effluent consisting of salt-depleted sea water and washdown water.

The nearest other discharges are St Keverne STW, discharging to the St Keverne Stream, approximately 3.5km away from Porthallow South bed, and Helford STW which enters the Helford estuary approximately 5.8km from Porthallow North beds. Flows to St Keverne and Helford STW both receive secondary treatment. Due to the distance and geography, these are not thought to have any appreciable impact on sewage derived microbiological contamination in the BMPAs.

Other possible sources of contamination in the area are from birds and dogs[5], but these are diffuse and the mussel lines in Porthallow Cove are not considered vulnerable from the latter in particular, due to their offshore location.

The lack of a harbour, established anchorage or appreciable boat facilities at Porthallow, would indicate that sewage discharges from boats[6] are not likely to present a significant source of contamination.

The surrounding area is largely agricultural[7], with the majority of land-use in the immediate area being arable. In the wider catchment the dominant livestock farmed are cattle and poultry, followed by sheep and pigs. The agricultural nature of the locality can contribute to faecal coliform loads to watercourses, particularly following rainfall events. Rainfall gauge data (Appendix IX) indicates that October, November and December are the wettest months on average, with an associated increased risk of agricultural run-off and the storm overflow discharging to the stream.

Overall the stream entering Porthallow Cove is considered to be the most influential point source of contamination on the cove, due to the inputs from Porthallow STW, Porthallow PS, potential diffuse agricultural pollution and the effect of rainfall on the latter. In the absence of detailed data on the circulation of currents in the vicinity of Porthallow Cove, the proposed harvesting area in the south at Porthallow South is considered to be the most vulnerable to this potential source of contamination.

HYDRODYNAMICS

[5] Appendix X
[6] Appendix VIII
[7] Appendix IX

The tidal range at Porthallow Cove is approximately 4.7m on spring tides and 2.3m on neap tides[8]. This variation in tidal range relative to the overall bathymetric profile off Porthallow (<12m at chart datum within 500m of the shoreline - encompassing the proposed harvesting areas) will markedly influence the total initial dilution available between any sources of pollution at any one time. A pollution event coinciding with low water spring tides being the worst case.

Tidal currents off the southern coast of Cornwall are generally less than 0.5m s^{-1} (0.97knots) (British Geological Survey, 1987), with tidal currents off the east coast of The Lizard peninsula reaching 0.56m s^{-1} (1.1 knots) (UKHO, TotalTide, 2002). Within Porthallow Cove, tidal currents are thought to be weak, although there is some residual tidal drift moving in a northerly direction (Porthkerris Divers, pers. com.). In the absence of more detailed data on water movements under differing environmental conditions within the vicinity of Porthallow Cove, this information suggests that an RMP established in the south of the harvesting area would adequately reflect the quality of waters overlying and bivalve molluscs within the whole harvesting area.

Locally the prevailing wind is south-westerly and as such the harvesting area is most vulnerable to sources of pollution in and to the south of the area, from contamination advected over the area (Appendix VI).

SUMMARY OF EXISTING MICROBIOLOGICAL DATA

Levels of faecal coliforms recorded from monitoring of the designated bathing water[9] at Porthallow have been consistently low. This bathing water complied with the Guideline[10] value from 2001−2008. However, there is some correlation between rainfall and bathing water results, with slightly higher values occurring following rainfall. For example, after one day of rainfall there is a statistically significant positive correlation (2002−2008 data; Spearman's Rank *rho* correlation coefficient=0.426; p=0.002).

Water samples were taken from Porthallow Stream during the shoreline survey. These were analysed for both presumptive total coliform and presumptive *E. coli* levels[11]. Sampling took place during dry weather conditions and results showed low levels of microbiological contamination.

Results from the bacteriological survey, carried out as part of the sanitary survey, also gave relatively low levels of *E. coli* in the mussel flesh, with both sites having

[8] Appendix IV
[9] Appendix XI
[10] The bathing season runs from 15 May to 30 September. Water is sampled approximately weekly throughout the season. Levels of bacteria must not exceed the Imperative (I) value (2000 for faecal coliforms 100ml^{-1}) and the Guideline (G) value (100 for faecal coliforms 100ml^{-1}) represents the ideal maximum value. Bathing waters in England and Wales are classified as:
Poor - fails at least one coliform I standard;
Good - passes coliform I standards but fails at least one coliform G standard;
Excellent - passes coliform G standard and faecal streptococci standards.
[11] Appendix XII

similar results. The range of results from Porthallow South and Porthallow North were both <20 to 490 MPN *E. coli* 100g^{-1} FIL.

CONCLUSION

The proposed aquaculture operation is in an open cove, rather than an estuary, favouring the dispersion of any potential contaminants from Porthallow. This fact, along with the limited number and volume of pollution sources, contributes to good water quality in the production area, as demonstrated by bathing water results.

The main sources of pollution are considered to be inputs to Porthallow stream, to the south west of Porthallow South BMPA, as described above. Given the above assessments on the effect of pollution sources (illustrated in Figure 3.1) and the hydrodynamic factors influencing the transport of contamination within Porthallow Cove, coupled with the existing empirical data on microbiological contamination of shellfish flesh and bathing waters, it is recommended that the monitoring point identified for the purposes of the bacteriological survey at Porthallow South should be maintained for the ongoing microbiological monitoring programme. This is located at a point within the proposed areas of mussel longlines that should best reflect any contamination from Porthallow Stream and in the unlikely event of an impact from the very small secondary treated sewage discharge to the south of the cove.

Figure 3.1 Overview of sources of pollution.

RECOMMENDATIONS FOR REPRESENTATIVE MONITORING POINTS AND CLASSIFICATION ZONE BOUNDARY

- One RMP at Porthallow South is recommended to monitor the production of *Mytilus* spp. at both Porthallow North and Porthallow South. This should adequately reflect the impact of potential pollution originating from Porthallow Stream which receives effluent from Porthallow sewage treatment works, pumping station and other diffuse catchment pollution sources.

- Coordinates for a recommended Classification Zone represented by an RMP at Porthallow South are given below:

Latitude / Longitude (WGS84)	NGR (OSGB36)
50° 04'.58 N 05° 04'.41 W	SW 8019 2411
50° 04'.59 N 05° 04'.09 W	SW 8057 2411
50° 04'.15 N 05° 04'.06 W	SW 8057 2329
50° 04'.14 N 05° 04'.38 W	SW 8019 2329

Geographic grid references of boundary points given in WGS84 datum.

The above Classification Zone boundary encompasses both, the areas identified for production as recorded on the Application Form and the areas of seabed for which a Crown Estate lease has been granted.

- As this is a new area there are no existing RMPs to be reviewed.

- The recommended maximum horizontal tolerance for the RMP is 10 metres. It is considered that this tolerance minimises the effects of spatial variability in the extent of microbiological contamination whilst preserving the fixed station concept.

- For preliminary classification, mussel samples should be taken from a bag located at a depth equivalent to the top of the longline dropper lines or from the top of one of the dropper lines. In the absence of any data on stratification or environmental partitioning of contaminants within the water column or between the water column and sediments off Porthallow, sampling as close to the surface as possible is more likely to best detect any contamination from buoyant freshwater sources entering the sea in this area fresh (e.g. stream) and faecal input from birds should they roost in the vicinity of the lines in the future.

- Once mussel longlines are established, samples should be obtained from the mussel rope dropper. In the event that sufficient adult mussels may not available within the tolerance given above, Cefas could be consulted over the use of bagged mussels.

- Mussels should be left *in situ* for at least two weeks at the RMP prior to sampling.

- The representative monitoring point for the new Porthallow North and Porthallow South BMPAs is shown in Figure 4.2 of the Sampling Plan that follows.

4. SAMPLING PLAN

GENERAL INFORMATION

Location Reference

Production Area	**Porthallow**
Cefas Main Site Reference	M034
Cefas Area Reference	FDR 4011
Ordnance survey 1:25000 map **Imray chart number**	**Explorer TM 103** **No 2400.11**

Shellfishery

Species/culture	*Mytilus* spp.	Suspended rope culture
Seasonality of harvest	Not applicable	

Local Food Authority

Falmouth & Truro Port Health Authority	The Docks, Falmouth, Cornwall, TR11 4NR	
E-mail 📧	fal@cieh.org.uk	01326 211581
Sampling Officer ☎	Terry Stanley	01326 211581

MONITORING POINTS AND FREQUENCY OF SAMPLING

See Table 4.1 and Figure 4.1 below.

