Centre for Environment Fisheries & Aquaculture Science

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Helford Estuary Sanitary Survey

Review

March 2014

Food Standards Agency

Cover photo: Mouth of the Helford Estuary

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Statement of use

Under EC Regulation 854/2004 which lays down specific rules for official controls on products of animal origin intended for human consumption a sanitary survey relevant to bivalve mollusc beds in Helford Estuary was undertaken in 2008. This provided an appropriate hygiene classification zoning and monitoring plan based on the best available information with detailed supporting evidence. The FSA is committed to reviewing sanitary surveys every six years or sooner if significant changes in pollution sources or the fishery have occurred that may require revision of the sampling plan. This report provides a six year review of information and recommendations for a revised sampling plan. The Centre for Environment, Fisheries & Aquaculture Science (Cefas) undertook this work on behalf of the Food Standards Agency (FSA).

Revision history

Version	Details	Approved by	Approval date
1	Draft for internal review	David Walker	19/02/2014
2	Draft for external review	Simon Kershaw	27/03/2014
Final	Final report post consultation	Simon Kershaw	25/06/2014

Consultation

Consultee	Date of consultation	Date of response
Cornwall Port Health Authority	28/03/2014	25/04/2014
Environment Agency	28/03/2014	06/05/2014
South West Water	28/03/2014	No response
Cornwall IFCA	28/03/2014	17/04/2014
Duchy of Cornwall Oysters	28/03/2014	No response
Defra	28/03/2014	09/04/2014

Dissemination

Food Standards Agency, Cornwall Port Health Authority. The report is available publicly via the Cefas website.

Recommended Bibliographic Reference

Cefas, 2014. Review of the Helford Estuary 2008 Sanitary Survey. Cefas report on behalf of the Food Standards Agency, to demonstrate compliance with the requirements for classification of bivalve mollusc production areas in England and Wales under EC Regulation No. 854/2004.

Contents

1. Introduction

1.1. Background

The Centre for Environment, Fisheries & Aquaculture Science (Cefas) is performing sanitary surveys for new bivalve mollusc production areas (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.’

In line with the EURL Good Practice Guide Cefas is contracted to undertake reviews of sanitary surveys on behalf of the Food Standards Agency. Reviews are to be undertaken at six yearly intervals after the original sanitary survey or sooner and where there are changes to the type and locations of the shellfisheries or significant changes in sources of pollution.

1.2. Helford Estuary review

This reviews information and makes recommendations for a revised sampling plan for existing mussel, native oyster and Pacific oyster classification zones in the Helford Estuary (Figure 1.1). This review identifies changes to information presented in the sanitary survey through a desk based study, and shoreline survey and updates the assessment and sampling plan as necessary.

Specifically, the review considers:

(a) changes to the shellfishery
(b) changes in microbiological monitoring results
(c) changes in sources of pollution impacting the production area or new evidence relating to the actual or potential impact of sources
(d) changes in land use in the area
(e) change in environmental conditions

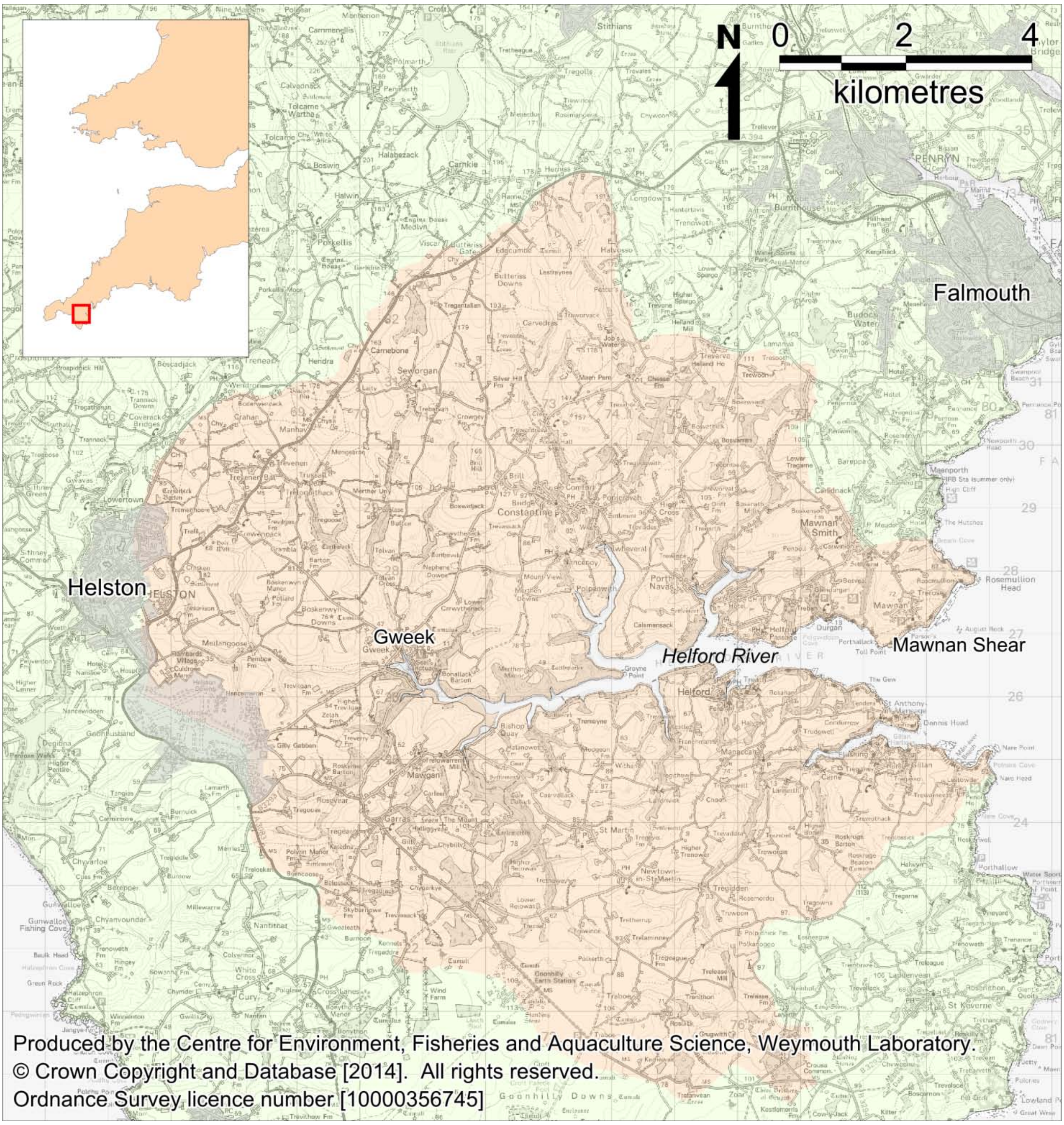

Figure 1.1: Location of the Helford Estuary

2. Shellfishery

2.1. Description of shellfishery

The rights to harvest shellfish from the Helford estuary are leased under licence from the Duchy of Cornwall. This lease covers most of the extent of the estuary from Gweek in the west to Mawnan Shear in the east. Figure 2.1 shows the current fishery. The description of the fishery below was compiled by information from communications with the Duchy Oyster Farm (M. Mercer, Pers. Comm. 2013, 2014) and Cornwall Port Health Authority (T. Stanley, Pers. Comm. 2014)

Since the sanitary survey was written, the main species produced in the estuary has changed from native oysters to Pacific oysters. Pacific oysters are grown from seed imported from Guernsey on a seed raft in the mouth of Porth Navas Creek for around three months until they reach a mass of approximately 0.2 g. At this point they are transported to nursery cages at Bosahan Cove towards the eastern end of the estuary where they are grown for an average of around one year until they reach 20 g in mass. The netted oysters are winched onto a boat and oysters are graded on a raft, before being taken to the western end of the main estuary (East of Groyne Point) where they are on-grown in a combination of trestles, cages, nets and beds until they reach marketable size. Here they are harvested by winching the bags and nets onto a boat. Before being marketed, the oysters are held in an area in Porth Navas Creek adjacent to the Duchy Oyster Farm premises for up to a month. Observation 30 from the shoreline survey (Appendix I) was of this holding area. While being held at Porth Navas the oysters are repeatedly exposed at low tide. This has the effect of strengthening the adductor muscle to produce a better quality product [improves shelf life]. Figure I.25 and Figure I.26, which were also taken at this location, show that what appears to be part of the holding area is located to the north-east of the quay and therefore fall just outside the current classification zone. Aerial photography (Google Earth and Bing Maps) also show the presence of operations to the north west of the quay.

It should be noted that the use of the Porth Navas holding area may cause logistical issues in the future. Regulation EC 853/2004 states that *'food business operators must not re-immerse live bivalve molluscs in water that could cause additional contamination.'* In practice this means that appropriate shellfish monitoring and a hygiene classification is required for Pacific oysters held at Porth Navas to demonstrate that no additional contamination occurs, and only oysters originating from areas of the same classification may be held there.

Mature/adult sized shellfish that are moved into this classification zone (whilst designated as a Production area) must not come from a classification zone with a lower classification (i.e. class C rather than class B). If Porth Navas Quay had a higher level of classification than the rest of the production area then, in order to be able to use this zone, it would need to be formally designated as a relaying area. As such, relayed shellfish would be required to be left here for at least two months, before being sold for human consumption. Bearing in mind the ‘all in/all out’ requirement of the legislation and the fact that the site is not large enough for separate batches to be stored safely without the potential for cross-contamination, it is considered that only one batch at a time could be relayed here. This might create operational difficulties.

The oysters are harvested year round and it is estimated that the Duchy Oyster Farm will produce approximately 50 tonnes of pacific oysters in 2014.

There are currently no native oysters harvested commercially in the estuary. However, the Duchy Oyster Farm plan to stock the Helford Estuary with native oysters from the nearby Fal estuary. It is likely that the native oysters will be grown in the classified area to the south of Porth Navas Creek.

Mussels are also harvested from the estuary but from wild stock. The harvesting of mussels is done sporadically. Previously this has mainly been done along the stretch of coast between Frenchman's Creek and Penarvon Cove. However there are also high densities of mussels along the shoreline between Porth Navas Creek and to the north of Frenchman's Creek and along the western edge of Helford Creek which have also been harvested in the past. Additionally, there are high concentrations of mussel from the eastern edge if Helford Creek extending easterly towards the mouth of the estuary. The Duchy Oyster Company has expressed an interest in harvesting mussels from this latter area and currently have no plans to harvest mussels from anywhere else in the estuary (T. Stanley, Pers Comm., 2014).

There are dense beds of cockles in the estuary and both cockles and mussels are commonly subject to non-commercial ‘casual gathering’ by hand. However, under the terms of the lease from the Duchy of Cornwall, the Duchy Oyster Farm has fishing rights for all of the shellfish in the estuary. This means that any harvesting by any parties other than the Duchy Oyster Farm is not legal.

There is anecdotal evidence that there is some degree of illegal commercial harvesting of mussels especially from The Bar (Appendix I: Shoreline Survey Report, observation 27). However the local industry commented that this activity is difficult to prove and there are no resources to police the area against poachers (M. Mercer, Pers Comm.).

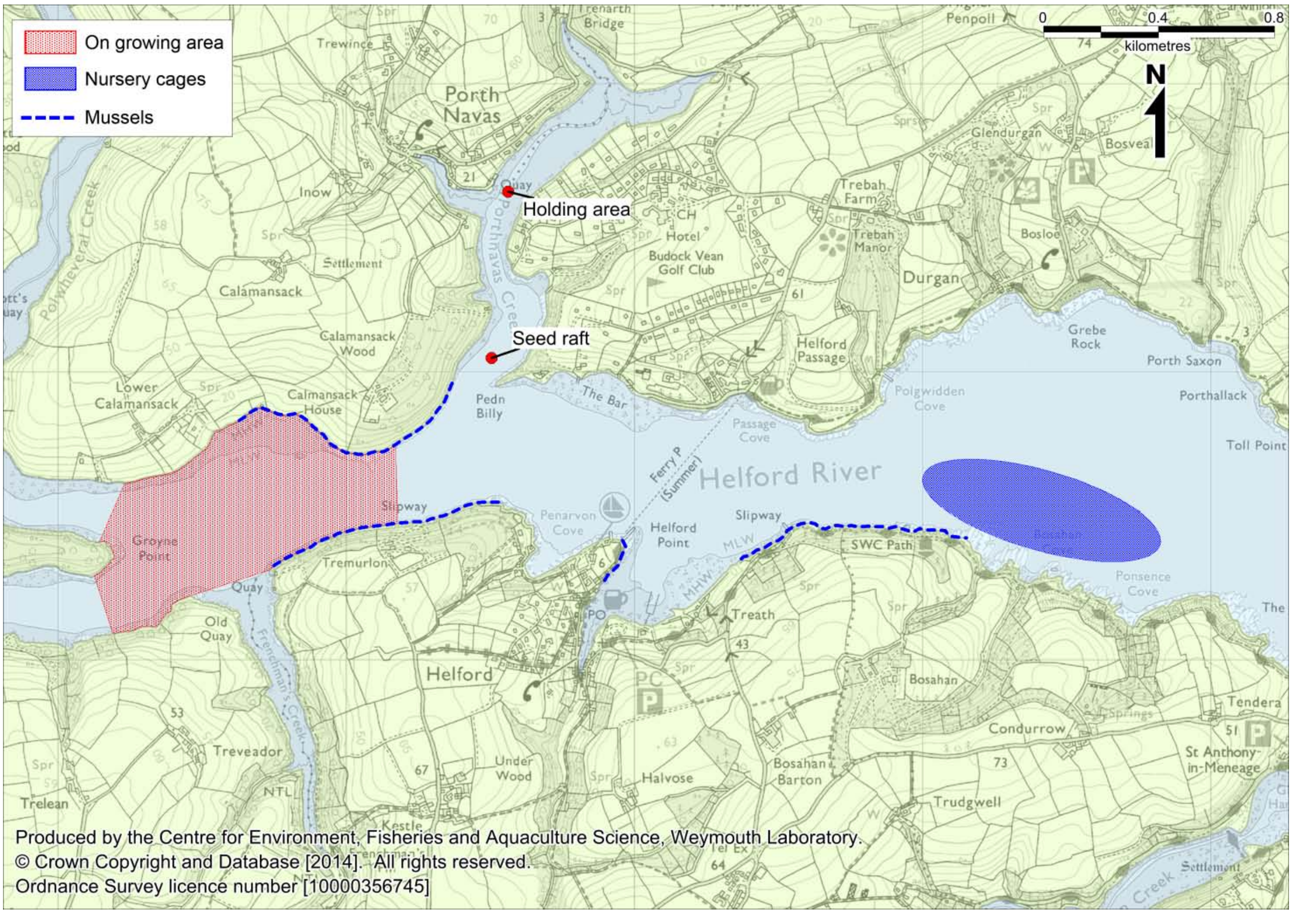

Figure 2.1: Locations of Pacific oyster operations and mussel beds in the Helford Estuary.

2.2. Hygiene classification

Table 2.1 lists all of the classifications within the Helford Estuary since 2002 and Figure 2.2 shows the locations of the current classification zones and representative monitoring points (RMPs). The majority of classifications in the estuary have been B, although Helford Creek was downgraded to a C in 2010, but upgraded back to B in 2011. Before the sanitary survey in 2008, native oysters at the East of Groyne Point (then called Groyne Point) bed were downgraded to C in 2004 and 2005, but have remained class B since.

Table 2.1: Classification history for the Helford Estuary since 2002.