REQUIREMENT FOR REVIEW

This sampling plan will be reviewed by the competent authority within six years or in light of any obvious known changes in sources of pollution of human (e.g. sewage improvement scheme) or animal origin.

Table 4.1 Number and location of Representative Monitoring Point (RMP) and frequency of sampling.

Classification Zone			Porthallow
RMP			B034Z
RMP name			Porthallow South
Geographic grid references (datum) of monitoring point	**OSGB36**	**Eastings** **Northings**	180243 23378
	NGR		SW 8024 2338
	WGS84	**Latitude** **Longitude**	50°04.19' N 05° 04.34' W
Species			*Mytilus* spp.
Growing method			Rope grown
Harvesting technique			Boat with mechanical arm
Sampling method			By hand from top of rope dropper (or buoyed sample bag(s) depending on circumstances and following consultation with Cefas
Depth			Bag level with top of mussel rope
Tolerance for monitoring point (m)			10
Frequency of sampling (Preliminary classification)			10 samples taken over at least 3 months (interval between sampling not less than 1 week).
Frequency of sampling (Full classification)			At least monthly over 1 year.

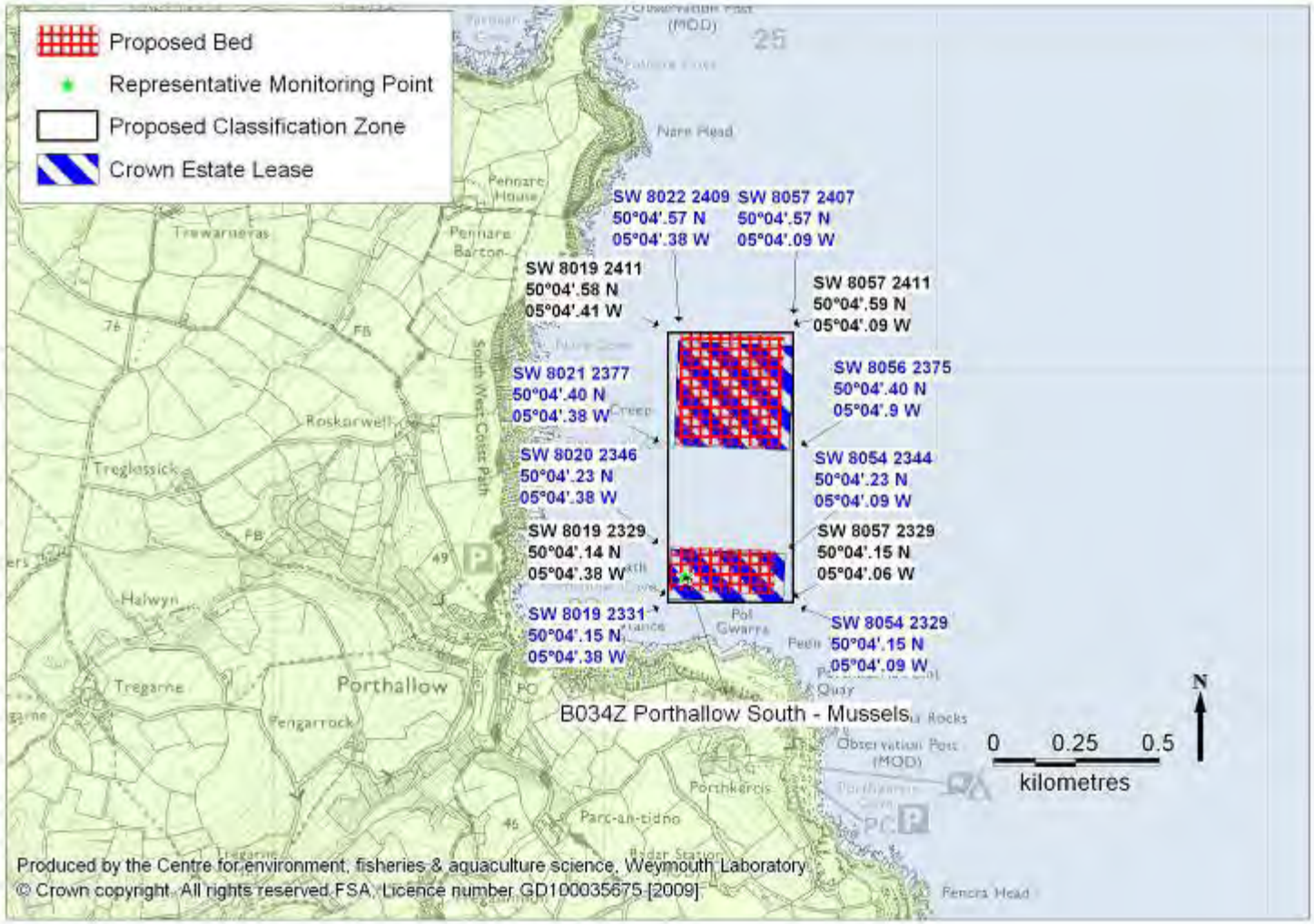

Figure 4.1 Location of Representative Monitoring Point (RMP) and Classification Zone boundary overlain on proposed aquaculture and Crown Estate lease areas
For unique RMP identification code see Table 3.1.

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APPENDICES

APPENDIX I

HUMAN POPULATION: DENSITY AND ACTIVITY

The sub-parish of St Keverne and Porthallow has a resident population of 1280 (Cornwall County Council Parish Population Statistics, 1981 and 1991-2000) (Figure I.1 and I.2); this population increases during the summer months due to tourism. The 2003 Tourism Survey showed 541,000 overnight stays and 1,415,000 day-visitors a year in the district (Kerrier Annual Monitoring Report 2006). The 2004−2005 Cornwall Visitor Survey found that beaches, coastal walks and sampling local produce are the most popular activities for visitors (Acumenia, 2006). Seasonal population increases, including the increased use of accommodation, leisure and transport facilities may result in a temporary increase in the risk of microbiological pollution.

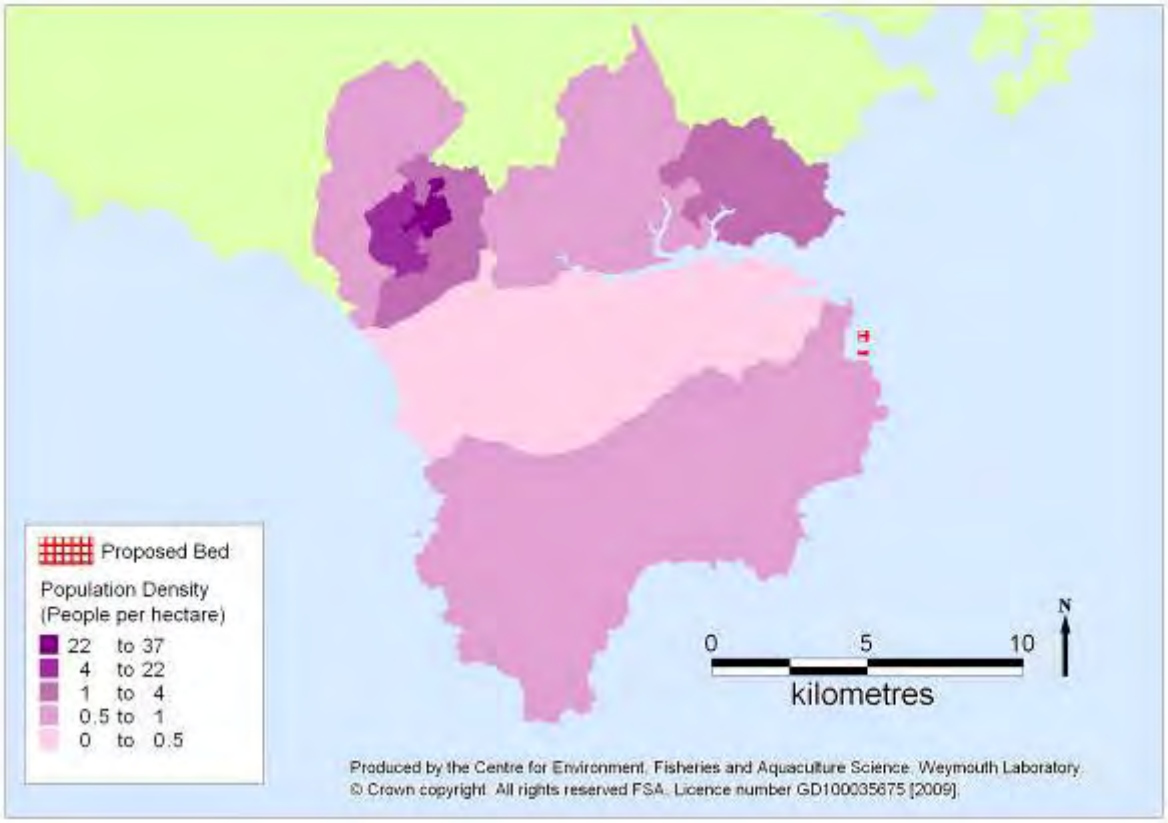

Figure I.1 Human population by Super Output Area (SOA).
Source: ONS, Super Output Area Boundaries. Crown copyright 2004.
Crown copyright material is reproduced with the permission of the Controller of HMSO.

Figure I.2 Kerrier District, showing St Keverne Ward and Porthallow.

There is a small beach at Porthallow, which is also a designated bathing water. Papadakis *et al*. (1997) found significant correlations between the number of swimmers present on beaches and the presence of pathogenic bacteria. More recently, Elmir *et al*. (2007) revealed the role of human skin as intermediate mechanism of pathogens transmission to the water column.

The microbiological load attributed to tourism is therefore expected to fluctuate on a seasonal basis in line with changes in visitor numbers and occupancy of holiday accommodation. Tourism will result in significant seasonal fluctuations in the population and quantity of sewage discharged.

APPENDIX II

HYDROMETRIC DATA: RAINFALL

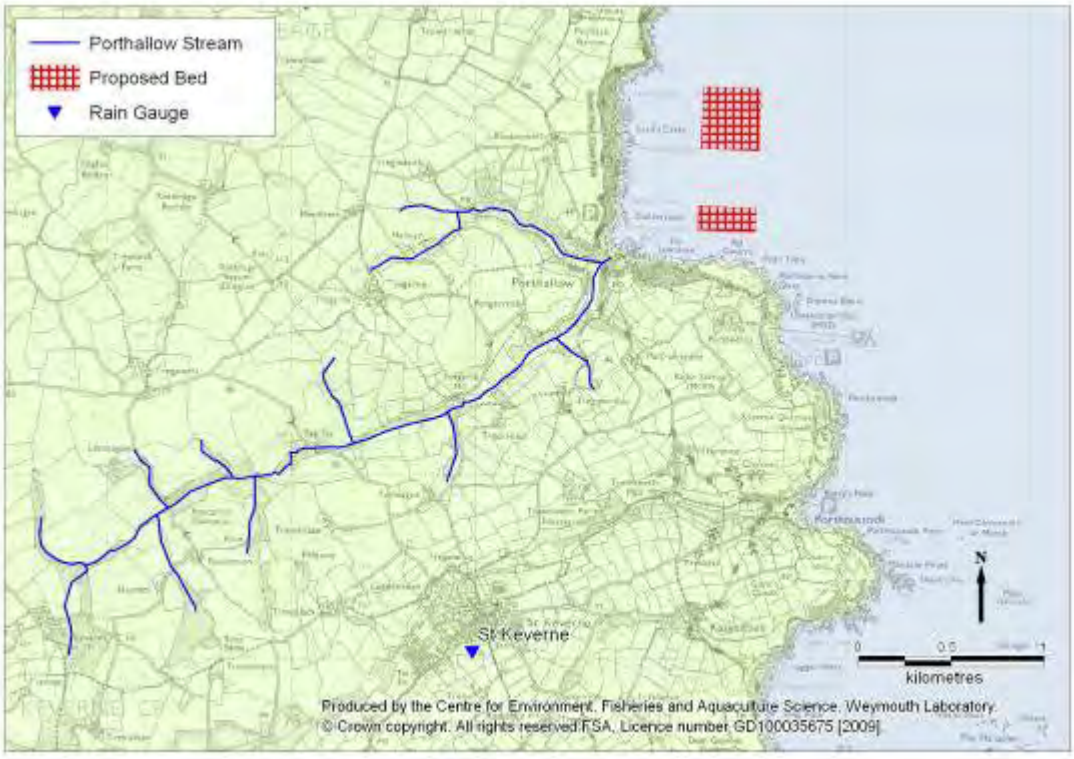

Figure II.1 Location of St Keverne rainfall gauge.

The rainfall gauge at St Keverne (Figure II.1) to the south-west of Porthallow has a continuous data set from June 2002. Figure II.2 shows total rainfall by month at St Keverne. This indicates that October, November and December are the wettest months on average (with spikes occurring in February and March in 2007 and 2008, respectively) and during these months there may therefore be an increased risk of contamination from land runoff and rainfall associated sewer overflow.

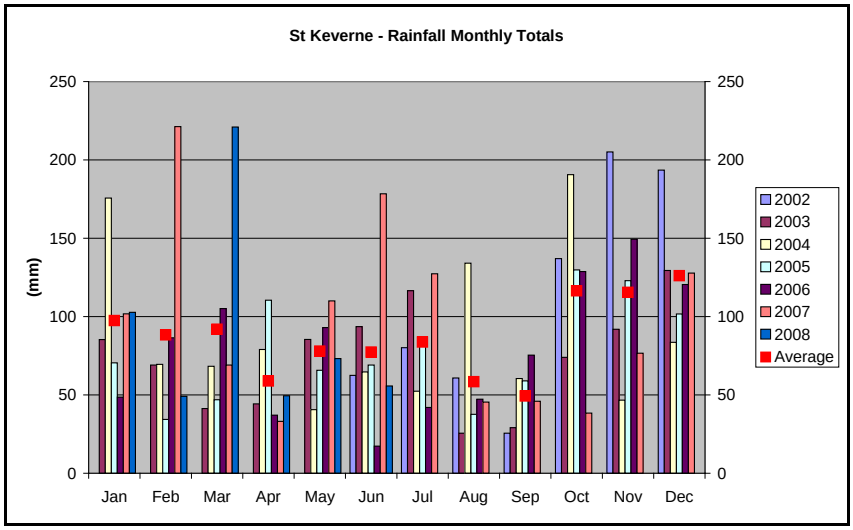

Figure II.2 Monthly variation in total rainfall at St. Keverne for 2002–2008.

Data provided by the Environment Agency (2007).

APPENDIX III

HYDROMETRIC DATA: FRESHWATER INPUTS

Porthallow Stream is the main freshwater input to Porthallow Cove, entering the cove approximately 0.6km south-west of the nearest proposed BMPA (Figure II.1 above). There is no river gauge on Porthallow Stream. Porthallow STW and PS discharge into this steam, which will also potentially receive diffuse pollution from agricultural run-off during heavy rainfall. As such, Porthallow Stream is seen as a significant contribution to microbiological load into Porthallow Cove.

APPENDIX IV

HYDRODYNAMIC DATA: TIDES AND TIDAL CURRENTS

Mean tide levels and ranges are shown in Table V.1 below.

Table V.1 Tide levels and ranges for the Helford Estuary (Entrance)

	Height (m) above Chart Datum				Range (m)	
Port	MHWS	MHWN	MLWN	MLWS	MST	MNT
Helford	5.3	4.2	1.9	0.6	4.7	2.3

Predictions for this secondary port are based on Plymouth (Devonport).

APPENDIX V

HYDROGRAPHIC DATA: GENERAL AND BATHYMETRY

Details of the bathymetry of Porthallow Cove are detailed in Admiralty Chart 2345, Coverack, Porthoustock, Porthallow and The Manacles (UKHO, 2001) and Imray chart 2400.11 (2002) (Figure IV.1).