Bed name	Species	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Porth Navas Quay	Mussels	B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
East of Groyne Point		B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
South of Porth Navas Bar		B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Helford Creek		-	-	-	-	-	B1	B	B1	C	B	B	B
Porth Navas Quay	Native oysters	B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
East of Groyne Point		B	B	C	C1	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
South of Porth Navas Bar		B	B	B4	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Porth Navas Quay	Pacific oysters	-	-	-	-	-	B	B	B	B1	B	B	B
East of Groyne Point		-	-	-	-	-	-	-	-	B	B	B-LT	B-LT
South of Porth Navas Bar		-	-	-	-	-	B	B	B	B	B	B-LT	B-LT
Bosahan		-	-	-	-	-	-	-	B	B	B	B	B

LT denotes long term classification

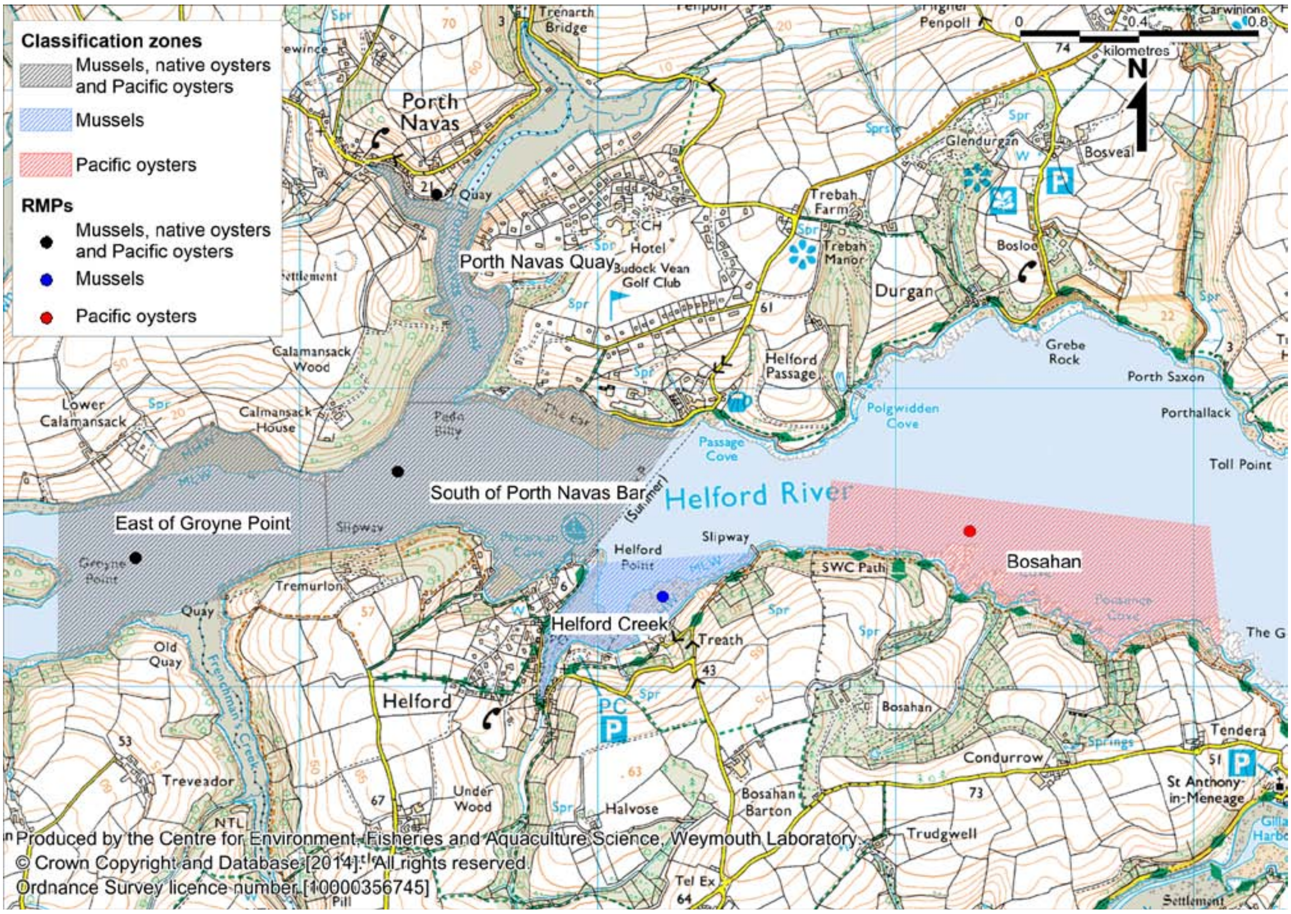

Figure 2.2: Current classification zones and RMPs in the Helford Estuary

Overall assessment

Since the sanitary survey, the fishery in the Helford Estuary has changed considerably. At the time of the survey, the main species that were harvested were native oysters and mussels. Currently only Pacific oysters are continually harvested, with mussels harvested occasionally. There are plans to reintroduce native oysters to the estuary in the near future.

Harvested shellfish are moved to a holding area in Porth Navas Creek before being sold. While this area is classified (Porth Navas Quay), it should be noted that any differences between this classification zone and those that are harvested will make this area unusable for this purpose.

The population within the catchment has increased by approximately 12% between 2001 to 2011 census data reports and the volume of sewage discharged is likely to have increased in response. However, confirmation of this is outside the scope of this review.

No changes have been made to the water company owned discharges since the sanitary survey reported in 2008. Gweek sewage treatment works (STW) was identified as the most significant source of contamination to the area before the sanitary survey (EA, 2003), and probably remains so. It was beyond the scope of this review to assess the performance of the Helford STW, which was installed just before the sanitary survey was written. While no significant difference was found in average *E. coli* levels before and after the installation of the Helford STW, there does appear to have been an overall trend of increasing *E. coli* levels at Helford Point. This is likely to be attributable to the increase in the volume of treated sewage being discharged as a single point source directly into Helford Creek instead of from several discharges dispersed over a wider area.

Numbers of livestock reported in the Kerrier District decreased between 2007 and 2010, however numbers may have increased since 2010. The livestock data reported for the Kerrier District may not be representative of the Helford catchment, as the District covers a much wider area. Livestock appears to be widely spread throughout the catchment, and so will not influence the positioning of the monitoring points.

No changes in bathymetry have occurred since the sanitary survey. A new jetty has been built in Helford Creek, and there are plans to change the structure of Gweek Quay. While these structures may affect the flow of water locally, they are unlikely to influence contamination in the shellfish.

Since the sanitary survey, most of the recommended RMPs for shellfish in the Helford Estuary have changed, and so it was not possible to directly compare most sites before and after the sanitary survey. Overall there have been more high results in mussels since the sanitary survey. Since the start of monitoring at the new RMPs, there has been a slight increase in *E. coli* levels at East of Groyne Point, but not at the other mussel RMPs (excluding Helford Point). *E. coli* levels in native oysters have remained largely unchanged since the sanitary survey, however there have been more high results (>4,600 MPN/100 g) in Pacific oysters.

3. Sampling plan

3.1. Recommendations

Mussels

Most of the harvestable mussels in the Helford are confined to rocky shores. Mussels are not continually harvested in the Helford Estuary. However, as harvesting of mussels is carried out sporadically, the option for them to be harvested needs to remain. Therefore it is recommended that all mussel RMPs are sampled quarterly to maintain classification, but sampling frequency should increase to monthly prior to the beds being harvested. Quarterly sampling will result in fewer samples for classification over the year. This increases the risk of a site being downgraded if there are a small number of high E. coli results. It is therefore left to the discretion of the local authority as to whether sampling is dropped to quarterly or not. A quarterly sampling system would require the harvester to inform the local authority in advance of any planned use of the mussel beds.

<u>Porth Navas Quay</u> - This zone is used as a holding area for mussels before they are marketed. The same classification zone and RMP are used for mussels as for Pacific oysters. Bagged mussels are used to represent mussels in this area. This practice is appropriate and should continue.

<u>East of Groyne Point</u> – This area represents mussels on the north and south shore at the western end of the estuary. This zone will mainly be influenced by contamination flowing downstream from Gweek and Constantine, with the possibility of a small level of contamination from Frenchman's Creek. The current zone and RMP are suitable for the continued classification of this area. However, there is the possibility of some contamination from runoff from the surrounding land. Should evidence come to light that this is the case, it may be necessary to alter the classification zones to reflect probable differences between the north and south shores.

<u>South of Porth Navas Bar</u> - This area represents mussels on the north and south shores of the estuary which will be influenced more by the discharge from Porthnavas Creek than Gweek and Constantine (represented by East of Groyne Point).

This zone is influenced by water flowing downstream from Gweek and Constantine, from Porth Navas Creek to the North and from Helford Creek and Passage Cove during the flood tide. Samples taken during the bacteriological survey indicate that levels of *E. coli* were low at the mouth of Porth Navas Cove and at Groyne point where the sources from Gweek and Constantine converge. However, Porth Navas Creek is relatively shallow, which means that contamination from upstream will be less dilute when it reaches the estuary. The relatively high level of *E. coli* found near Passage Cove may represent a locally significant source of contamination. However, there is likely to be a large degree of dilution between here and the nearest shellfish bed.

On balance it is likely that the Porth Navas Creek is the largest source of contamination for this classification zone. The current RMP, which is located towards the western end of the zone, is unlikely to be representative of this zone. It is therefore recommended that the RMP is moved to the mouth of Porth Navas Creek. Additionally, as this area is not currently in use it is recommended that samples are taken quarterly with monthly sampling resuming when the zone comes back into use.

Padgagarrack Wood - This zone represents the mussels that grow on the rocky shores east of Helford creek towards Bosahan. The main sources of contamination for this zone are likely to be those sources in Helford Creek, including Helford STW and Helford Brook Additionally contamination from the Helford River itself will have an impact on these mussels.. The RMP should therefore be located at the western end of this zone.

Native oysters

Native oysters are not currently harvested in the Helford Estuary. However there are plans to reintroduce them for commercial exploitation in the near future. The three current native oyster classification zones are the same zones as for Pacific oysters (excluding Bosahan), and Pacific oysters are used to represent native oysters for classification. This should continue to be the case and so the recommended classification zone and RMP locations for native oysters are the same as for Pacific oysters below.

Pacific Oysters

There are currently four classification zones for Pacific oysters in the Helford Estuary as recommended by the sanitary survey. Although the operations of the fishery have changed considerably since the sanitary survey, the boundaries for the classifications remain on the most part suited to the current fishery. The exception to this is Porth Navas Quay as explained below.

Porth Navas Quay - This zone is used as a holding area for Pacific oysters before they are marketed. Parts of the holding area appear to lie just to the north-east of the current classification zone. Therefore the zone should be extended north-eastwards to the end of the oyster farm buildings to incorporate the entire operation.

This zone is subject to flow from two streams at the northern end of Porth Navas Creek (Mawnan Smith Brook and Porth Navas Stream) as well as one stream to the west (Trewince Stream). There are some small private discharges to Trewince Stream. Upstream of the Mawnan Smith Brook is the village of Mawnan Smith, which is a larger conurbation than the village of Porth Navas. The Parc-An-Manns pumping station emergency overflow (PSEO) is permitted to discharge into this stream. A sample from the bacteriological survey showed that water taken from the mouth of this stream had an *E. coli* concentration of 1,800 *E. coli* cfu/100 ml indicating that there was some contamination coming from the stream. Additionally, water sampling data presented in the sanitary survey (page 54) indicate that of these three streams, Mawnan Brook had the highest level of faecal contamination.

The current location of the RMP for this zone is 'sheltered' from much of the contamination from upstream by the quay. It is therefore recommended that the RMP be relocated to the north-eastern side of the quay.

East of Groyne Point - This area is used for the on-growing of Pacific oysters that have been moved from the Bosahan nursery area. This zone will mainly be influenced by contamination flowing downstream from Gweek and Constantine, with the possibility of a small level of contamination from Frenchman's Creek. The current zone and RMP are suitable for the continued classification of this area.

South of Porth Navas Bar - This area is not currently used for Pacific oyster production. However, the Duchy Oyster Farm plans to reintroduce native oysters to this area in the near future. It is recommended that this zone remain classified for both Pacific oysters and native oysters.

This zone is influenced by water flowing downstream from Gweek and Constantine, from Porth Navas Creek to the North and from Helford Creek and Passage Cove during the flood tide. Samples taken during the bacteriological survey indicate that levels of *E. coli* were low at the mouth of Porth Navas Cove and at Groyne point where the sources from Gweek and Constantine converge. However, Porth Navas Creek is relatively shallow, which means that contamination from upstream will be less dilute when it reaches the estuary. The relatively high level of *E. coli* found near Passage Cove may represent a locally significant source of contamination. However, there is likely to be a large degree of dilution between here and the nearest shellfish bed.

On balance it is likely that the Porth Navas Creek is the largest source of contamination for this classification zone. The current RMP, which is located towards the western end of the zone, is unlikely to be representative of this zone. It is therefore recommended that the RMP is moved to the mouth of Porth Navas Creek. Additionally, as this area is not currently in use it is recommended that samples are taken quarterly with monthly sampling resuming when the zone comes back into use.

Bosahan - This area is used as a nursery for Pacific oysters. The main sources of contamination for this area are Helford Creek and springs discharging to Bosahan and Ponsence Coves. Contamination from Helford Creek will be subject to a large amount of dilution due to the water depth (up to 15 m at chart datum) between the creek and Bosahan. The levels of *E. coli* measured under dry conditions in the fresh water spring inputs at Bosahan, during both the shoreline survey for this review and that for the sanitary survey in 2008, were relatively low. The current zone and RMP are suitable for the continued classification of this area. This is a nursery area, with oysters being moved to East of Groyne Point for on-growing, and so no oysters are currently taken from here to be sold. It is therefore recommended that sampling frequency is reduced to quarterly with monthly sampling resuming if the harvesters change their operating procedures.

3.2. General information

Location Reference

Production area	Helford Estuary
Cefas main site reference	M034
Ordnance survey 1:25,000 map	Explorer 103 (The Lizard)
Admiralty / Imray charts	No 147 / No 2400.11

Shellfishery

Species/culture	Mussels (*Mytilus spp.*) Native oysters (*Ostrea edulis*) Pacific oysters (*Crassostrea gigas*)	Wild Cultured Cultured
Seasonality of harvest	Year round	

Local Enforcement Authority

Name	Cornwall Port Health Authority
Environmental health officer	Terry Stanley
Telephone number ☎	0300 1234 212
Fax number	
E-mail	envhealthandlicensing@cornwall.gov.uk

Requirement for review

The Guide to Good Practice for the Microbiological Monitoring of Bivalve Mollusc Harvesting Areas (EU Working Group on the Microbiological Monitoring of Bivalve Mollusc Harvesting Ares, 2010) indicates that sanitary assessments should be fully reviewed every six years. This assessment is therefore due for formal review in 2020. The assessment may require review in the interim should any significant changes in sources of contamination come to light.

Table 4.1: Number and location of representative monitoring points (RMPs) and frequency of sampling for classification zones within the Helford estuary

Classification zone	RMP*	RMP name	NGR	Latitude & Longitude (WGS84)	Species	Growing method	Harvesting technique	Sampling method	Sampling species	Tolerance	Frequency	Comments
Porth Navas Creek	TBA	Oyster farm	SW7554327664	50°6.393'N 05°8.425'W	Mussels	Cultured	Hand/bagged	Hand/bagged	Mussels	10 m	Quarterly	-
East of Groyne Point	TBA	East of Groyne	SW7445026430	50°5.703'N 05°9.297'W	Mussels	Cultured	Bagged	Bagged	Mussels	10 m	Quarterly	-
South of Porth Navas Creek	TBA	Pedn Billy	SW7542326944	50°6.002'N 05°8.500'W	Mussels	Cultured	Bagged	Bagged	Mussels	10 m	Quarterly	-
Padgagarrack Wood	TBA	East Helford Creek	SW7638126367	50°5.713'N 05°7.677'W	Mussels	Wild	Hand-picked	Hand-picked	Mussels	100 m	Quarterly	-
Porth Navas Creek	TBA	Oyster farm	SW7554327664	50°6.393'N 05°8.425'W	Native oysters	Cultured	Bagged	Bagged	Pacific oysters	10 m	Monthly	-
East of Groyne Point	TBA	East of Groyne Point	SW7445026430	50°5.703'N 05°9.297'W	Native oysters	Cultured	Bagged	Bagged	Pacific oysters	10 m	Monthly	-
South of Porth Navas Creek	TBA	Pedn Billy	SW7542326944	50°6.002'N 05°8.500'W	Native oysters	Cultured	Bagged	Bagged	Pacific oysters	10 m	Quarterly	-
Bosahan	TBA	Bosahan	SW7725026520	50°5.815'N 05°6.955'W	Native oysters	Cultured	Bagged	Bagged	Pacific oysters	10 m	Quarterly	-
Porth Navas Creek	TBA	Oyster farm	SW7554327664	50°6.393'N 05°8.425'W	Pacific oysters	Cultured	Bagged	Bagged	Pacific oysters	10 m	Monthly	-
East of Groyne Point	TBA	East of Groyne Point	SW7445026430	50°5.703'N 05°9.297'W	Pacific oysters	Cultured	Bagged	Bagged	Pacific oysters	10 m	Monthly	-
South of Porth Navas Creek	TBA	Pedn Billy	SW7542326944	50°6.002'N 05°8.500'W	Pacific oysters	Cultured	Bagged	Bagged	Pacific oysters	10 m	Quarterly	-
Bosahan	TBA	Bosahan	SW7725026520	50°5.815'N 05°6.955'W	Pacific oysters	Cultured	Bagged	Bagged	Pacific oysters	10 m	Quarterly	-