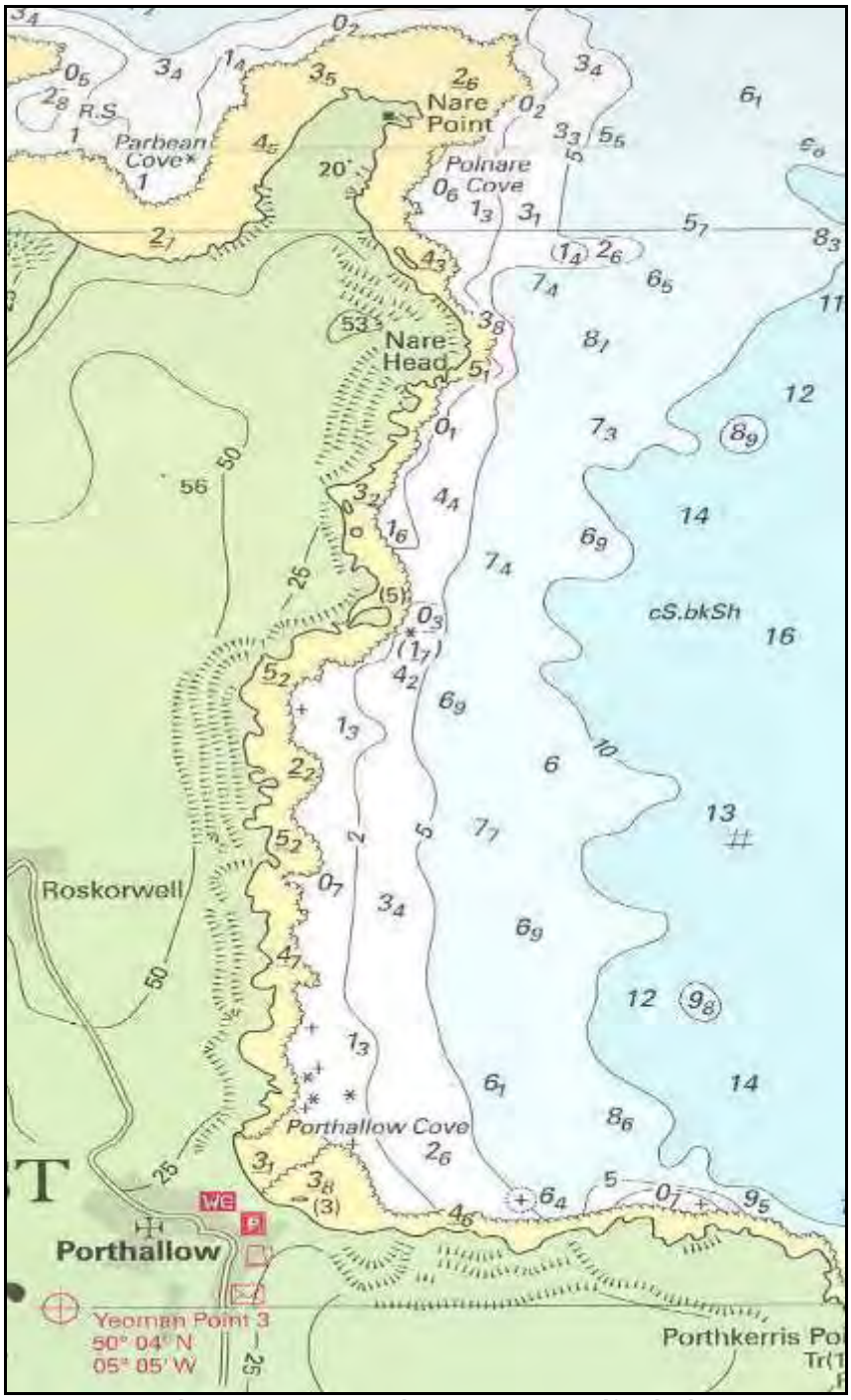

Figure IV.1 Imray Chart 2400.11, Helford River. Porthallow Cove hydrographic data.
Reproduced from Imray Chart 2400.11 (2002) with

APPENDIX VI

METEOROLOGICAL DATA: WIND PATTERN

Wind data between 1992 and 1998 from Culdrose meteorological station have been analysed. Figure VI.1 represents an analysis of the percentage of time that wind is recorded as blowing from different cardinal sectors over a seven-year period. For example, inset B shows that 16% of winds blew from the south-east sector. Together, insets A and B show that winds from the westerly and south-westerly sectors predominate.

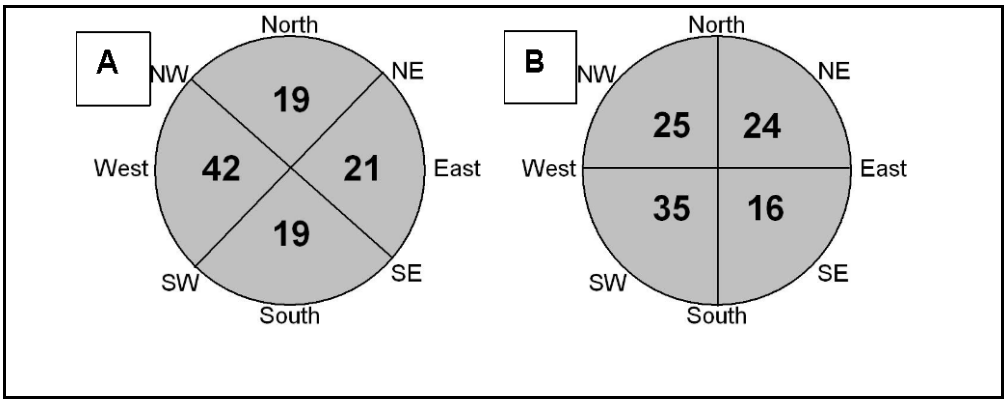

Figure VI.1. Percentage of wind direction by time for given sectors over the period 01 Jan 1992–31 Dec 1998.
Derived from Culdrose meteorological station.
Data provided by the Environment Agency (2007).

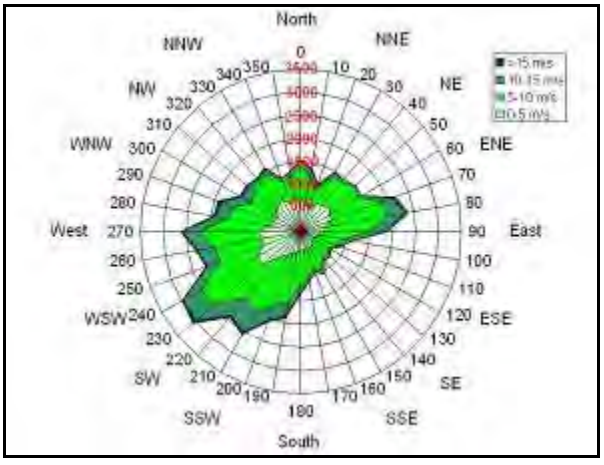

Figure VI.22. Wind rose showing direction and mean wind speed by hourly count over the period 01 Jan 1992–31 Dec 1998.
Derived from Culdrose meteorological station.
Data provided by the Environment Agency (2007).

The wind rose in Figure VI.2 shows that the prevailing wind is south-westerly and that the majority of winds with a speed over 10ms^{-1} contained a south-westerly component. Therefore the harvesting area is most vulnerable to sources of

pollution in and to the south of the area from contamination advected over the area on prevailing wind driven currents.

APPENDIX VII

SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION
SEWAGE DISCHARGES

There is one sewage treatment works (STW) in Porthallow that discharges to Porthallow Stream, approximately 0.8km upstream of where the stream flows into Porthallow Cove. The STW provides ultraviolet disinfection (UV) tertiary treatment of all flows up to three times dry weather flow. Flow above this level is diverted to the works storm tank which has two hours storage. UV efficacy data for the effluent is summarised in Table VII.2 below.

Table VII.2 Summary statistics of faecal coliform data for final effluent post UV-disinfection monitoring

		CFU Faecal coliforms 100ml^{-1}			
Name	**Period**	Number of samples	Geometric mean	Minimum	Maximum
Porthallow STW	2003−06	49	69	1	1400

A summary of the discharges potentially impacting on the proposed harvesting area in Porthallow Cove are given in, Table VII.1 and Figure V.II below.