**RMP codes will be generated once the report has been agreed and finalised.*

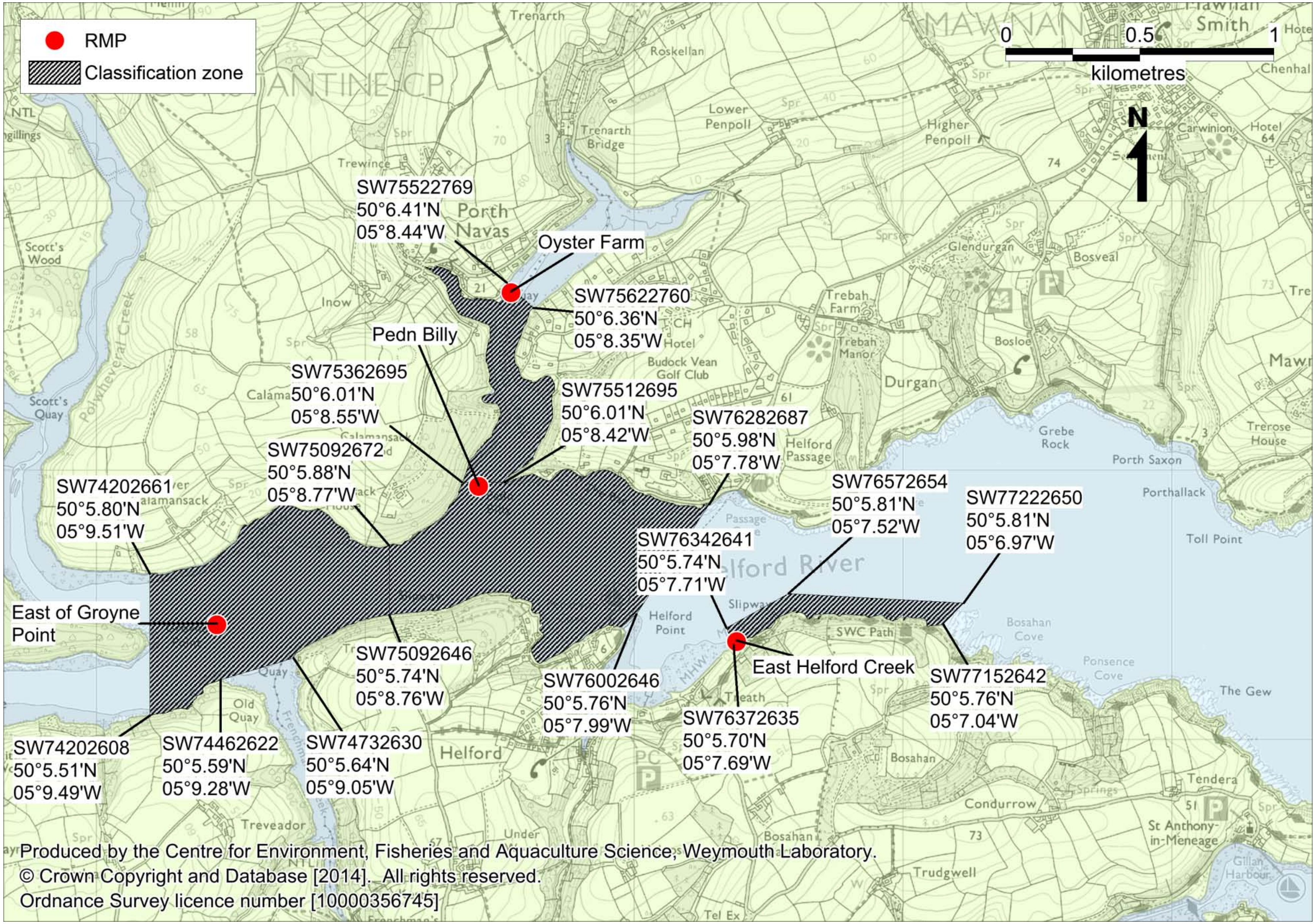

Figure 4.1: Recommended zoning and monitoring arrangements (mussels)

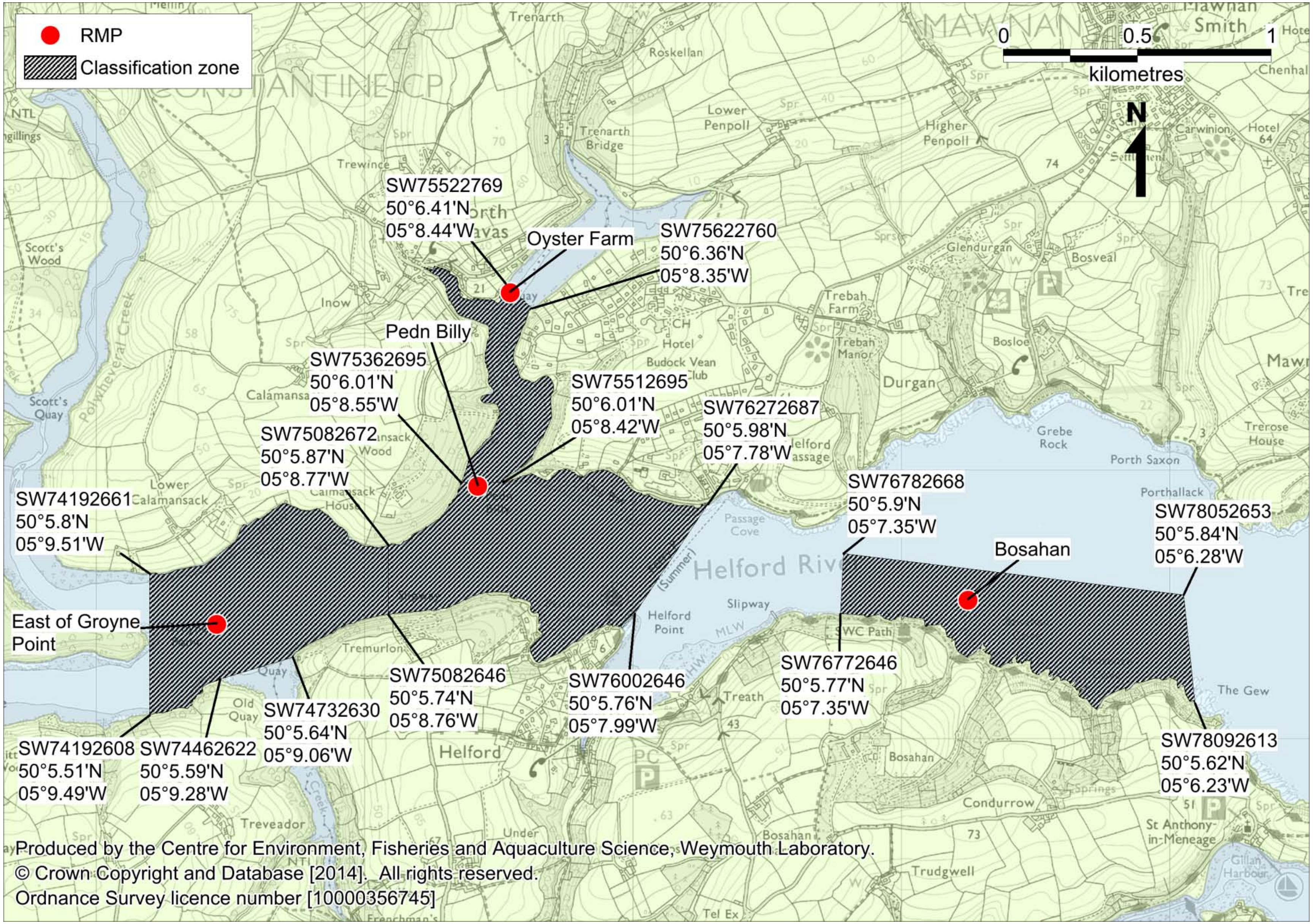

Figure 4.2: Recommended zoning and monitoring arrangements (native and Pacific oysters)

Figure 4.3: Current and recommended mussel RMPs. East of Groyne Point remains unchanged.

Figure 4.4: Current and recommended oyster RMPs. East of Groyne Point and Bosahan remain unchanged.

4. Pollution sources

4.1. Human population

In the Helford River Sanitary Survey Report (2008) the population data presented were collected in the 2001 census. Since the report was written another census was conducted in 2011, and so changes in the human population in the catchment are discussed here.

Figure 5.1 shows population densities in census Lower Layer Super Output Areas (LSOAs) within or partially within the Helford catchment area, derived from data collected from the 2011 census. Between the 2001 and 2011 censuses there were no changes in population densities within the ranges presented in Figure 5.1.

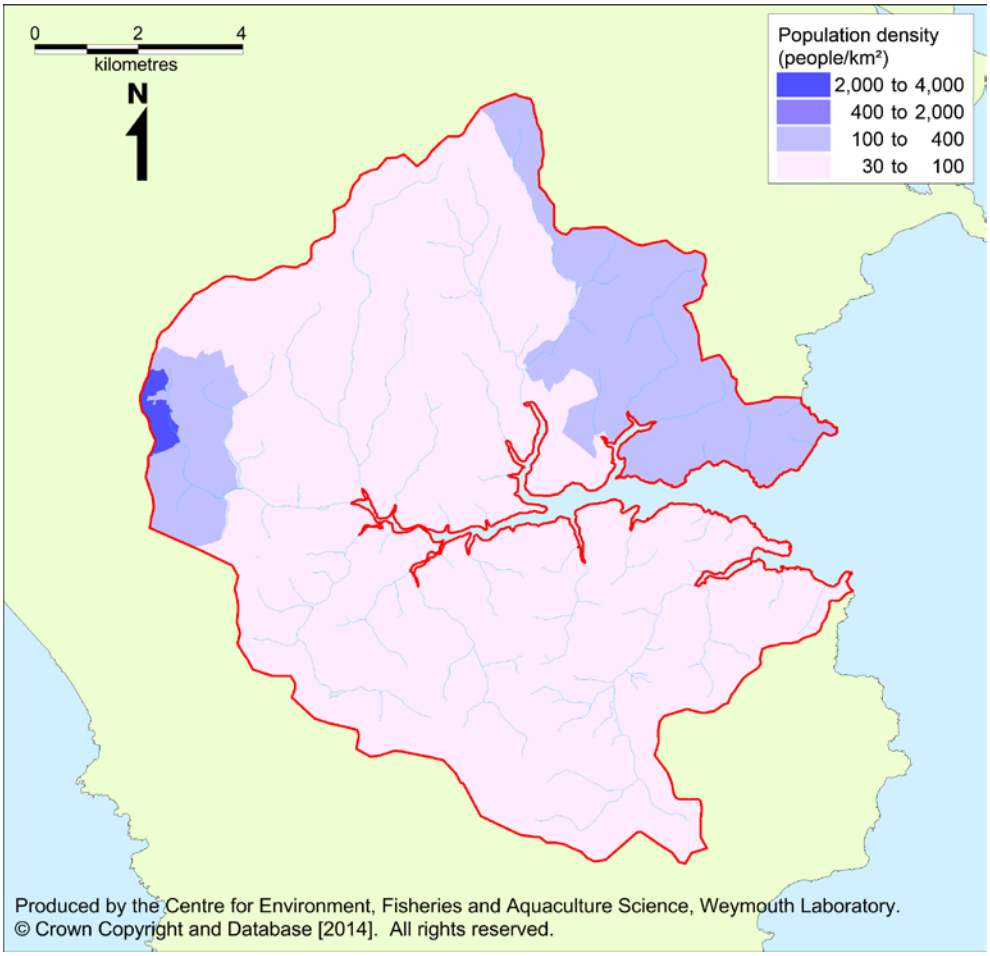

Figure 5.1: Human population density in census LSOAs in the Helford catchment.

Total resident population within the census areas contained within or partially within the catchment area increased by around 12% from 23,000 in 2001 to 26,000 in 2011. Table 5.1 shows the changes in the total populations and population densities for each of the LSOAs. Kerrier area 010C, which is in the north east of the catchment had a population increase of almost 51% between the censuses. Kerrier areas 011E, 011G and 013C, all located towards the west of the catchment, had population increases of over 20%. Those

LSOAs that are directly adjacent to the shellfish production areas (Kerrier 010A, 010B and 013B) all had population increases of less than 10%.

Table 5.1: Changes in populations in LSOAs in the Helford catchment between 2001 and 2011.

LSOA name	Total population			Population density (people/km²)		
	2001	2011	% change	2001	2011	% change
Kerrier 010C	1276	2601	50.9	118.3	241.9	50.9
Kerrier 011E	1375	1951	29.5	263.9	376.0	29.5
Kerrier 011G	1409	1912	26.3	2201.6	2999.9	26.3
Kerrier 013C	1407	1776	20.8	45.1	57.1	20.8
Kerrier 009D	2150	2372	9.4	58.9	65.2	9.4
Kerrier 011B	1469	1570	6.4	345.6	371.2	6.4
Kerrier 010B	2002	2137	6.3	59.3	63.5	6.3
Kerrier 011C	1553	1655	6.2	3611.6	3819.8	6.2
Kerrier 010D	1399	1486	5.9	144.5	154.1	5.9
Kerrier 013B	1132	1200	5.7	39.4	41.9	5.7
Kerrier 009C	2004	2101	4.6	114.6	120.7	4.6
Kerrier 010A	1738	1753	0.9	113.2	114.6	0.9
Kerrier 013E	2107	2008	-4.9	50.5	48.3	-4.9
Kerrier 013A	1956	1842	-6.2	66.7	63.1	-6.2

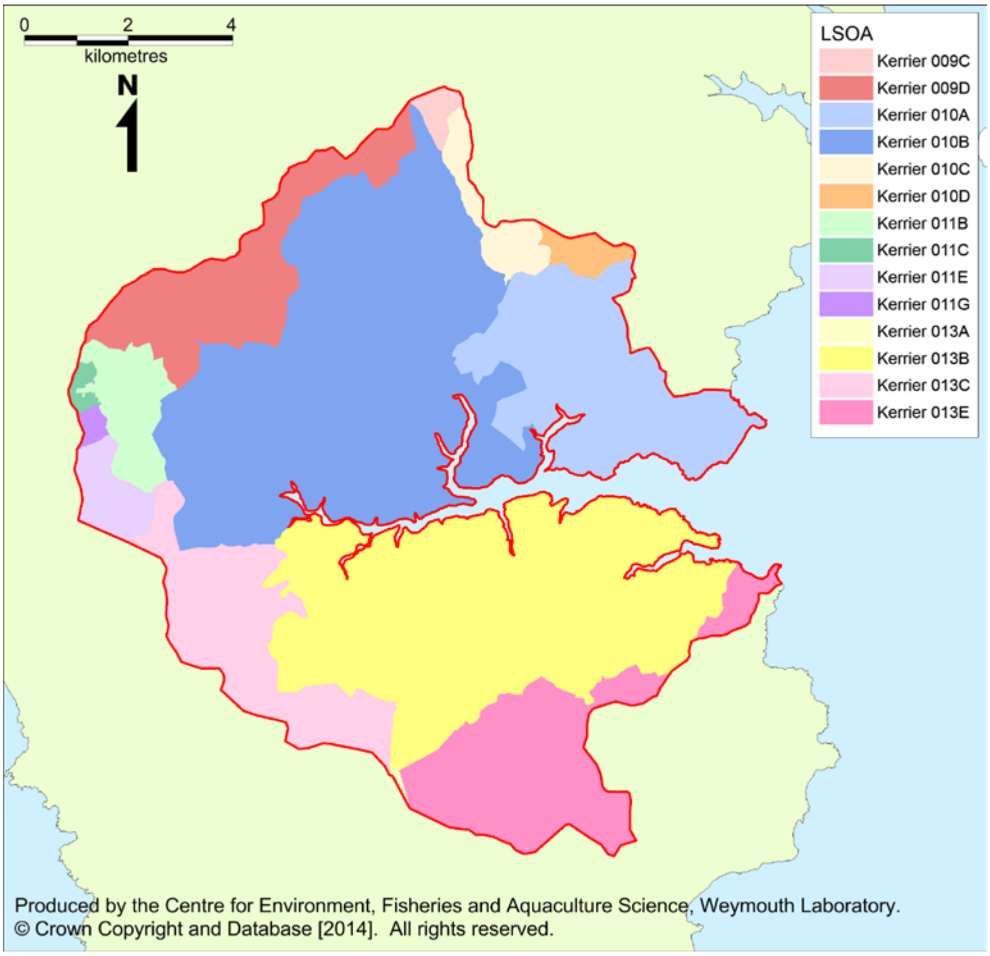

Figure 5.2: Locations of the LSOAs which are within or intersect the Helford catchment.

4.2. Sewage

Figure 5.3 shows the locations of all of the current discharges identified in the Environment Agency (EA) national permit database (October 2013) which fall within in the Helford Estuary and river catchment. The catchment area boundary used for this review is different from that used in the original sanitary survey. This is due to updated procedures for creating new GIS data for catchment areas. The newly defined catchment area has eliminated several discharges from this report, none of which were reported as significant in the original sanitary report.

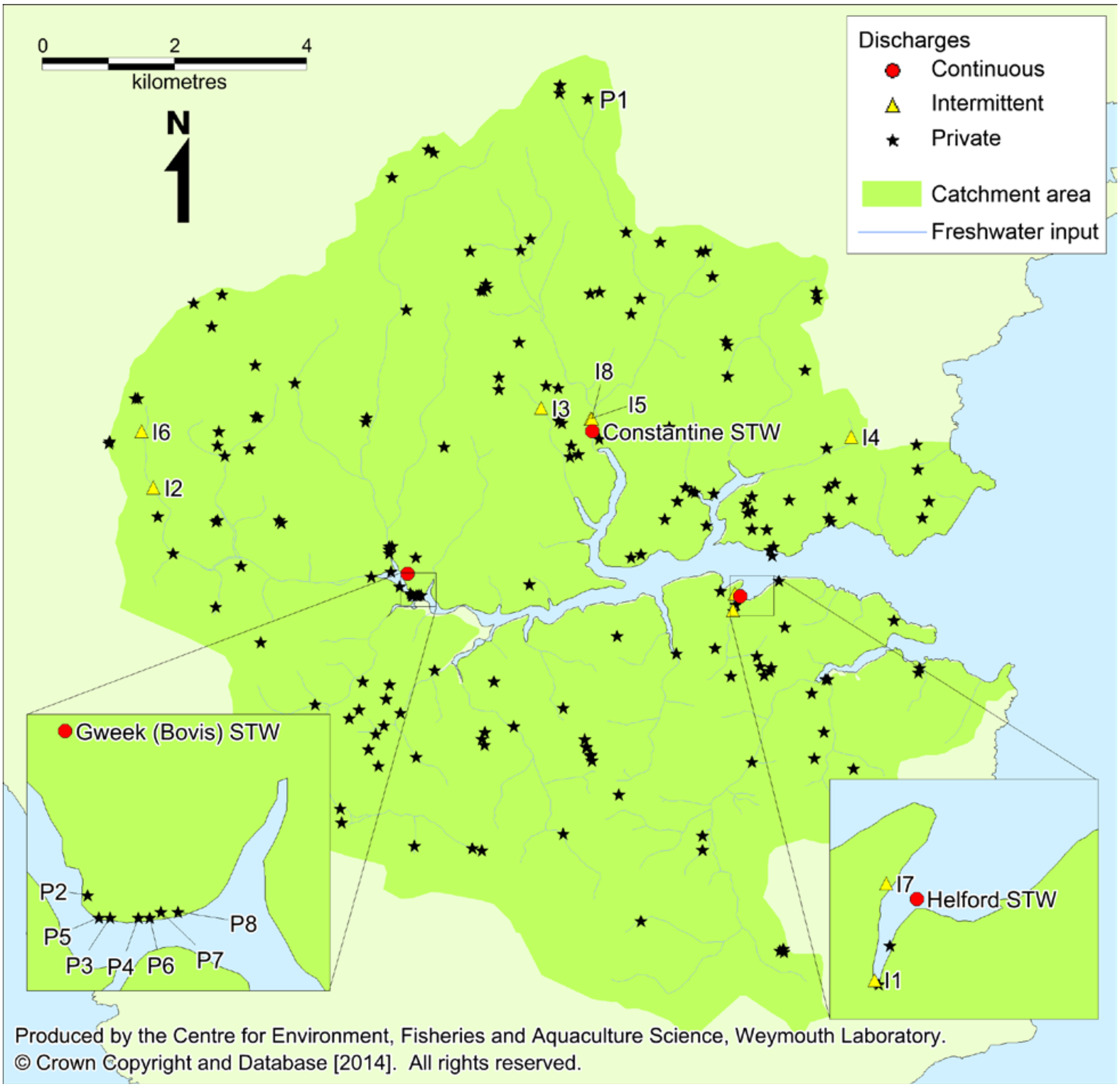

Figure 5.3: Discharges in the Helford catchment (Table 5.2,Table 5.3, and Table 5.4 for details)
Data from Environment Agency

Table 5.2 lists the continuous water company discharges in the Helford catchment. No changes have been made to these continuous water company discharges in the catchment since the sanitary survey was carried out. The pollution reduction plan for the Helford River (EA, 2009) states that an investigation carried out in collaboration with the University of Exeter attributed most of the bacterial pollution in the estuary to the village of

Gweek. An upgrade to the Gweek (Bovis) STW was not funded, and a desk based study of the sewerage infrastructure at Gweek and the Gweek (Bovis) STW were proposed but have not been undertaken to date.

In addition to the continuous water company discharges, there are nine intermittent discharges as detailed in Table 5.3. No new intermittent discharges have been permitted, and no existing ones have been revoked, since the 2008 sanitary survey. Table 5.5 shows the frequency and duration of spills from intermittent discharges in the Helford catchment where data were available. Constantine STW overflow recorded the largest number of spills. In all but one year from 2005 to 2012 inclusive it spilled on more than 10 occasions, averaging 22 spills per year over this period. In 2008 it spilt for 8.41% of the time.

There are 179 private discharges in Helford catchment listed in the current EA consents database (Table 5.4), compared with 151 that were presented in sanitary survey (within the new catchment area). It was not feasible within the resources available, nor considered necessary, to compare all of these discharges. Therefore, only those private discharges with a maximum daily flow exceeding 100 m^3 were compared. Two private discharges fulfil this criteria (Kessel Downs Quarry and National Seal Sanctuary). While only one discharge (470 m^3d^{-1}) was originally reported for the National Seal Sanctuary, seven, are recorded on the current EA national permit database with a combined maximum daily output of 3,240 m^3d^{-1}. However according to the latest EA database, permits for all of these discharges were issued on 20/12/2001 and no records of new discharges being built could be found. It is therefore assumed that all seven of these discharges existed when the sanitary survey was created.

Table 5.2: Continuous water company discharges within the Helford catchment.

Name	NGR	Treatment	Dry weather flow (m³/day)	Receiving environment	Fluvial distance to nearest CZ (km)
Helford STW	SW75922618	2° (Biological filtration)	50	Saline Estuary	0.0
Gweek (Bovis) STW	SW70902652	2° (Biological filtration)	Not reported	Saline Estuary	3.8
Constantine STW	SW73692867	3° (UV disinfection)	150	Freshwater river	2.7

Data from Environment Agency

Table 5.3: Intermittent water company discharges within the Helford catchment.

Number on map	Name	NGR	Receiving environment	Fluvial distance to nearest CZ (km)
I1	Ford PS	SW75812597	Saline Estuary	0.0
I2	Gwealmayowe SPS	SW67062782	Freshwater river	8.5
I3	Constantine Bridge PSCSO/EO	SW72922903	Freshwater river	3.1
I4	Parc-An-Manns PSEO	SW77602859	Freshwater river	2.3
I5	Penbothidno CSO	SW73662886	Freshwater river	3.0
I6	Trenethic Barton Estate PS	SW66882867	Freshwater river	9.4
I7	Shipwrights PS	SW75842622	Saline Estuary	0.0
I8	Constantine STW overflow	SW73682886	Freshwater river	3.0

Data from Environment Agency

Table 5.4: Private discharges within the Helford catchment with maximum daily flows above 100 m³.

Number on map	Name	NGR	Reported in 2008 sanitary survey?	Maximum daily flow (m³)	Effluent type	Receiving environment	Fluvial distance to nearest CZ (km)
P1	Kessel Downs Quarry	SW73623370	Yes	1,600	Site drainage	Freshwater river	8.9
P2	National Seal Sanctuary	SW70942623	Yes	470	Process effluent	Freshwater river	3.4
P3	National Seal Sanctuary	SW70982619	No	470	Process effluent	Freshwater river	3.3
P4	National Seal Sanctuary	SW71032619	No	470	Process effluent	Freshwater river	3.3
P5	National Seal Sanctuary	SW70962619	No	420	Process effluent	Freshwater river	3.3
P6	National Seal Sanctuary	SW71052619	No	470	Process effluent	Freshwater river	3.3
P7	National Seal Sanctuary	SW71072620	No	470	Process effluent	Freshwater river	3.3
P8	National Seal Sanctuary	SW71102620	No	470	Process effluent	Freshwater river	3.2

Data from Environment Agency

Table 5.5: Spills from intermittent discharges in the Helford River catchment.

		Number of spills								% time spilling							
Discharge	**NGR**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Constantine Bridge PSCSO/EO	SW72922903	NDA						1	8	NDA						<0.01	1.47
Constantine STW overflow	SW73682886	17	19	28	38	21	9	20	33	0.66	0.37	0.32	8.41	0.53	0.24	0.95	2.36
Penbothidno CSO	SW73662886	2	6	3	4	2	2	1	3	0.01	0.01	0.01	0.01	0.01	0.28	0.01	0.01
Shipwrights PS	SW75842622	NDA						1	NDA	NDA						0.01	NDA

Data from Environment Agency

Spills assessment derived using EA 12/24 hour block counting method

NDP = No data provided

Figures highlighted are spills ≥ 3% time in the year indicated

4.3. Boats

A study conducted by Latham and colleagues (2012) reported that there are approximately 750 moorings in the Helford Estuary. This is 150 moorings more than were reported in the 2008 sanitary survey. These moorings are distributed with approximately 80, 470, 50 and 150 moorings at Durgan, main river, Calamansack and Porth Navas respectively (Figure 5.4).

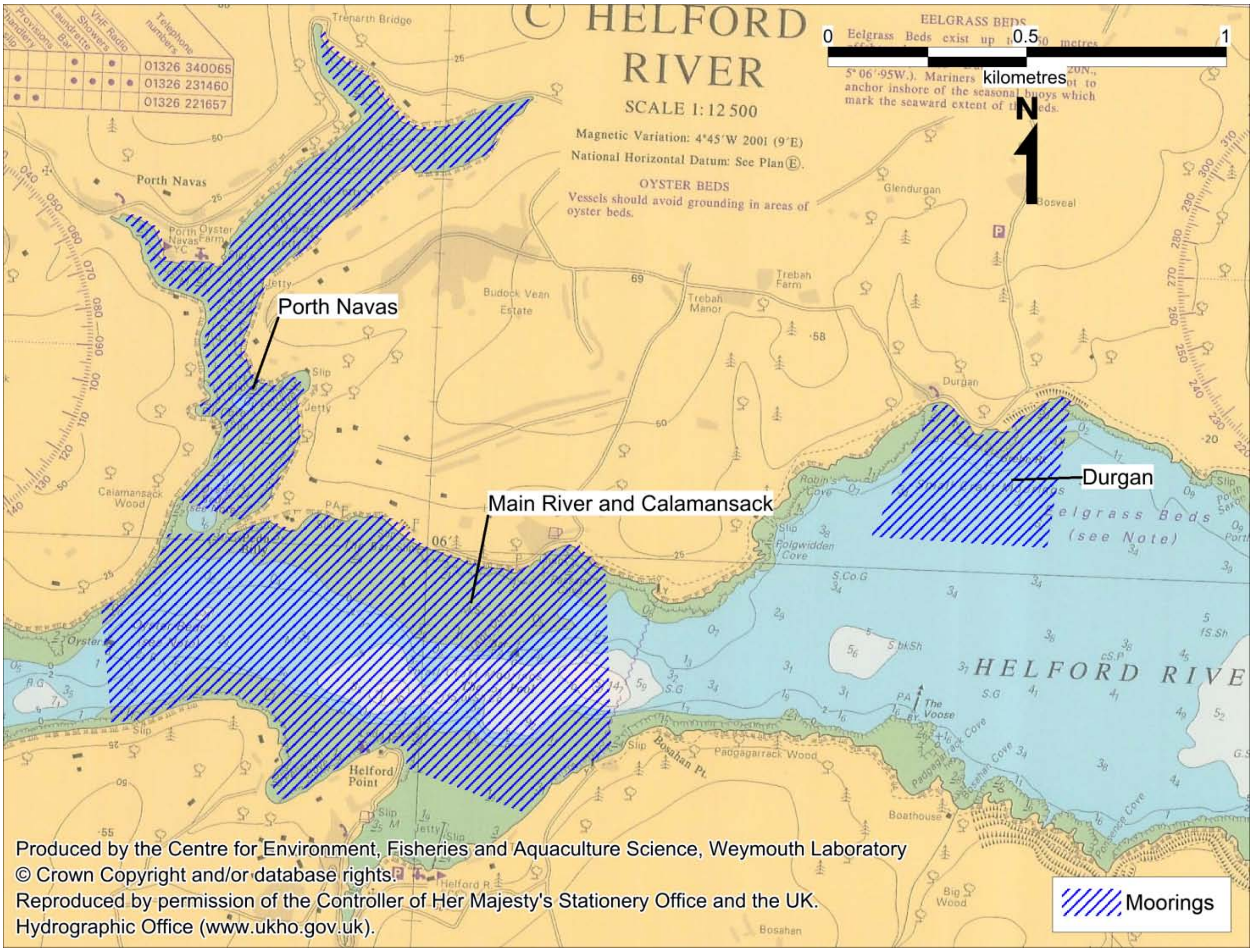

Figure 5.4: Moorings in the Helford Estuary. Adapted from Latham *et al.*, 2012.

4.4. Agriculture

No livestock data were freely available for the same area assessed in the sanitary survey report (Helford catchment). However, the livestock numbers for the Kerrier district area were available for both 2007 and 2010. The Helford catchment lies entirely within the Kerrier district, but only makes up 24% of the total area of the district. Therefore the changes in livestock numbers shown in Table 5.6 may not be truly representative of the Helford catchment.

There has been an overall decline in livestock in the Kerrier district, with the largest decrease being chickens.

Table 5.6: Livestock data for the Kerrier District in 2007 and 2010.

	2007	2010	% difference
Cattle	43,921	42,756	-2.7
Sheep	13,065	12,318	-5.7
Pigs	6,270	4,809	-23.3
Chickens	206,042	54,006	-73.8

Data from Defra (2007) and Defra (2010)

4.5. Wildlife

For the five winters up to 2011/2012 an average count of 419 waders and wildfowl and 595 gulls and terns was reported within the Helford estuary (Austin et al. 2014). The 2008 sanitary survey mainly details bird numbers for woodland and farmland species and therefore are not directly comparable to the most up to date information.

No other freely available sources of wildlife data could be found that were published after the sanitary survey.

5. Hydrography

The bathymetry of the Helford Estuary has remained largely unchanged since the sanitary survey. Comparisons of the 2004 and 2007 editions of Imray Chart 2400.11 show that there have been no changes to the depths within the estuary and no corrections for the 2007 edition relate to changes in bathymetry. Figure 6.1 shows the Imray chart for the Helford River.

The jetty in Helford Creek was not present on the OS maps used in the sanitary survey, but according to the Imray Chart (2400.11) that was current during the survey (2007 edition), there was a jetty present. Since the sanitary survey, the jetty has been modified to increase mooring space. While this change has not been reflected in the chart corrections, it is clear on the OS maps (Figure 6.2).

Planning permission has been granted to modify Gweek Quay and work on the quay is not due to start in June 2014. The modifications will increase the intertidal area by approximate 1,300 m^2 (Figure 6.3), but are unlikely to affect the level of contamination to the shellfisheries.

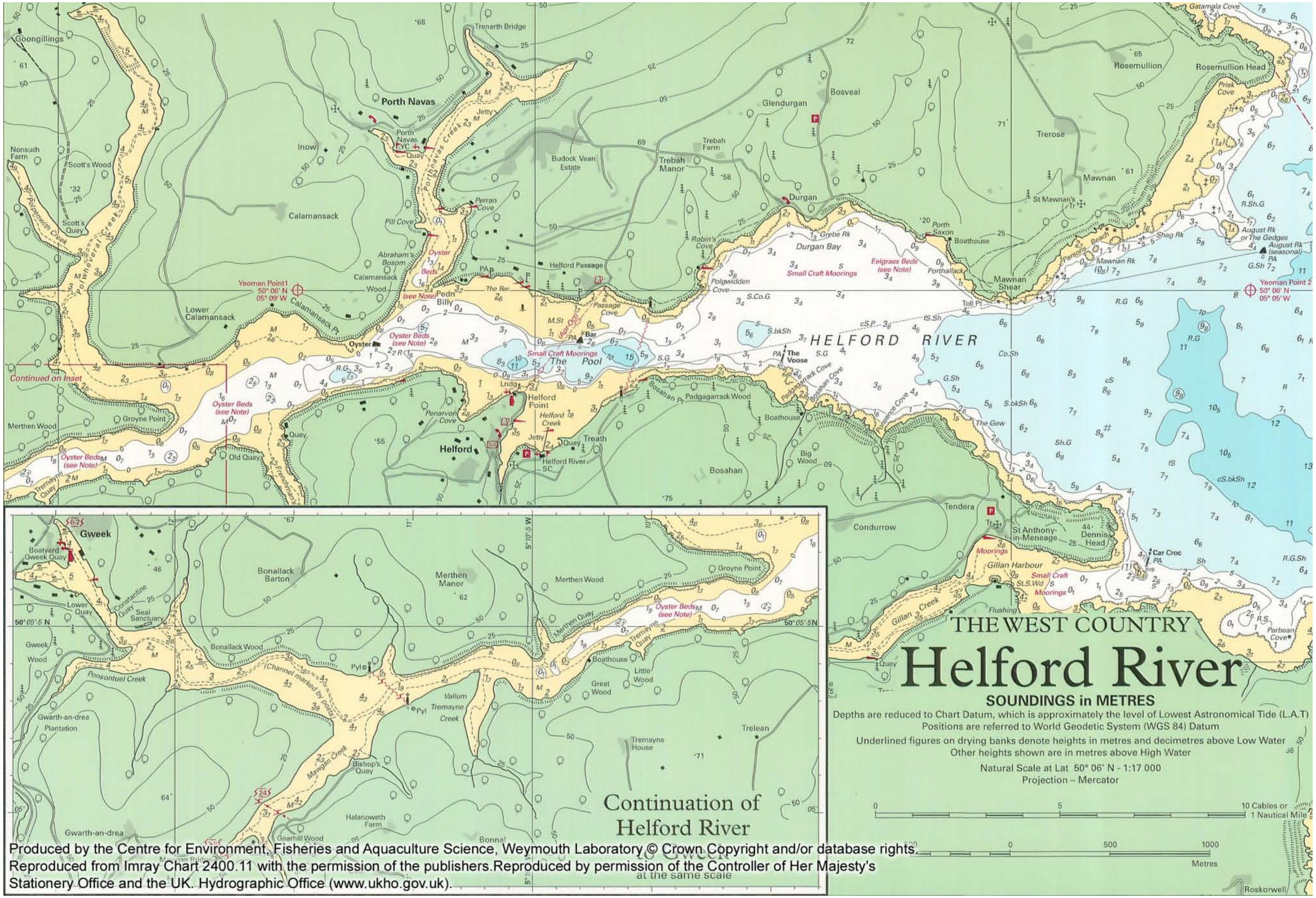

Figure 6.1: Hydrographic chart of the Helford River (Imray 2400.11, 2007 edition).