Table VII.1 Continuous and intermittent sewage discharges to Porthallow Cove

Name	Treatment level	DWF (m^3/day)	**NGR of outfall**
Porthallow STW	Tertiary (biological+UV)	36	SW 7960 2290
Cornish Sea Salt Co.	Secondary	0.8 (max)	SW 8032 2314
Cornish Sea Salt Co.	Trade (salt-depleted sea water and washdown water)	358	SW 8032 2314
Porthallow PS EO/CSO	Not available	Not available	SW 7972 2318

Figure VII.1 Sewage discharges at Porthallow Cove.

APPENDIX VIII

SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION BOATS

There are no harbour or permanent moorings at Porthallow. During the Shoreline Survey two registered fishing boats, were seen winched up above the high water (HW) line, together with half a dozen other non-registered fishing launches (Figure VIII.1).

Figure VIII.1 Boats at Porthallow.
Google Earth ™ mapping service, 2009.

APPENDIX IX

SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION AGRICULTURE

Farming is the main land use in the wider catchment, with the dominant livestock farmed (by numbers) being cattle and poultry, followed by sheep and pigs (Figure IX.1).

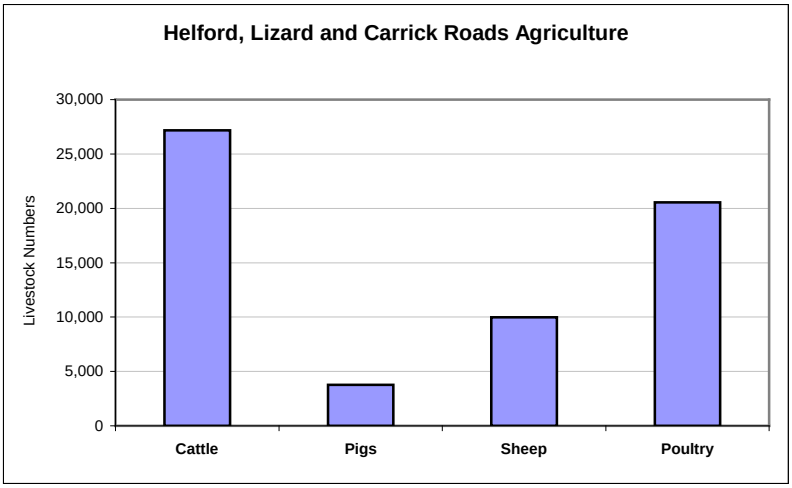

Figure IX.1. Numbers of livestock in the Helford, Lizard and Carrick Roads Agriculture.
(Defra, Livestock by Catchment, June 2007 Agricultural Survey)

Most of the catchment is utilised for agricultural purposes and dominated by small holding farms, the majority (36%) characterised as permanent grassland (Defra, June Agricultural Survey, 2004).

There are 1007 farm holdings in the Kerrier District encompassing Postcode Districts TR10-13 (Defra, 2004). The southern area is mostly used for dairy, cattle and sheep production, whereas mixed and other types of farms dominate in the northern area. Dairy, cattle and sheep account for 14% and 24% of all farm types in the catchment, respectively.

The concentration of faecal coliforms excreted in the faeces of animal and humans and corresponding loads per day are summarised in Table IX.1.

Table IX.1 Levels of faecal coliforms and corresponding loads excreted in the faeces of warm-blooded animals.

Farm Animal	Faecal coliforms (No. g^{-1} wet weight)	Excretion rate (g day^{-1} wet weight)	Faecal coliform load (No. day^{-1})
Chicken	1 300 000	182	2.3×10^{8}
Cow	230 000	23 600	5.4×10^{9}
Pig	3 300 000	84 000 000	8.9×10^{8}
Sheep	16 000 000	38 000 000	1.8×10^{10}
Human	13 000 000	3 000 000	1.9×10^{9}

Data from Geldreich (1978) and Ashbolt et al. (2001).

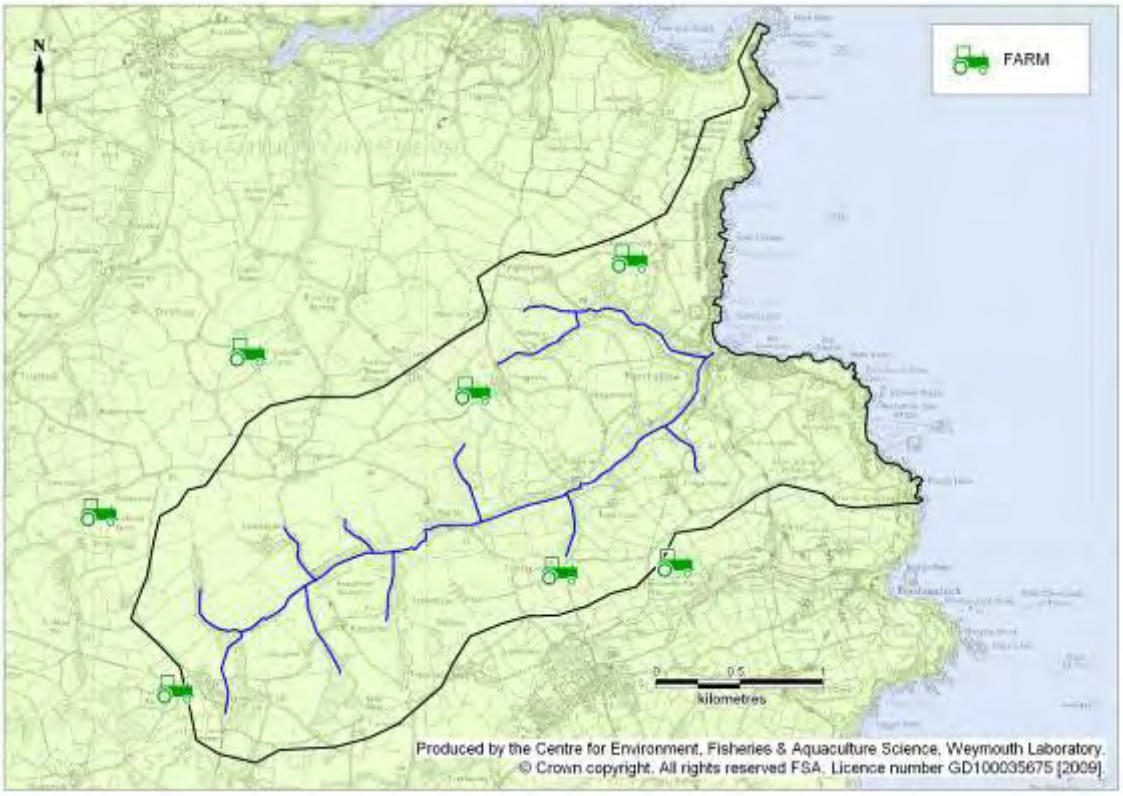

Figure IX.2 Locations of farms in the vicinity of Porthallow catchment
Locations taken from 1:25,000 Ordnance Survey map.

Clearly farmyards can significantly contribute to loads of faecal indicator microorganisms to watercourses or coastal waters when they have a ready and renewable source of faecal material, a direct hydrological connection with open water channels exists and a sufficient proportion of livestock farms are present in the catchment (Edwards *et al*., 2008). The potential impact of any such watercourse needs therefore to be considered in relation to the siting of RMPs for the microbiological monitoring programme.

Whilst the area is predominantly agricultural, in the immediate vicinity of Porthallow Cove, land use is mostly arable, rather than used for grazing. However, due to the level of agricultural activity in the vicinity of the proposed harvesting area and the location of Porthallow Stream, Porthallow Cove may be impacted to some degree by agricultural land-runoff, particularly following rainfall events.

APPENDIX X

SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION WILDLIFE AND DOMESTIC ANIMALS

Dog faeces are a potential source of microbiological contamination to nearshore shellfish beds especially those on intertidal areas. There are no restrictions on the presence of dogs on Porthallow beach at any time of year. During the shoreline survey no dogs were observed on the first day, and only one at the time of the survey on the second day.