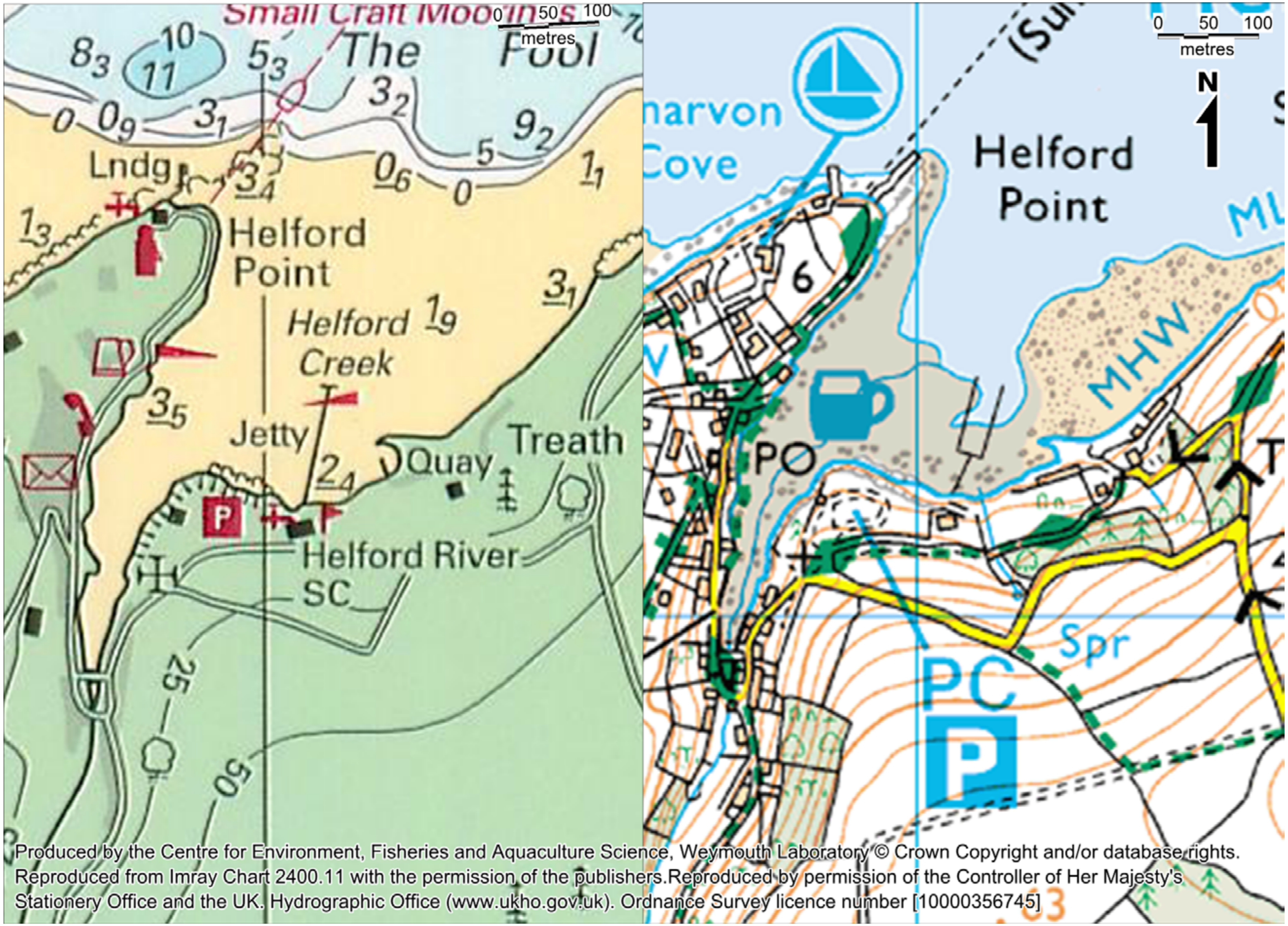

Figure 6.2: Comparison of Helford Creek as represented by the Imray 2400.11 chart (2007 edition) and OS 103 map (2009 edition).

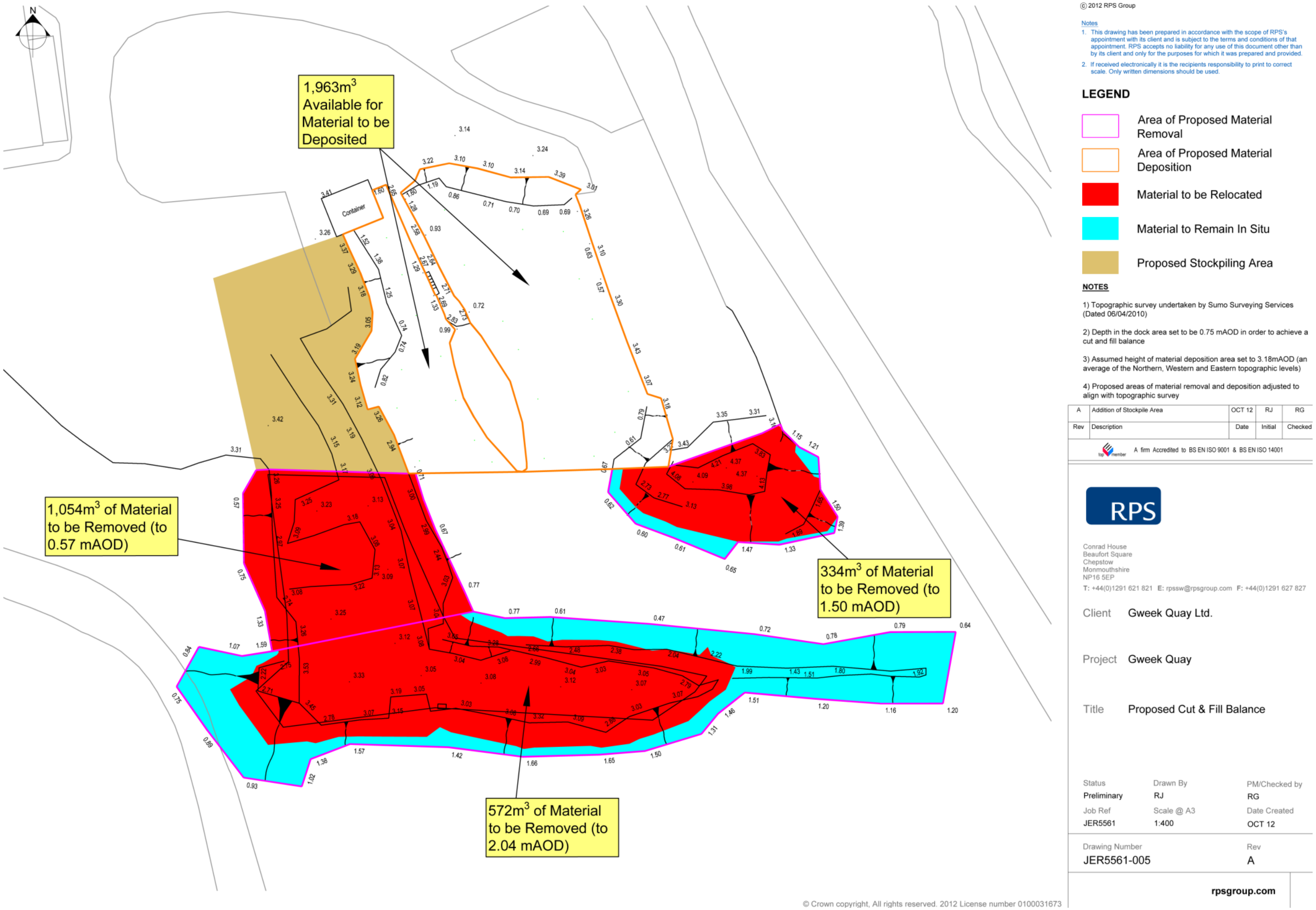

Figure 6.3: Map of the proposed changes to Gweek Quay (Cornwall Council, 2012)

6. Rainfall

The Camborne weather station is located approximately 11 km north-west of the Helford catchment. Average monthly rainfall for five year periods before and after the sanitary survey was prepared are shown in Figure 7.1.

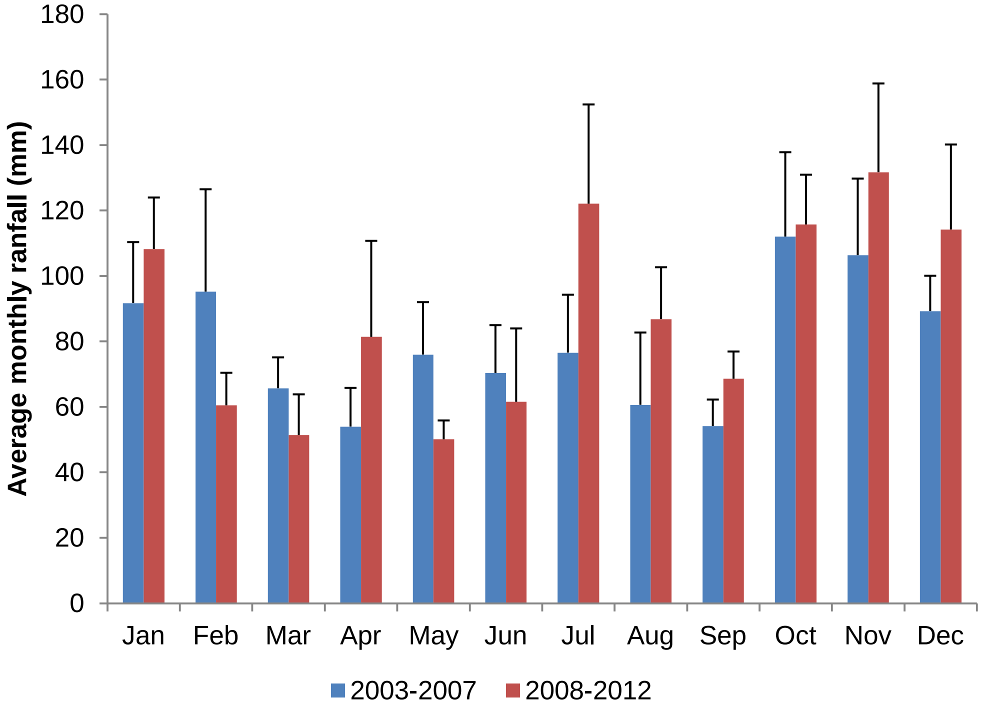

Figure 7.1: Average monthly rainfall at Camborne for five year periods before and after the sanitary survey was written
Data from Met office (2014)

To determine whether there have been any changes in rainfall since the sanitary survey was prepared, two sample T-tests were run for each month using monthly totals for the periods 2003-2007 and 2008-2012. All of the T-tests showed that there were no significant differences in monthly rainfall between the two time periods ($p = 0.105$ to 0.905).

7. Microbial monitoring results

7.1. Summary statistics and geographical variation

Between January 2002 and January 2014, there have been a total of 21 recommended monitoring points (RMPs) for bivalve shellfish in the Helford Estuary, including nine for mussels, six for native oysters and six for pacific Oysters. However, many of these RMPs were not sampled simultaneously and several are no longer in use.

Since May 2005, the Rosehill Relaying Site mussel RMP has not been used and the Frenchman's Creek mussel RMP was sampled on only one occasion in 2003. In September 2008, the Porth Navas and Calamansack Bar mussel, native oyster and Pacific oyster RMPs and the Groyne Point mussel and native oyster RMP were replaced by the Porth Navas Quay, South of Porth Navas Bar and East of Groyne Point respectively.

All native oyster RMPs are no longer in use, and results for Pacific oysters are now used for native oyster classification.

The geometric mean results of shellfish flesh monitoring from all RMPs sampled from 2002 onwards are presented in Figure 8.1 to Figure 8.3. Summary statistics are presented in Table 8.1 and boxplots are shown in Figure 8.4 to Figure 8.6. Frenchman's Creek was only sampled on one occasion and so will not be considered further.

Table 8.1: Summary statistics for *E. coli* results (MPN/100 g) from bivalve RMPs in the Helford Estuary from 2002 to 2014. Sites shaded in grey are current.

Site	Species	No.	Date of first sample	Date of last sample	Geometric mean	Min.	Max.	% over 230	% over 4,600	% over 46,000
Porth Navas[1]	Mussel	65	28/01/2002	27/08/2008	397.0	<20	16,000	67.7	7.7	0.0
Rosehill Relaying Site	Mussel	30	15/01/2002	09/05/2005	363.7	<20	5,400	66.7	3.3	0.0
Porth Navas Quay	Mussel	49	29/09/2008	04/12/2013	549.1	50	35,000	73.5	6.1	0.0
South of Porth Navas Bar	Mussel	60	09/09/2008	09/12/2013	431.7	<20	170,000	65.0	11.7	1.7
Calamansack Bar[2]	Mussel	75	15/01/2002	27/08/2008	364.7	<20	16,000	53.3	10.7	0.0
Groyne Point[3]	Mussel	70	15/01/2002	12/08/2008	311.9	<20	5,400	55.7	1.4	0.0
Frenchmans Creek	Mussel	1	30/09/2003	30/09/2003	70.0	70	70	0.0	0.0	0.0
East of Groyne Point	Mussel	54	09/09/2008	09/12/2013	615.8	<20	24,000	72.2	16.7	0.0
Helford Point (Pre Aug 2008)	Mussel	20	08/08/2006	01/07/2008	170.9	40	3,500	40.0	0.0	0.0
Helford Point (Post Aug 2008)	Mussel	55	09/09/2008	09/12/2013	516.9	20	160,000	69.1	9.1	1.8
Porth Navas[1]	Native oyster	71	15/01/2002	27/08/2008	236.9	<20	>18,000	50.7	2.8	0.0
Porth Navas Quay	Native oyster	10	29/09/2008	15/12/2009	167.1	<20	3,500	60.0	0.0	0.0
South of Porth Navas Bar	Native oyster	47	09/09/2008	25/02/2013	302.1	<20	9,200	57.4	6.4	0.0
Calamansack Bar[2]	Native oyster	70	15/01/2002	27/08/2008	313.0	<20	>18,000	60.0	5.7	0.0
Groyne Point[3]	Native oyster	71	15/01/2002	12/08/2008	343.5	<20	>18,000	66.2	5.6	0.0
East of Groyne Point	Native oyster	39	09/09/2008	09/05/2012	445.0	<20	16,000	66.7	17.9	0.0
Porth Navas[1]	Pacific oyster	28	13/02/2006	27/08/2008	214.4	<20	1,300	57.1	0.0	0.0
Porth Navas Quay	Pacific oyster	46	29/09/2008	04/12/2013	223.7	<20	16,000	56.5	4.3	0.0
South of Porth Navas Bar	Pacific oyster	21	09/09/2008	09/12/2013	234.9	20	9,200	47.6	4.8	0.0
Calamansack Bar[2]	Pacific oyster	28	13/02/2006	12/08/2008	217.9	20	2,200	50.0	0.0	0.0
East of Groyne Point	Pacific oyster	20	09/09/2008	09/12/2013	346.0	50	2,400	75.0	0.0	0.0
Bosahan (Pre Aug 2008)	Pacific oyster	15	22/01/2007	12/08/2008	181.0	20	5,400	40.0	6.7	0.0
Bosahan (Post Aug 2008)	Pacific oyster	56	09/09/2008	15/10/2013	217.1	<20	54,000	46.4	5.4	1.8

[1]Replaced by Porth Navas Quay
[2]Replaced by South of Porth Navas Bar
[3]Replaced by East of Groyne Point

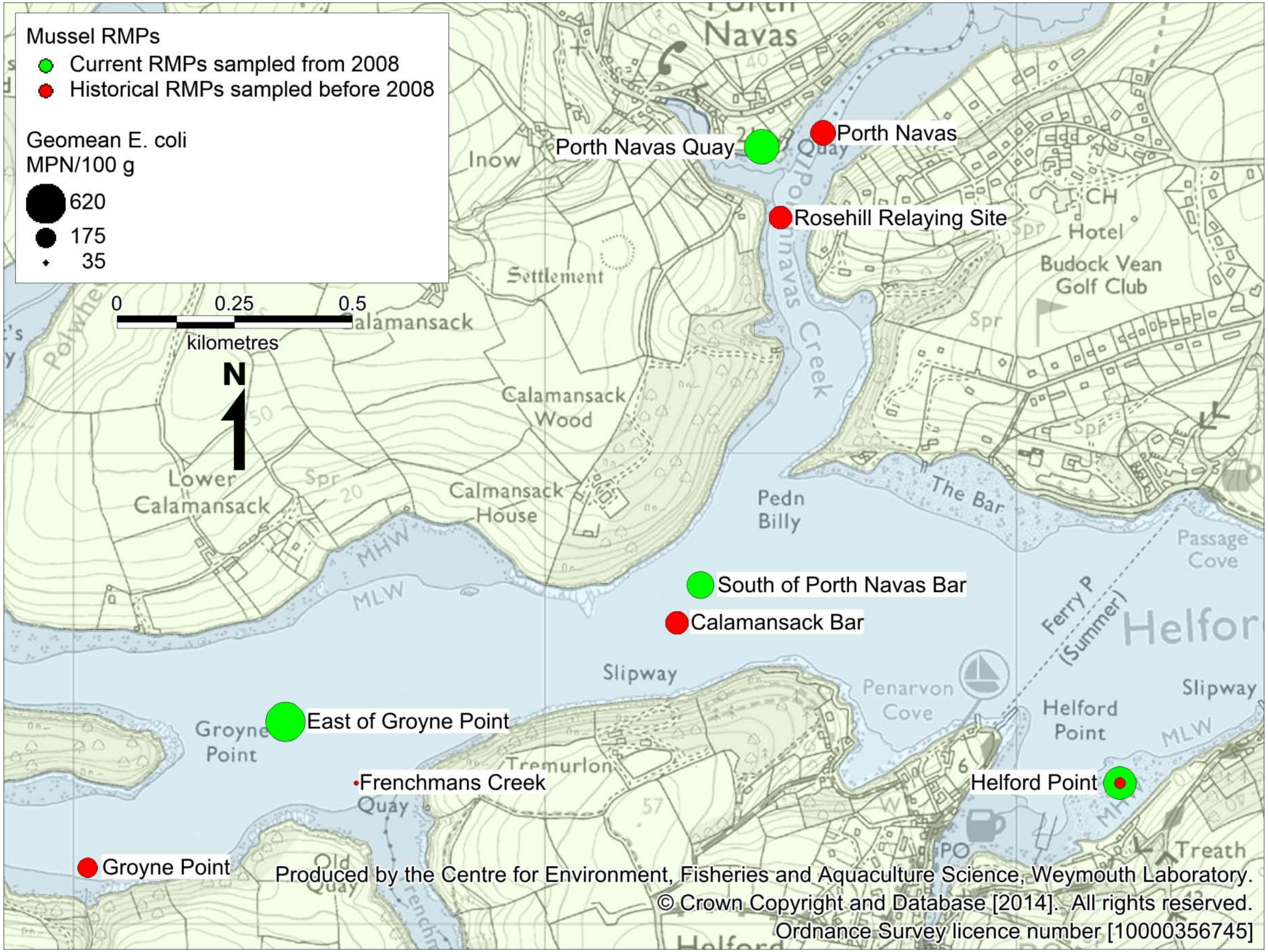

Figure 8.1: Current and historical mussel RMPs sampled since 2002.

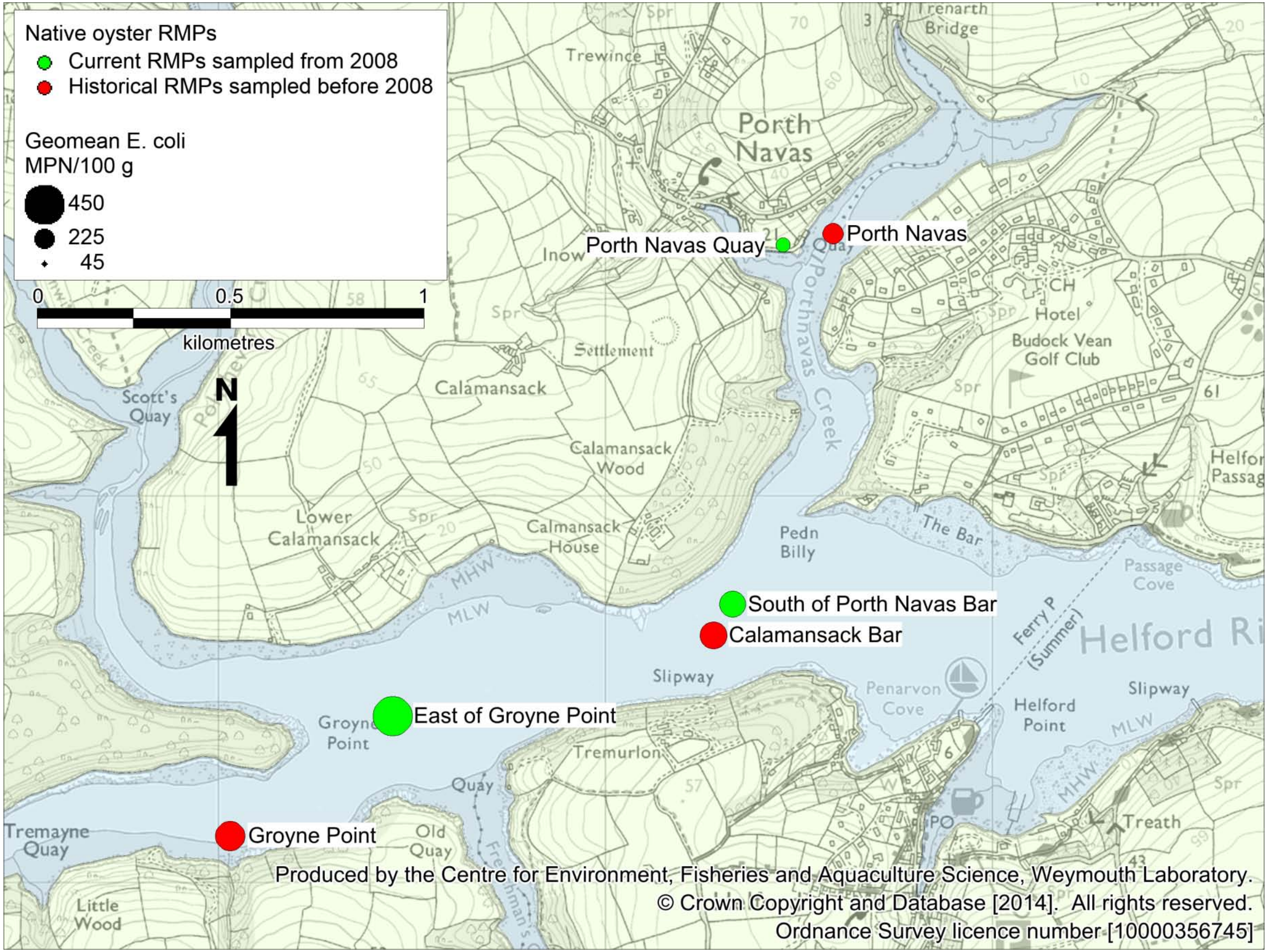

Figure 8.2: Current and historical native oyster RMPs sampled since 2002.

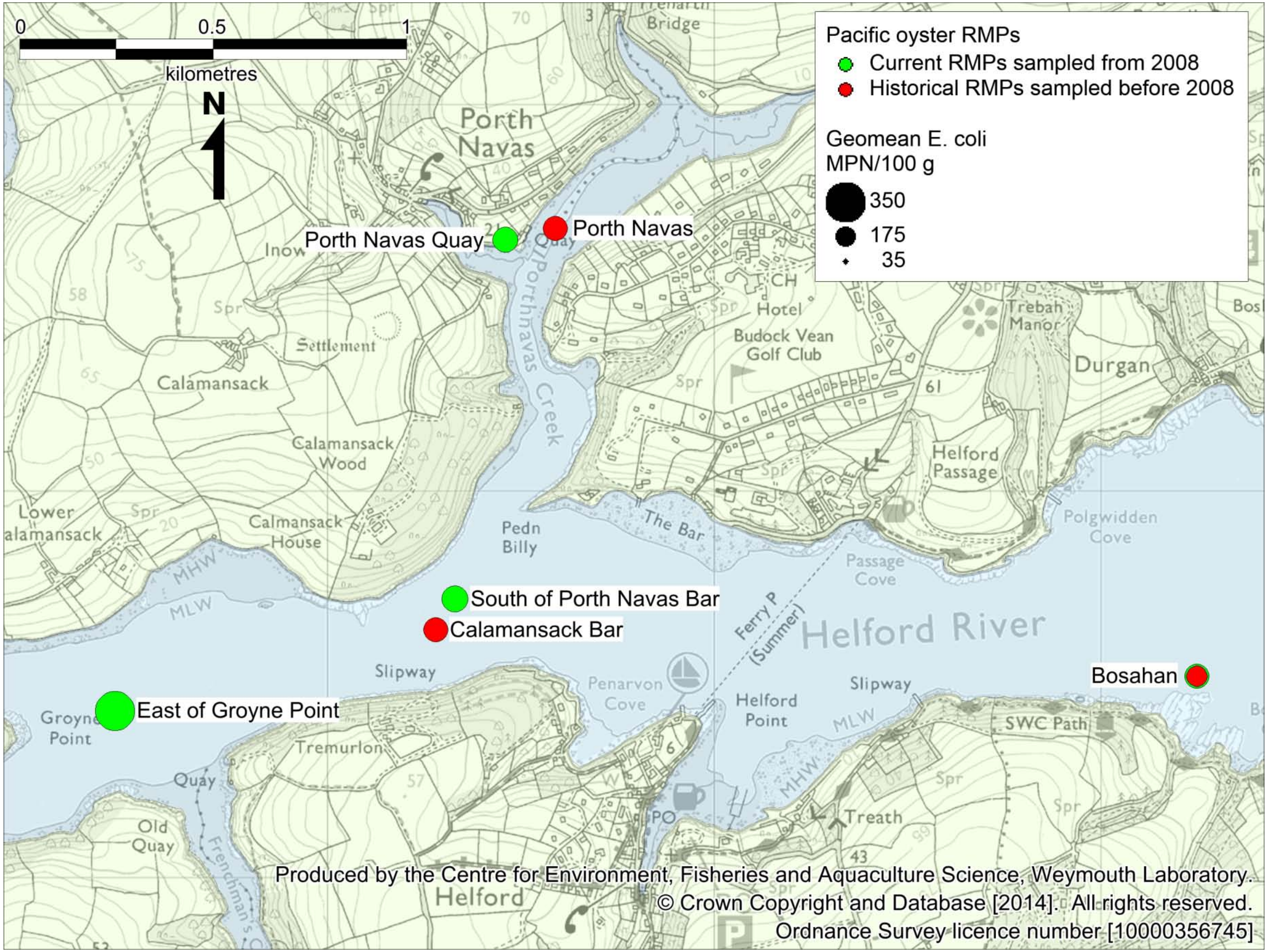

Figure 8.3: Current and historical Pacific oyster RMPs sampled since 2002.

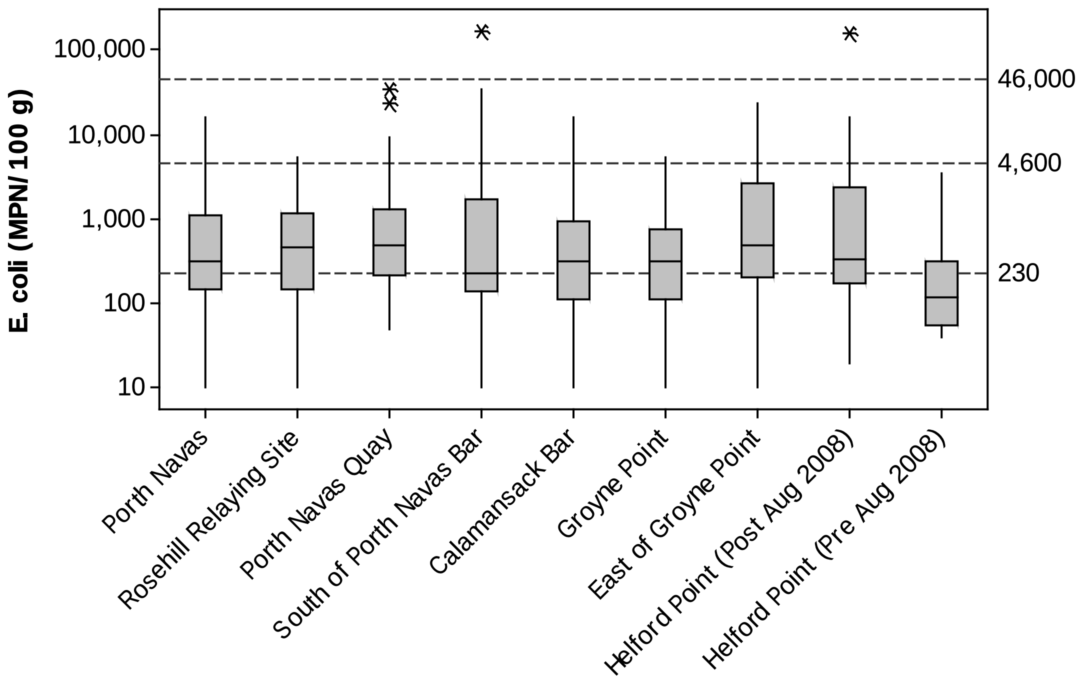

Figure 8.4: Boxplots of *E. coli* results from mussel RMPs from 2002 onwards.

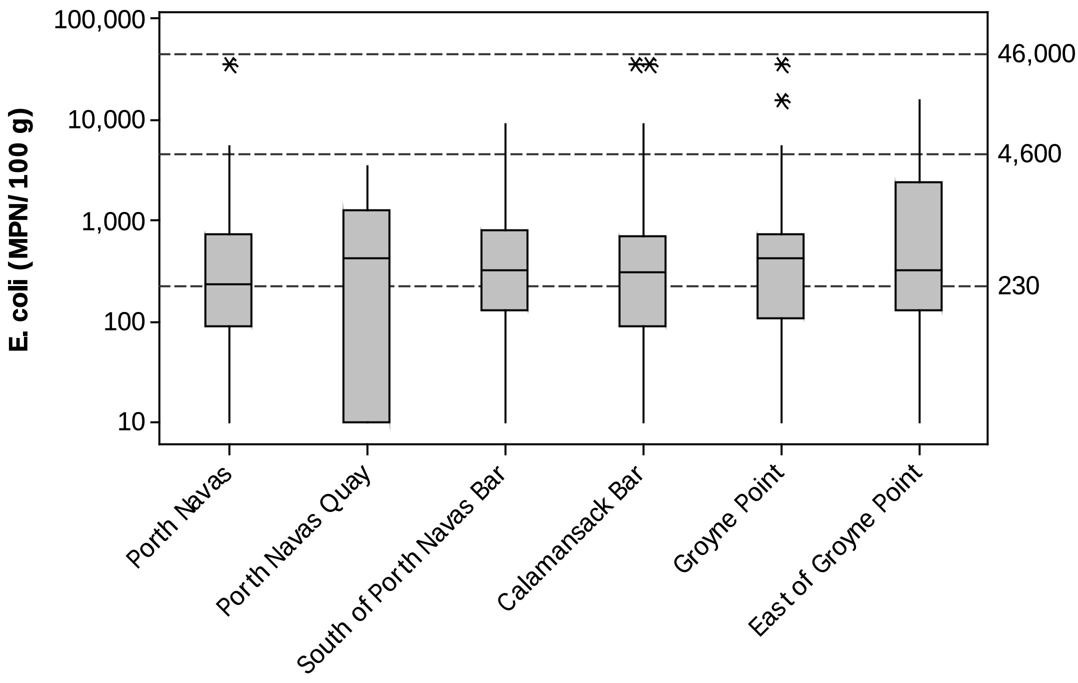

Figure 8.5: Boxplots of *E. coli* results from native oyster RMPs from 2002 onwards.

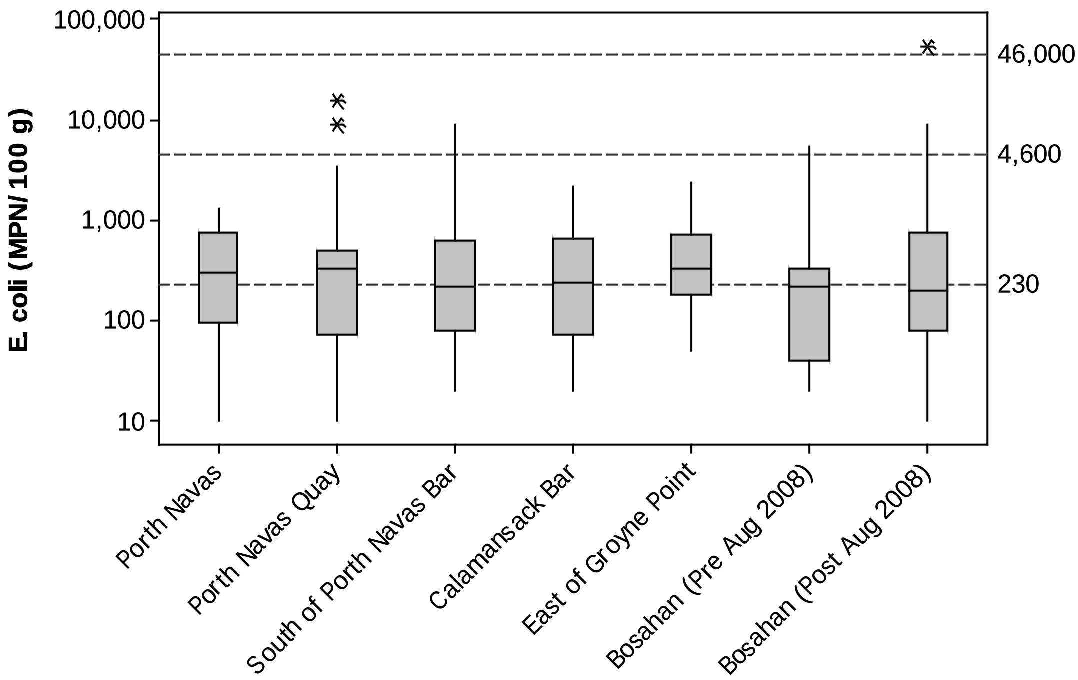

Figure 8.6: Boxplots of *E. coli* results from Pacific oyster RMPs from 2002 onwards.

One-way ANOVA tests showed that there were no significant differences in *E. coli* levels between sites for mussels (p=0.073), native oysters (p=0.406) or Pacific oysters (p=0.940). Additional T-tests were run to specifically test for differences in *E. coli* levels in mussels from Helford Point and Pacific oysters from Bosahan taken before and after August 2008. No significant difference in *E. coli* levels was found at Bosahan (p=0.718), but *E. coli* levels at Helford Point were found to be significantly higher after August 2008 than before (p=0.006).

Comparisons of RMPs were carried out on a pair-wise basis by running correlations (Pearson's) between sites that shared sampling dates, and therefore environmental conditions, on at least 20 occasions. Those sites which correlated significantly were likely to share contamination sources, or be affected by environmental conditions in a similar manner.

The four mussel RMPs that existed before the sanitary survey were compared. No significant correlation was found between Porth Navas and Rosehill Relay area (r=0.169, p=0.469) or Calamansack Bar (r=0.130, p=0.411). However, there were significant correlations between Port Navas and Groyne Point (r=0.328, p=0.033) and between Groyne Point and Calamansack Bar (r=0.670, p<0.001). The four mussel RMPs recommended in the sanitary survey were also compared in this way. South of Porth Navas Bar correlated significantly with East of Groyne Point (r=0.611, p<0.001) and Helford Point (r=0.778, p<0.001). Additionally East of Groyne Point correlated significantly with Helford Point (r=0.636, p<0.001). Samples from Porth Navas Quay did not share 20 or more sampling days with any other site and so was not compared.