No roosting birds were seen on the water during the sanitary survey, and indeed very few birds were in evidence at all. Previous studies have indicated significant concentrations of microbiological contaminants (thermophilic campylobacters, salmonellae, faecal coliforms and faecal streptococci) in intertidal sediment samples in the Northwest UK supporting large communities of birds (Obiri-Danso and Jones, 2000). However, birds, particularly if resting/roosting on the plastic floats of mussel longline headlines, could constitute a localised source of contamination for the mussel production area. Float instability is an important factor determining the presence of birds on longline systems (Comeau *at al*., in press). The type of plastic float to be used on the longlines at Porthallow is believed to be sufficiently unstable in order to deter resting/roosting of birds (Steve Kestin, pers. com.). Given the above it is considered that birds roosting on floats located along the longline should not present a risk of contamination.

APPENDIX XI

MICROBIOLOGICAL DATA
WATER

There is one Bathing Water at Porthallow, designated under Directive 76/160/EEC (European Communities, 1976, 2006)[12]. This is within 350m of the proposed mussel production area (Figure XI.1).

Figure XI.1. EC Bathing Waters Directive monitoring site at Porthallow, in relation to the proposed harvesting areas

The compliance history of this site against the mandatory and guideline standards of the Directive is given in Table XI.1 below.

Table XI.1 Compliance of Porthallow beach against standards of the EEC Bathing Waters Directive (Data source Environment Agency).

Beach	2001	2002	2003	2004	2005	2006	2007	2008
Porthallow Cove	G	G	G	G	G	G	G	G

[12] The bathing season runs from 15 May to 30 September. Water is sampled throughout the season. Levels of bacteria must not exceed the Imperative (I) value (2000 for faecal coliforms 100ml^{-1}) and the Guideline (G) value (100 for faecal coliforms 100ml^{-1}) represents the ideal maximum value. Bathing waters in England and Wales are classified as:
Poor - fails at least one coliform I standard;
Good - passes coliform I standards but fails at least one coliform G standard;
Excellent - passes coliform G standard and faecal streptococci standards.

N.B. G=meets Guideline values.

Porthallow bathing water has achieved Guideline values for the eight years from 2001-2008. This suggests that levels of faecal contamination in seawater in the vicinity of the proposed harvesting area are generally low, at least during the bathing season.

Actual levels of faecal coliforms concentrations in seawater at the designated bathing water at Porthallow are summarised in the Table XI.2 below. Geometric means of faecal coliforms in the bathing water are very low, and are equivalent to achieving Class A under the hygiene monitoring programme.

Table XI.2. Summary statistics of faecal coliforms in Porthallow bathing water for the period 2000–2008.

Year	Number of samples	Numbers below limit of detection	Range CFU $100ml^{-1}$			
			Minimum	Maximum	Median	Geometric mean
2001	20	8	<10	176	<10	<10 (6.6)
2002	20	18	<10	27	<10	<10 (5.4)
2003	20	11	<2	8	<10	<10 (2.7)
2004	20	5	<2	88	<2	<10 (2.2)
2005	20	5	<2	77	<2	<10 (1.9)
2006	20	4	<2	10	1.5 (<2?)	<10 (2.2)
2007	20	7	<2	492	3	<10 (5.4)
2008	20	5	<2	192	10.5	<10 (9.0)
2000 –2008	160	63	<10	492	5 (<10?)	<10 (3.8)

Data provided by the Environment Agency (2008).

Correlation between bathing water microbiological data (faecal coliforms) and amount of rainfall shows some significance, particularly when considering total rainfall over time (Table XI.3). There is a statistically significant positive correlation (correlation=0.426; *p*=0.002) between levels of faecal coliforms and rainfall in the previous 24h of sampling. This may be due to agricultural run-off during rainfall, entering Porthallow Stream and then reaching Porthallow Cove. This could have implications for water quality at the RMPs in Porthallow Cove BMPA, whereby elevated rainfall may result in increased *E.coli* concentrations seen in hygiene monitoring samples. Given that there is no historical hygiene data, it is yet to be demonstrated whether there is in fact also an effect on *E.coli* levels in the shellfish flesh.

Table XI.3. Spearman's Rank correlation coefficients between total daily rainfall (mm) (Porthallow) and Faecal coliforms at Porthallow Bathing Water (2002–2008)

N		Rainfall (mm)													
		Individual 24h periods								Cumulative periods					
		Day of sampling	-1 day	-2 day	-3 day	-4 day	-5 day	-6 day	- 7 day	-1 day	-2 days	-3 days	-4 days	-5 days	-6 days	-7 days
118	r	0.173	0.426	0.215	0.090	0.253	0.068	0.152	0.158	0.413	0.459	0.397	0.302	0.245	0.237	0.250
	p	0.262	0.002*	0.139	0.517	0.076	0.649	0.307	0.253	0.001*	0.000*	0.000*	0.003*	0.014*	0.018*	0.010

Pearson correlation coefficient (r) ranges between +1 and -1. The significance of r is tested by determining whether its value differs from 0.
A correlation of +1 means that there is a perfect positive linear relationship between rainfall and MPN of E. coli.
A correlation of -1 means that there is a perfect negative linear relationship between rainfall and MPN of E. coli*.*
A correlation of 0 means that there is no linear relationship between rainfall and MPN of E. coli.
** Statistically significant at the 0.05 level.*
Correlation analysis performed using Log10-transformed E. coli concentrations. Less-than faecal coliform results were assigned half the numerical value before transformation. Greater-than E. coli *results were assigned double the numerical value before transformation*

Porthallow stream was also sampled and tested for faecal coliform concentrations at the same time that the bathing water samples were taken. Figure XI.2 shows the range of levels of faecal coliforms in the stream since 2000. The middle values are all similar, indicating that there is little fluctuation in faecal coliform concentrations in the stream over time. During most years, boxes are fairly symmetrical, with very few outlying results. Results indicate that Porthallow stream is a potential source of a degree of microbiological contamination with respect to the proposed BMPA.

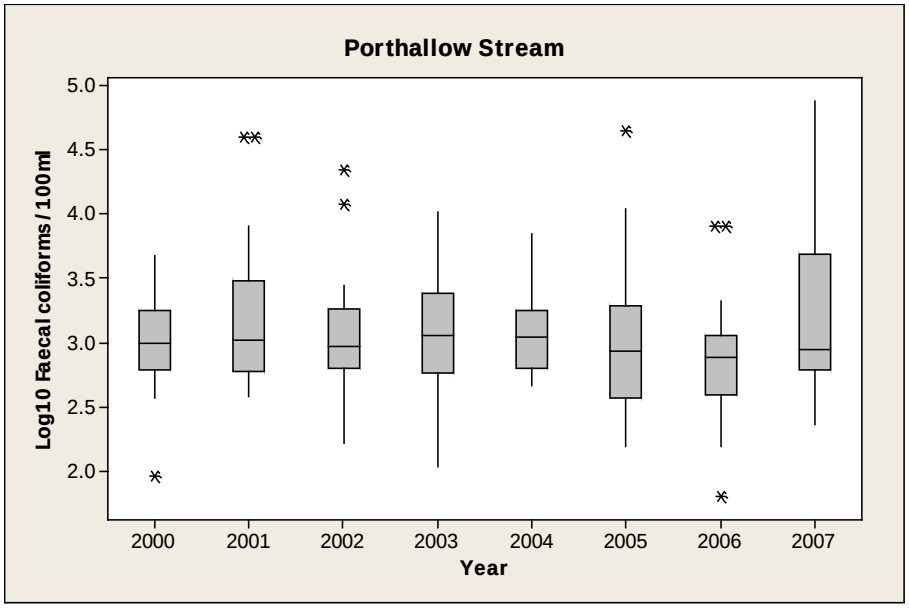

Figure XI.2 Concentration of faecal coliforms in Porthallow Stream since 2000
Data provided by the Environment Agency (2008).

APPENDIX XII
MICROBIOLOGICAL DATA
SHELLFISH FLESH

There has been no BMPAs previously established in Porthallow Cove and the area is not currently designated as a Shellfish Water. Therefore there is no existing shellfish hygiene data to review, other than that collected as part of the bacteriological survey, which is reported in Appendix XIV.

APPENDIX XIII

SHORELINE SURVEY

Water samples were taken from Porthallow Stream North and South during the sanitary survey. These were analysed for both presumptive total coliform and presumptive *E. coli* levels (Table XIII.1).

Table XIII.1 Microbiological results of water sampling in Porthallow Stream

Stream	Presumptive total coliforms (CFU/100ml)	Presumptive *E. coli* (CFU/100ml)
Porthallow Stream North	500	380
Porthallow Stream South	640	600

SHORELINE SURVEY RECORD FORM

N.B. Coordinate datums: National Grid References (NGR) given as OSGB36, Latitude Longitudes given as WGS84

General Information

1	RMP IDs	B34AA (Porthallow North) and BO34Z (Porthallow South)	
2	**Bed Name/Coordinates (**Areas for which classification has been applied for in the Application Form)	Porthallow North (White Rocks site) (Lazy L)	50º 04.40'N 5º.04.38'W 50º 04.40'N 5º.04.09'W 50º 04.57'N 5º 04.38'W 50º 04.57'N 5º 04.09'W
		Porthallow South (Porthkerris site) (Lazy L-B)	50º 04.15'N 5º.04.38'W 50º 04.15'N 5º.04.09'W 50º 04.23'N 5º 04.38'W 50º 04.23'N 5º 04.09'W
3	Production Area	Porthallow	
4	**Area of Bed(s)**	Approximately: North = 1km^2 South = 0.4km^2	
5	**SWD Flesh Point**	N/A	
6	**SWD Water Point**	N/A	
7	**BWD Sampling Point(s)**	SW 7986 2327 50º 04.12'N 5º 04.66'W	
8	**Applicant's Details**	Steve Kestin Elvan, Constantine, Falmouth, TR11 5RR ☎ 01326 341319	
9	**Cefas Officer(s)**	Simon Kershaw	
10	**Local Authority Officer(s)**	Colin Bate, Sampling Officer Falmouth Port Health Authority	
11	**Date/time of survey:**	15th July 2008 10:00 - 2:30 (boat) 16:00-17:30 (shore) 16th July 2008 09:00 – 10:00 (shore)	
12	**Extent of Survey Area**	Gillan Approach - Porthkerris (mfv "Patrice") ~2.5km Porthkerris & Porthallow (shores) ~0.25 & 0.3km	
13	**Map/Chart References**	OS Explorer 103 / Imray Chart 2400.11	

14	Predicted Tides *0004A* *Helford River Entrance* Totaltide (BST)	High Water (time/height)	16:08 (4.5m)
		Low Water (time/height)	10:16 (1.7m)
15	Weather Forecast	Met Office Inshore Waters 14/07/08 – Outlook from 0700 Tue 15/07/08 NW 4/5, sea state moderate, drizzle fog patches developing. Vis. Moderate occasionally. Very poor. 5d Falmouth forecast Tue 10:00 overcast, 17°c, W 14mph, Vis - G Tue 13:00 overcast, 17°c, W 15-26mph, Vis – VG	
16	Air temperature	24.6°c @ 10:15hrs 16/07/08	
17	Wind	Mean 2kn Max 6.1 @ 029°M = NNE Beaufort Force 2	
18	Precipitation	Occasional fine drizzle at time of boat survey Preceding 24hrs 0.3mm Preceding 48hrs 0.3mm Day of sampling (15/07/08) none recorded Day of sampling (16/07/08) none recorded	
19	Rivers/streams/springs	Porthallow Stream North Porthallow Stream South	
20	River flows (observed)	Porthallow north and south streams flowing see images Low level stream outfall pipes discharging. High level pipes dry (see images)	
21	River flows (gauged)	N/A	
22	Key Discharges (Cefas database)	Porthallow STW (UV) DWF 36m^3/d NGR SW 8069 2293 Porthallow PS CSO NGR SW 7972 2318	
23	Air Pressure	1026hPa @ 10:15 16/07/08	
24	Discharges (observed)	Twin low level outfalls for combined stream discharges at SW 79796 23249 N 50 04.074’ W 005 04.649’ Twin high level outfalls for combined stream discharges at SW79785 23244 N 50 04.070’ W 005 04.658’ Salt Factory discharge from cleft in cliff River (stream) bank wall by bridge outside Five Pilchards Pub (below confluence of streams) - downstream west bank = three outfalls - downstream east bank = one outfalls - upstream west bank = one outfall - upstream east bank = one outfall	

25	Boats/Port	• No swinging/drying moorings or harbour • 2 registered fishing boats (winched above MHW line) PZ462 & FH587 plus half a dozen other non-registered fishing launches
26	Dogs	None at time of survey 15/07 One at time of survey 16/07/08
27	Other animals	No roosting birds on water Very few birds in evidence
28	Strand line SRD	15/07/08 4 partly decomposed panty liners (2 on recent HW line, 2 on Spring tide line). Pothallow Bay 16/07/08 09:55 Potential panty liner on recent strand line 50° 04'.080N 05° 04'.685W / SW 7982 2319
29	Samples Taken (ashore)	Porthallow Stream North 09:20 16/07/08 (PCE) 50° 08'.638N 05° 05'.131W SW 7964 3166 Temp. 14.9°c on arrival Coiforms cfu/100ml - 500 *E. coli* cfu/100ml - 380 Porthallow Stream South 09:21 16/07/08 (PCW) 50° 04'.031N 05° 04'.826W SW 7965 2311 Temp. 14.9°c on arrival Coliforms cfu/100ml – 640 *E. coli* cfu/100ml – 600 Water temperature at confluence 14.9°c Sea Water salinity in Porthallow Bay 15/07/08 34.9 psu @ 28°c 50º 04'.224N 05º 04'.251W / SW 8035 2344

30	Samples Taken (boat)	Bagged samples from mfv 'Partice' 1) Buoy marked 'Lady L' 50º 04'.224N 05º 04'.251W / SW 8035 2344 Total depth @ time sampling 14.5m Depth (sample bag) surface- 3.5m **Bag towed to NEW position** 50º 04'.189N 05º 04'.339W / SW 8024 2338 Total depth @ time 11.0m Depth (sample bag) surface- 2.5m 2) Buoy marked 'Lady L' Porthallow North (white rocks) 50º 04'.425N 05º 04'.430W / SW 8015 2382 Total depth @ time 10.2m Depth (sample bag) surface- 2.5m **Bag towed to NEW position** 50º 04'.436N 05º 04'.379W / SW 8021 2384 Total depth @ time 11.2m Depth (sample bag) surface- 2.5m

Figure XIII. i) confluence of Porthallow stream north and south, ii) Porthallow stream near bridge, with various pipes, iii) detail of a pipe to Porthallow stream, iv) location of Porthallow stream discharging at Porthallow beach, v) Porthallow STW, vi) Porthallow stream flowing into the sea, vii) strand line on Porthallow beach, viii) outfall for Cornish Sea Salt Company Limited

Figure XIII.2 Extent of boat and shoreline survey, including locations of samples taken.

APPENDIX XIV

BACTERIOLOGICAL SURVEY

OBJECTIVES

The bacteriological survey aimed to determine spatial variation of levels of microbiological contamination in mussels in Porthallow North and South BMPAs, in order to identify best locations for Representative Monitoring Point/s (RMPs) for classification purposes.

SAMPLING SITES

Two sampling points were selected, one in the corner of each proposed BMPA nearest to the mouth of Porthallow Stream (Figure XV.1), which is considered to be the main source of pollution, due to sewage discharge and agricultural inputs.

Figure XV.1 Sampling points for the Bacteriological Survey at Porthallow North and Porthallow South.

- Porthallow North (OSGB36; Eastings, Northings): 180214 23838, is approximately 0.35km from the nearest shore, and 0.7km north-east of Porthallow beach.

- Porthallow South 180243 23378, is approximately 0.48km north-east of Porthallow beach.

The survey was undertaken during the period September 2008 to date. Mussel samples were collected from both monitoring points by the Local Food Authority (LFA) (Falmouth and Truro Port Health Authority) and quantified for *E. coli* by Truro Microbiology Laboratory (NHS). Results for these are given in Tables XV.1 and XV.2, and summarised in Table XV.3.