E. coli levels in native oysters collected from Porth Navas correlated significantly with samples collected from Calamansack Bar (r=0.435 p=0.002) and Groyne Point (r=0.552, p<0.001). Samples from Calamansack Bar also correlated significantly with samples from Groyne Point (r=0.576, p<0.001). Enough native oyster samples were collected on the same days from the RMPs recommended in the sanitary survey only at South of Porth Navas Bar and East of Groyne Point. There was a significant correlation in *E. coli* levels at these sites (r=0.730, p<0.001).

Only Porth Navas and Calamansack Bar, the two historical Pacific oyster RMPs shared 20 or more sampling days. The *E. coli* levels at these sites correlated significantly (r=0.694, p <0.001).

The significant correlations in *E. coli* levels between most sites suggest that the sources of contamination and environmental impacts on contamination are similar throughout the Helford estuary. Conversely, the lack of correlation between Porth Navas and Rosehill Relaying Site and between Porth Navas and Calamansack Bar, indicate that these sites did not share contamination sources or were affected differently by environmental conditions.

7.2. Overall temporal patterns in results

Figure 8.7 to Figure 8.9 show time series of *E. coli* results in shellfish samples taken from 2002 to 2014. At the end of June 2007 a new sewage treatment works (STW) was opened at Helford which combined several small discharges. Two sample T-tests were run to compare the results from those RMPs which existed before and after the STW came online. Table 8.2 shows the results of these tests. There were no significant differences between *E. coli* results before and after the installation of the Helford STW.

Table 8.2: Results of T-tests comparing *E. coli* levels in shellfish before and after the installation of the Helford STW.

Site	Species	Degrees of freedom	T value	P value
Porth Navas	Mussel	24	0.62	0.541
Calamansack Bar		17	0.12	0.909
Groyne Point		16	0.18	0.858
Helford Point		15	1.86	0.083
Porth Navas	Native oyster	20	-0.61	0.551
Calamansack Bar		21	-1.67	0.111
Groyne Point		17	0.06	0.951
Porth Navas	Pacific oyster	25	0.18	0.855
Calamansack Bar		24	-0.9	0.375
Bosahan		3	-0.43	0.694

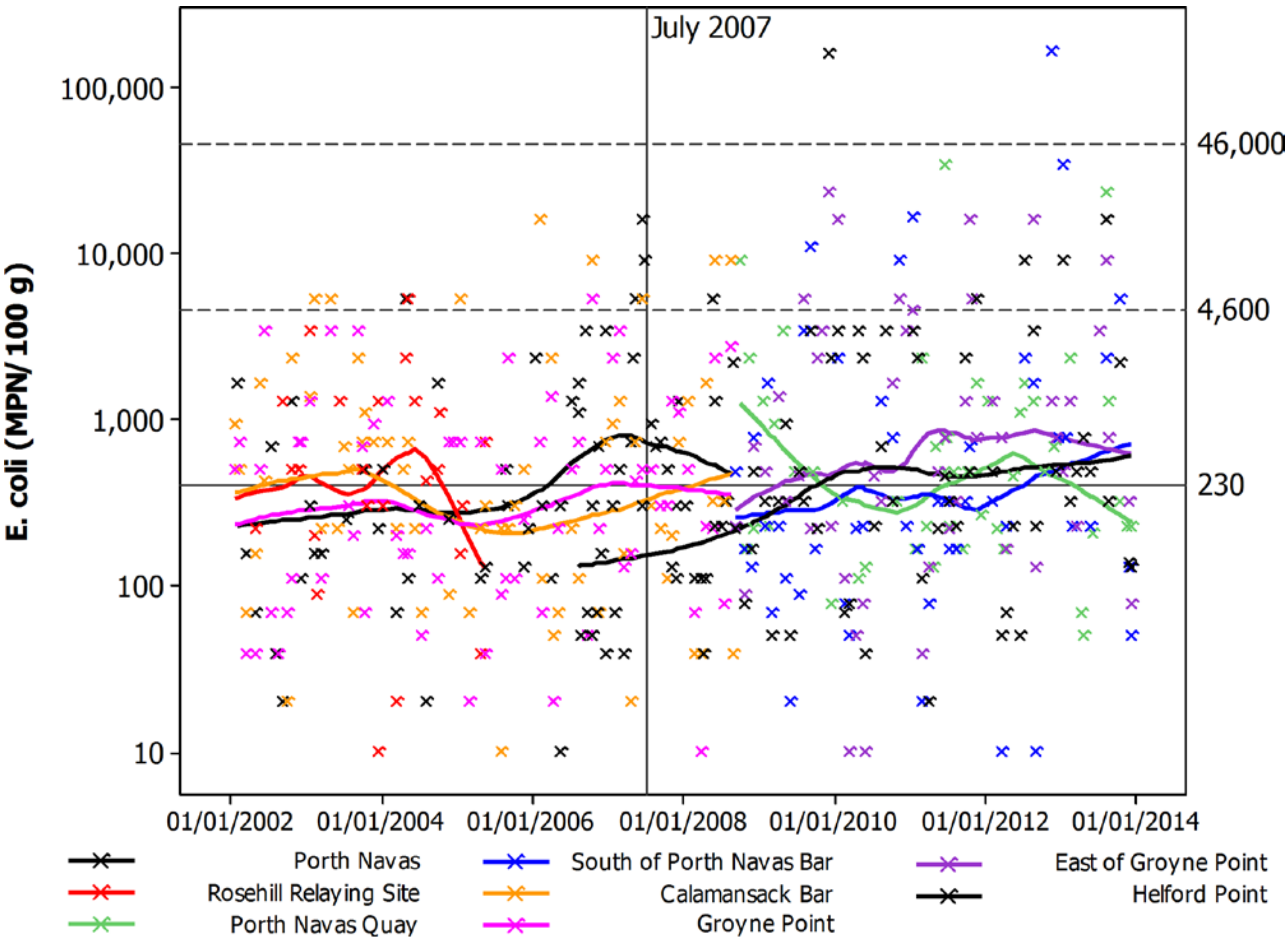

Figure 8.7: Scatterplot of *E. coli* results for mussels overlaid with loess lines.

There appears to have been a slight increase in the level of *E. coli* at Helford point as supported by the significant T-test result for samples taken before and after August 2008. While the T-test to compare samples taken before and after June 2007 showed no significant difference in results here before and after the installation of the Helford STW, too few samples were taken before the installation of the STW to confidently determine whether the STW has had an impact on shellfish contamination or not. Results at East of Groyne Point also appear to have increased since sampling started there in 2008. There have been more high results in mussels since 2008. It is possible that this is due to changes in contamination levels in the estuary. However as the sampling locations were changed in 2008, it is likely that the increase in high results reflects more protective locations for sampling as recommended by the sanitary survey.

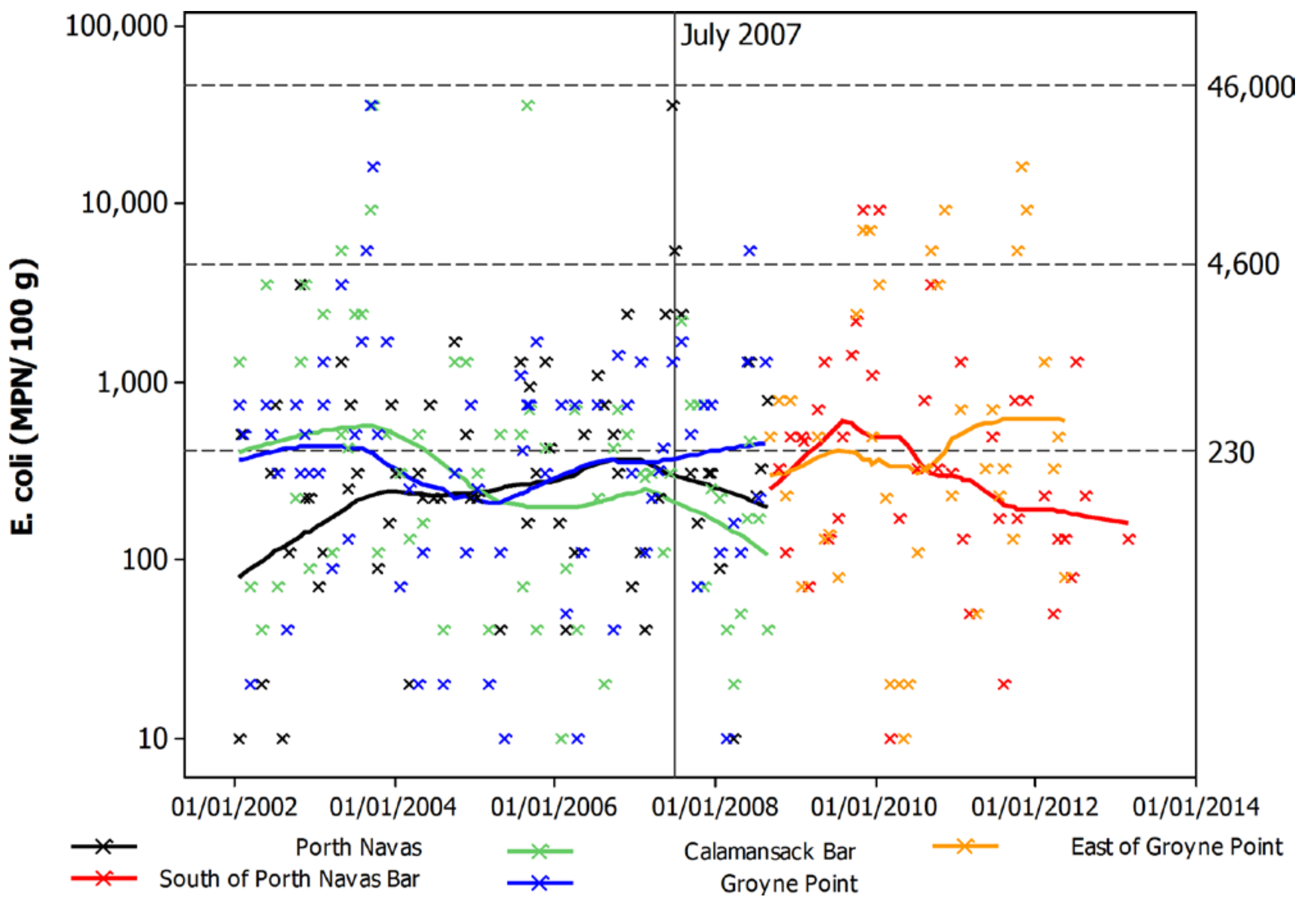

Figure 8.8: Scatterplot of *E. coli* results for native oysters overlaid with loess lines.

E. coli levels have remained largely unchanged in native oysters since 2002.

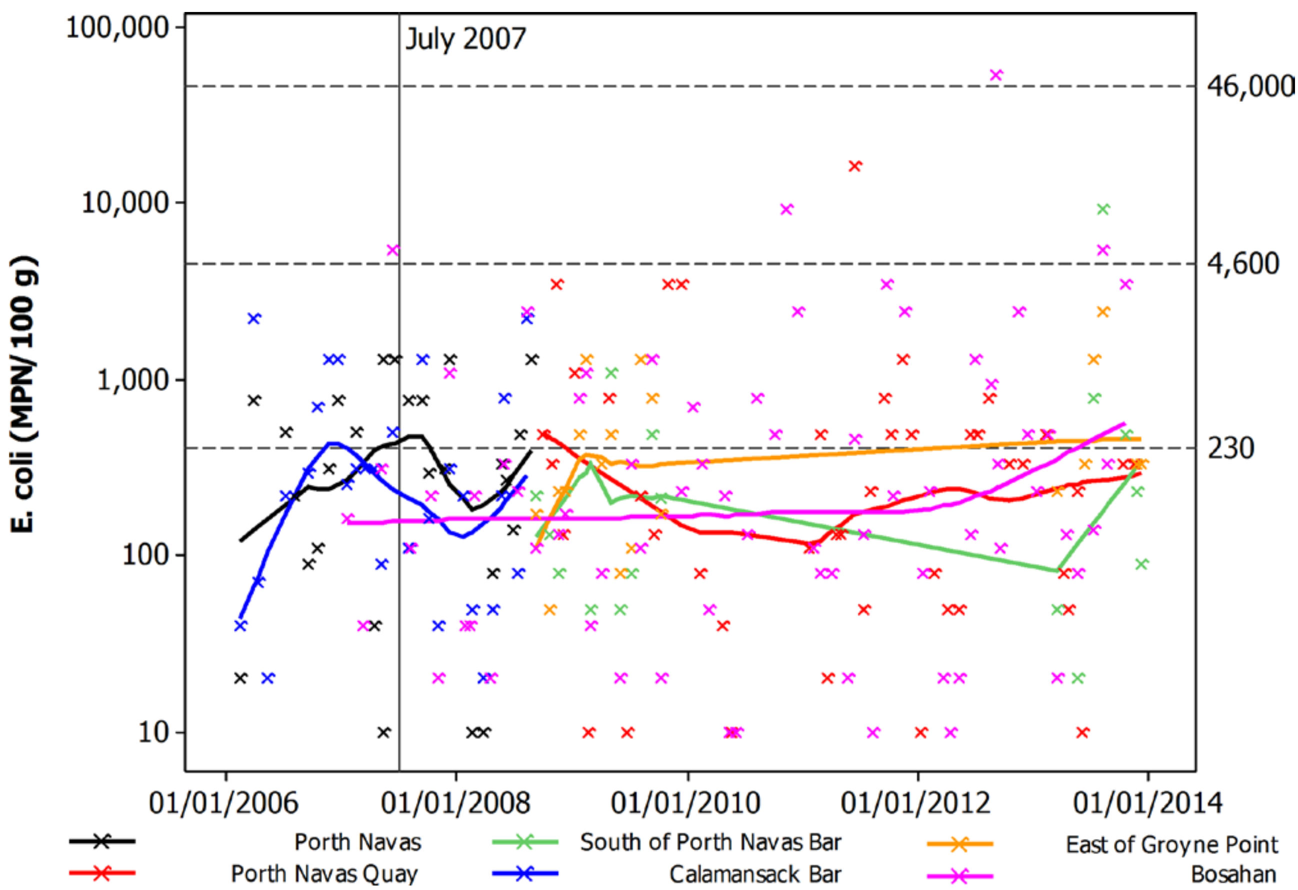

Figure 8.9: Scatterplot of *E. coli* results for Pacific oysters overlaid with loess lines.

E. coli levels have remained largely unchanged in Pacific oysters since the start of sampling in 2006.

7.3. Seasonal patterns of results

The seasonal patterns of results from 2002 to 2014 were investigated by species and RMP. Figure 8.10 to Figure 8.12 show the variation in *E. coli* levels between seasons at different RMPs sampled for two years or longer.

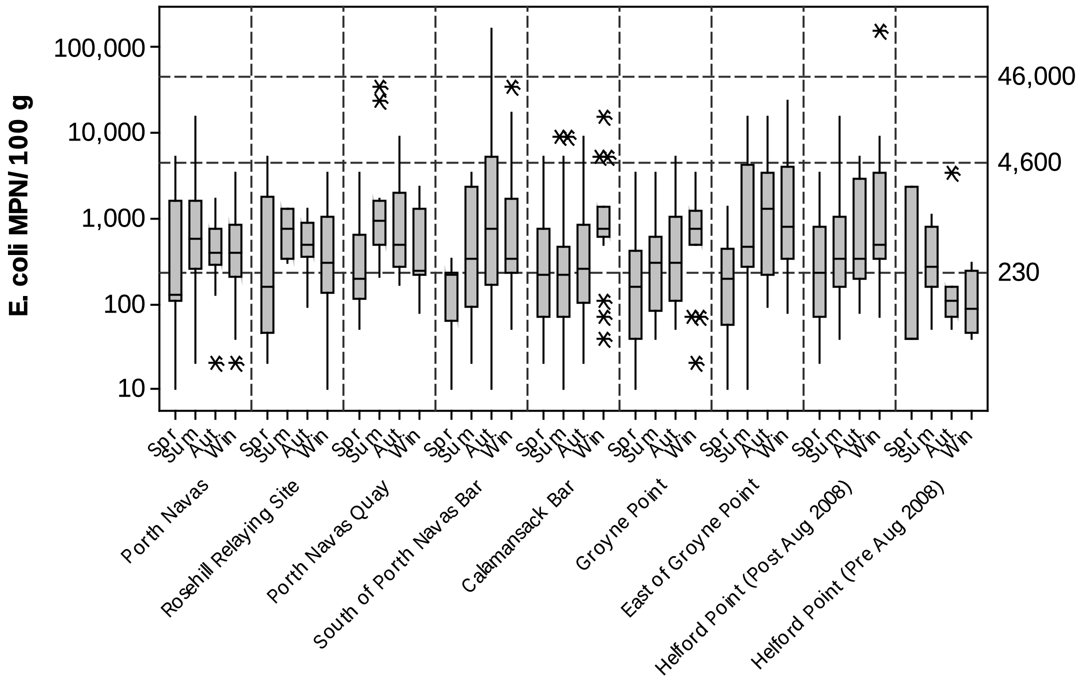

Figure 8.10: Boxplot of *E. coli* results in mussels by RMP and season

One-way ANOVA tests showed that there was significant variation in *E. coli* results between seasons at the Porth Navas Quay (p=0.031), South of Porth Navas Quay (p=0.012) and East of Groyne Point (p=0.025) mussel RMPs. Post-ANOVA Tukey tests showed that at Porth Navas Quay there was significantly lower *E. coli* levels in spring than in summer; at South of Porth Navas Bar there were significantly lower *E. coli* levels in spring than autumn; at East of Groyne Point there were significantly lower levels of *E. coli* in spring than in autumn and winter.