Given that Porthallow Cove is a new shellfish area, microbiological data for shellfish currently available for Porthallow Cove are from the bacteriological survey. Results so far for Porthallow North and Porthallow South are included (Tables XII.1 and XII.2).

Table XV.1 Microbiological results for mussels from Porthallow South.

Collection Date	Test Date	MPN *E. coli* /100g
09/09/08	09/09/08	170
20/10/08	20/10/08	40
17/11/08	17/11/08	< 20
08/12/08	09/12/08	230
26/01/09	No sample taken as bag was missing on this occasion	
10/02/09	10/02/09	490
03/03/09	03/03/09	<20

Table XV.2 Microbiological results for mussels from Porthallow North.

Collection Date	Test Date	MPN *E. coli* /100g
09/09/08	09/09/08	460
20/10/08	20/10/08	< 20
17/11/08	17/11/08	50
08/12/08	09/12/08	130
26/01/09	26/01/09	130
10/02/09	10/02/09	490
03/03/09	No sample taken as bag was missing on this occasion	

Table XV.3 Microbiological results from the bacteriological survey at Porthallow Cove.

						MPN *E. coli* 100g^{-1} FIL			
Bed name	Sampling site	Species	n	Date of first sample	Date of last sample	Min.	Max.	GM	Median
Porthallow Cove North	B34AA	*Mytilus* spp.		09/09/2008					
Porthallow Cove South	BO34Z	*Mytilus* spp.		09/09/2008					

CONCLUSIONS

Sample results from both sites gave low levels of *E. coli*, with no significant variation between either site. Given the assessment on the effect of pollution sources and the hydrodynamic factors influencing the transport of contamination within Porthallow Cove, coupled with the existing empirical data on microbiological contamination of shellfish flesh and Bathing Waters distribution, it is recommended that the monitoring point identified for the purposes of the

bacteriological survey at Porthallow South should be maintained for the ongoing microbiological monitoring programme.

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List of Abbreviations

AONB	Area of Outstanding Natural Beauty
BMPA	Bivalve Mollusc Production Area
CD	Chart Datum
Cefas	Centre for Environment Fisheries & Aquaculture Science
CFU	Colony Forming Units
CSO	Combined Sewer Overflow
Defra	Department for Environment, Food and Rural Affairs
DWF	Dry Weather Flow
EA	Environment Agency
E. coli	*Escherichia coli*
EC	European Community
EEC	European Economic Community
EO	Emergency Overflow
ESA	Environmentally Sensitive Area
FIL	Fluid and Intravalvular Liquid
FSA	Food Standards Agency
GM	Geometric Mean
HAT	Highest Astronomical Tide
ISO	International Organization for Standardization
km	Kilometre
LFA	Local Food Authority
M	Million
m	Metres
ml	Millilitres
mm	Millimetres
MPN	Most Probable Number
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
OSGB36	Ordnance Survey Great Britain 1936
PS	Pumping Station
RMP	Representative Monitoring Point
SAC	Special Area of Conservation
SSSI	Site of Special Scientific Interest
UV	Ultraviolet
WGS84	World Geodetic System 1984

Glossary

Bathing Water	Element of surface water used for bathing by a large number of people. Bathing waters may be classed as either EC designated or non-designated OR those waters specified in section 104 of the Water Resources Act, 1991.
Bivalve mollusc	Any marine or freshwater mollusc of the class Pelecypoda (formerly Bivalvia or Lamellibranchia), having a laterally compressed body, a shell consisting of two hinged valves, and gills for respiration. The group includes clams, cockles, oysters and mussels.
Classification of bivalve mollusc production or relaying areas	Official monitoring programme to determine the microbiological contamination in classified production and relaying areas according to the requirements of Annex II, Chapter II of EC Regulation 854/2004
Coliform	Gram negative, facultatively anaerobic rod-shaped bacteria which ferment lactose to produce acid and gas at 37 °C. Members of this group normally inhabit the intestine of warm-blooded animals but may also be found in the environment (eg on plant material and soil).
Combined Sewer Overflow	A system for allowing the discharge of sewage (usually dilute crude) from a sewer system following heavy rainfall. This diverts high flows away from the sewers or treatment works further down the sewerage system.
Discharge	Flow of effluent into the environment.
Dry Weather Flow (DWF)	The average daily flow to the treatment works during seven consecutive days without rain following seven days during which rainfall did not exceed 0.25 mm on any one day (excludes public or local holidays). With a significant industrial input the dry weather flow is based on the flows during five working days if production is limited to that period.
Ebb tide	The falling tide, immediately following the period of high water and preceding the flood tide. Ebb-dominant estuaries have asymmetric tidal currents with a shorter ebb phase with higher speeds and a longer flood phase with lower speeds. In general, ebb-dominant estuaries have an amplitude of tidal range to mean depth ratio of less than 0.2.
EC Directive	Community legislation as set out in Article 189 of the Treaty of Rome. Directives are binding but set out only the results to be achieved leaving the methods of implementation to Member States, although a Directive will specify a date by which formal implementation is required.
Emergency Overflow	A system for allowing the discharge of sewage (usually crude) from a sewer system or sewage treatment works in the case of equipment failure.
Escherichia coli (E. coli)	A species of bacterium that is a member of the faecal coliform group (see below). It is more specifically associated with the intestines of warm-blooded animals and birds than other members of the faecal coliform group.
E. coli O157	E. *coli* O157 is one of hundreds of strains of the bacterium *Escherichia coli*. Although most strains are harmless, this strain produces a powerful toxin that can cause severe illness. The strain O157:H7 has been found in the intestines of healthy cattle, deer goats and sheep.
Faecal coliforms	A group of bacteria found in faeces and used as a parameter in the Hygiene Regulations, Shellfish and Bathing Water Directives, *E. coli* is the most common example of faecal coliform. Coliforms (see above) which can produce their characteristic reactions (e.g. production of acid from lactose) at 44 °C as well as 37 °C. Usually, but not exclusively, associated with the intestines of warm-blooded animals and birds.
Flood tide	The rising tide, immediately following the period of low water and preceding the ebb tide.

Flow ratio	Ratio of the volume of freshwater entering into an estuary during the tidal cycle to the volume of water flowing up the estuary through a given cross section during the flood tide.
Geometric mean	The geometric mean of a series of N numbers is the N^{th} root of the product of those numbers. It is more usually calculated by obtaining the mean of the logarithms of the numbers and then taking the anti-log of that mean. It is often used to describe the typical values of a skewed data such as one following a log-normal distribution.
Hepatitis A	This is a 27nm diameter virus that contains RNA as its nucleic acid. It is transmitted by the faecal-oral route and although most infections are unapparent or mild feverish episodes, it can cause inflammation of the liver resulting in jaundice.
Hydrodynamics	Scientific discipline concerned with the mechanical properties of liquids.
Hydrography	The study, surveying, and mapping of the oceans, seas, and rivers.
Norovirus	Norovirus (previously known as Norwalk-like viruses and Small round structured viruses) are small, 27-to 32-nm, structured RNA viruses classified as caliciviruses which have been implicated as the most common cause of nonbacterial gastroenteritis outbreaks.
Salmonellosis	Salmonella are a genus of Gram-negative, usually motile, rod-shaped bacteria found in the intestines of humans, other animals and birds which can cause gastroenteritis.
Secondary Treatment	Treatment to applied to breakdown and reduce the amount of solids by helping bacteria and other microorganisms consume the organic material in the sewage or further treatment of settled sewage, generally by biological oxidation.
Sewage	Sewage can be defined as liquid, of whatever quality that is or has been in a sewer. It consists of waterborne waste from domestic, trade and industrial sources together with rainfall from subsoil and surface water.
Sewage Treatment Works (STW)	Facility for treating the waste water from predominantly domestic and trade premises.
Sewer	A pipe for the transport of sewage.
Sewerage	A system of connected sewers, often incorporating inter-stage pumping stations and overflows.
Storm Water	Water which runs off roofs, roads, gulleys, etc. In some areas, storm water is collected and discharged to separate sewers, whilst in combined sewers it forms a diluted sewage.
Waste water	Any waste water but see also “sewage”.

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