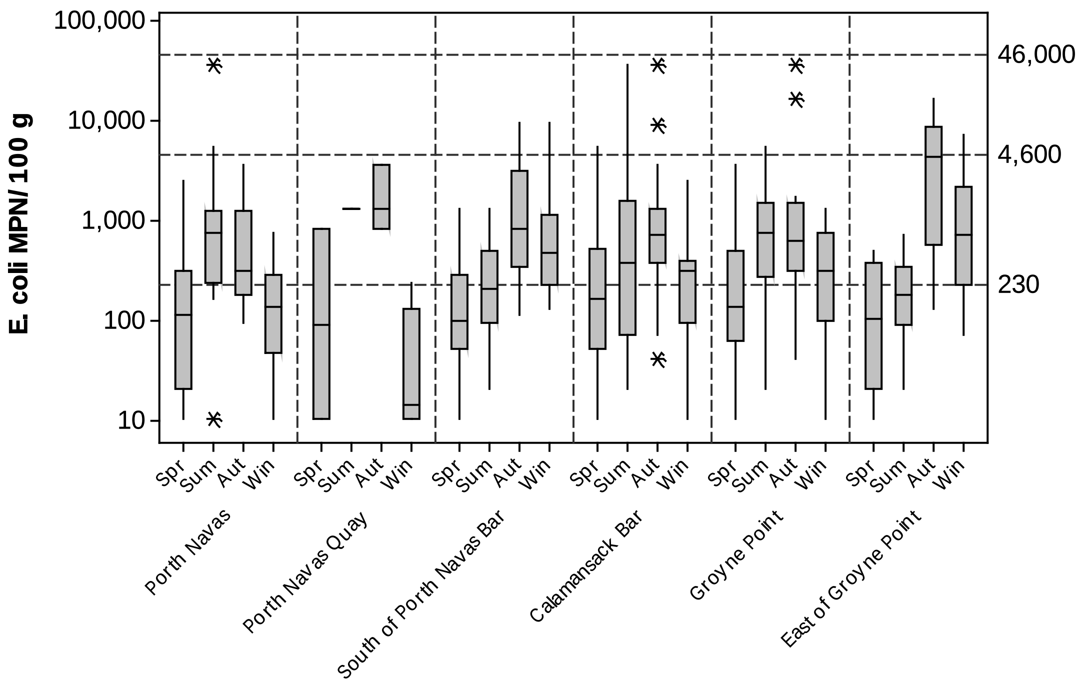

Figure 8.11: Boxplot of *E. coli* results in native oysters by RMP and season

One-way ANOVA tests showed that there was significant variation in *E. coli* levels between seasons at the Porth Navas (p<0.001), South of Porth Navas Bar (p=0.001), Groyne Point (p=0.017) and East of Groyne Point (p<0.001) native oyster RMPs. Post ANOVA Tukey tests showed that *E. coli* levels at Porth Navas were significantly higher in summer and autumn than in spring and winter; at South of Porth Navas Bar and East of Groyne Point *E. coli* levels were significantly higher in the autumn than the spring and summer, and significantly higher in winter than spring; at Groyne Point, *E. coli* levels were significantly higher in autumn than spring.

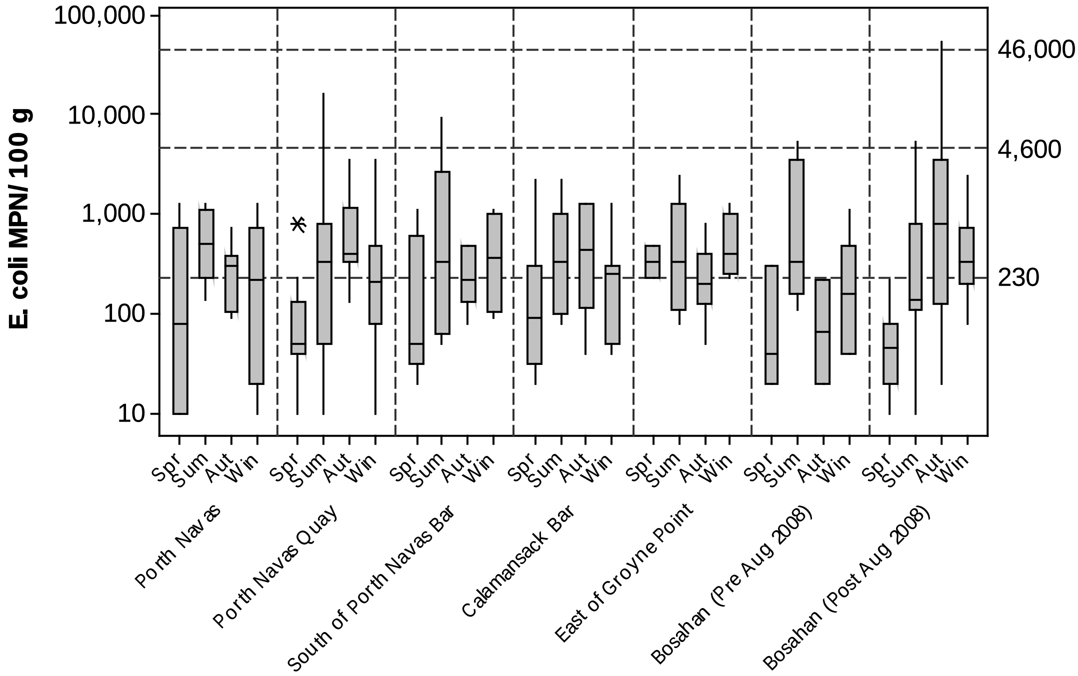

Figure 8.12: Boxplot of *E. coli* results in Pacific oysters by RMP and season

One-way ANOVA tests showed that there was significant variation in *E. coli* levels between seasons at the Porth Navas Quay (p=0.029) and Bosahan (Post August 2008) (p<0.001) Pacific oyster RMPs. Post ANOVA Tukey tests showed that at Porth Navas Quay there were significantly lower *E. coli* levels in spring than in autumn; at Bosahan there were significantly lower levels of *E. coli* in spring than any other season.

7.4. Influence of tide

To investigate the effects of tidal state on *E. coli* results, circular-linear correlations were carried out against the high/low and spring/neap tidal cycles for each RMP where more than 30 samples had been taken. Results of these correlations are summarised in Table 8.3, and significant results are highlighted in yellow.

Table 8.3: Circular linear correlation coefficients (r) and associated p values for *E. coli* results against the high/low and spring/neap tidal cycles

		High/low tides		Spring/neap tides	
Site Name	**Species**	**r**	**p**	**r**	**p**
Porth Navas		0.114	0.445	0.238	0.029
Rosehill Relaying Site		0.190	0.379	0.202	0.333
Porth Navas Quay		0.037	0.940	0.225	0.098
South of Porth Navas Bar	Mussel	0.254	0.025	0.367	<0.001
Calamansack Bar		0.070	0.703	0.088	0.573
Groyne Point		0.044	0.877	0.101	0.506
East of Groyne Point		0.419	<0.001	0.493	<0.001
Helford Point (Post Aug 2008)		0.401	<0.001	0.431	<0.001
Porth Navas	Native oyster	0.195	0.075	0.148	0.224

South of Porth Navas Bar		0.348	0.005	0.356	0.004
Calamansack Bar		0.258	0.012	0.134	0.302
Groyne Point		0.248	0.015	0.094	0.551
East of Groyne Point		0.244	0.117	0.256	0.095
Porth Navas Quay	Pacific oyster	0.036	0.947	0.243	0.078
Bosahan (Post Aug 2008)		0.135	0.380	0.268	0.022

Figure 8.13 and Figure 8.14 present polar plots of $\log_{10}$ *E. coli* results against tidal states on the high/low cycle for the correlations indicating a statistically significant effect. High water at Helford River (entrance) is at 0° and low water is at 180°. Results of 230 *E. coli* MPN/100g or less are plotted in green, those from 231 to 4,600 are plotted in yellow, and those exceeding 4,600 are plotted in red.

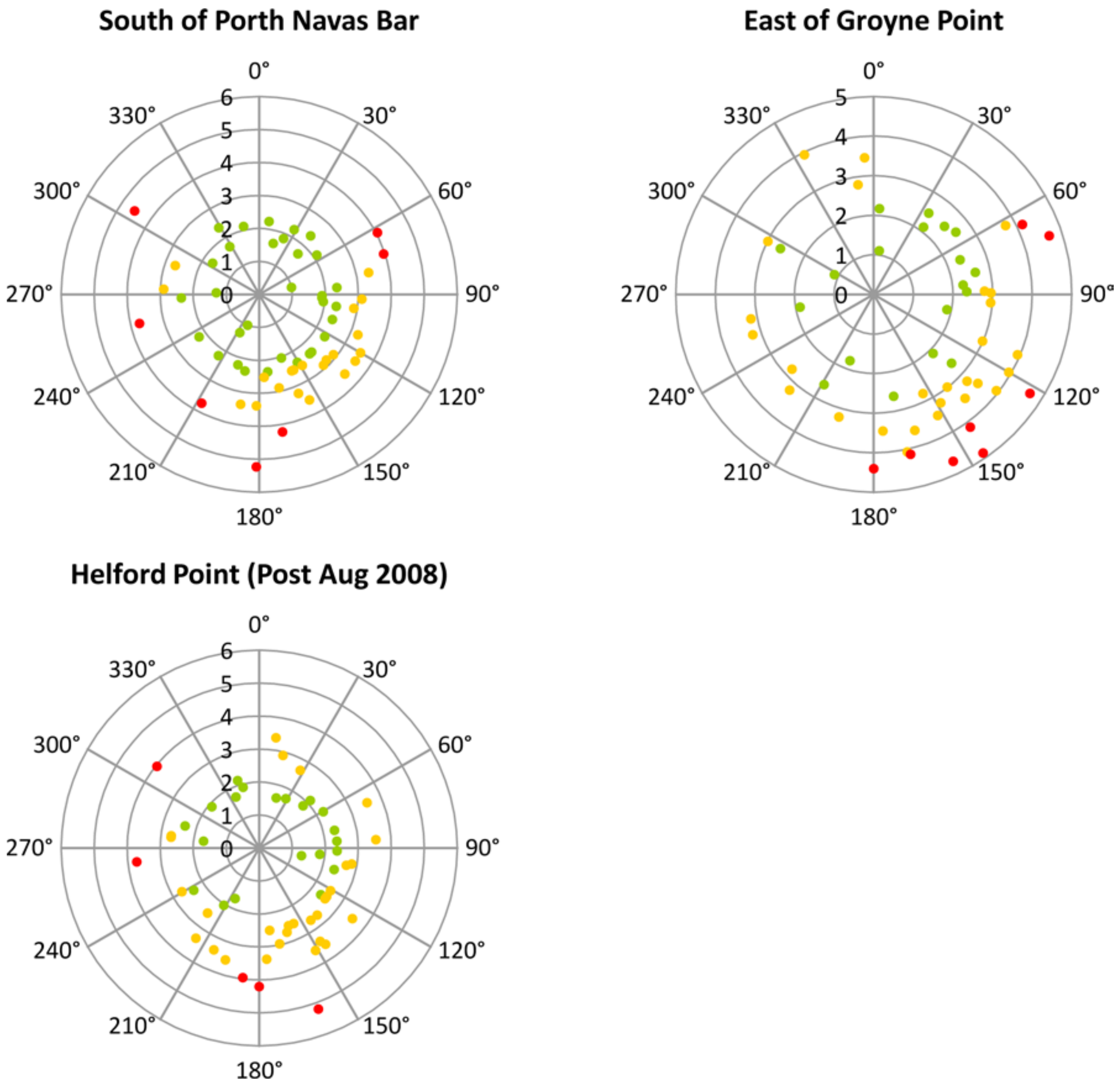

Figure 8.13: Polar plots of log10 *E. coli* results (MPN/100g) at mussel RMPs against high/low tidal state

At South of Porth Navas Bar and East of Groyne Point, there tended to be higher results in the ebb tide towards low water. This may indicate that the main sources of contamination are located upstream of the monitoring points and more contamination reaches the mussels as the tide moves down-estuary. This may be combined with lower levels of dilution as the volume of water in the estuary decreases. At Helford Point higher *E. coli* levels tended to occur around low tide, which may be due to decreased dilution.

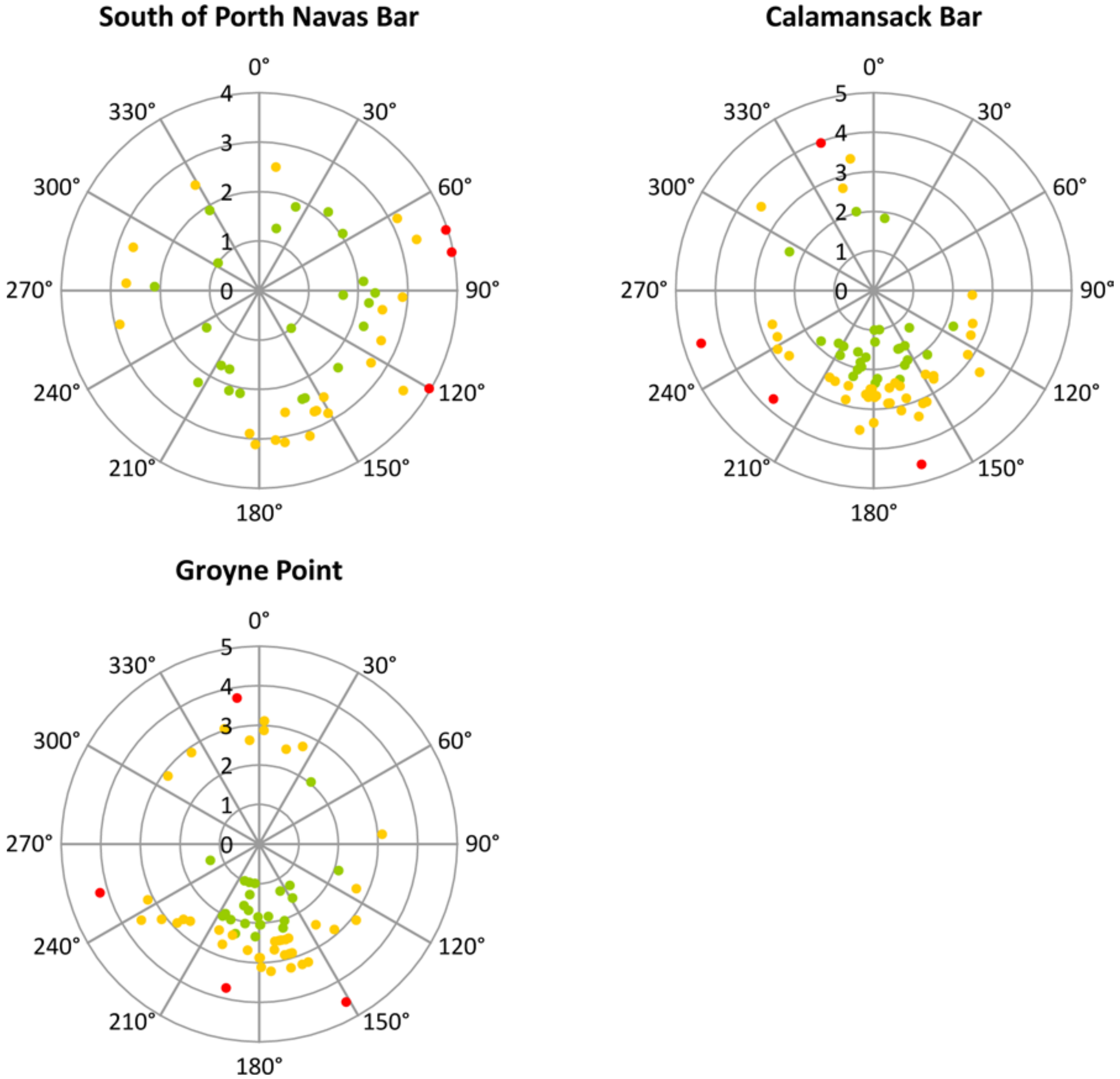

Figure 8.14: Polar plots of log10 *E. coli* results (MPN/100g) at native oyster RMPs against high/low tidal state

At South of Porth Navas Bar, there tended to be higher *E. coli* results during the ebb tide and during the slack tide there tended to be lower results. This indicates that the main contamination sources may be up-estuary and not in close proximity to the RMP. Some high results during the flood tide indicate that there may also a source of contamination down-estuary. At Calamansack Bar and Groyne Point most samples were taken at low tide and so it is not possible to determine a pattern in the results despite the significant correlation.

Figure 8.15 to Figure 8.17 present polar plots of log10 *E. coli* results against the spring neap tidal cycle for each RMP. Full/new moons occur at 0º, and half moons occur at 180º, and the largest (spring) tides occur about 2 days after the full/new moon, or at about 45º, then decrease to the smallest (neap tides) at about 225º, then increase back to spring tides. Results of 230 *E. coli* MPN/100g or less are plotted in green, those from 231 to 4,600 are plotted in yellow, and those exceeding 4,600 are plotted in red.

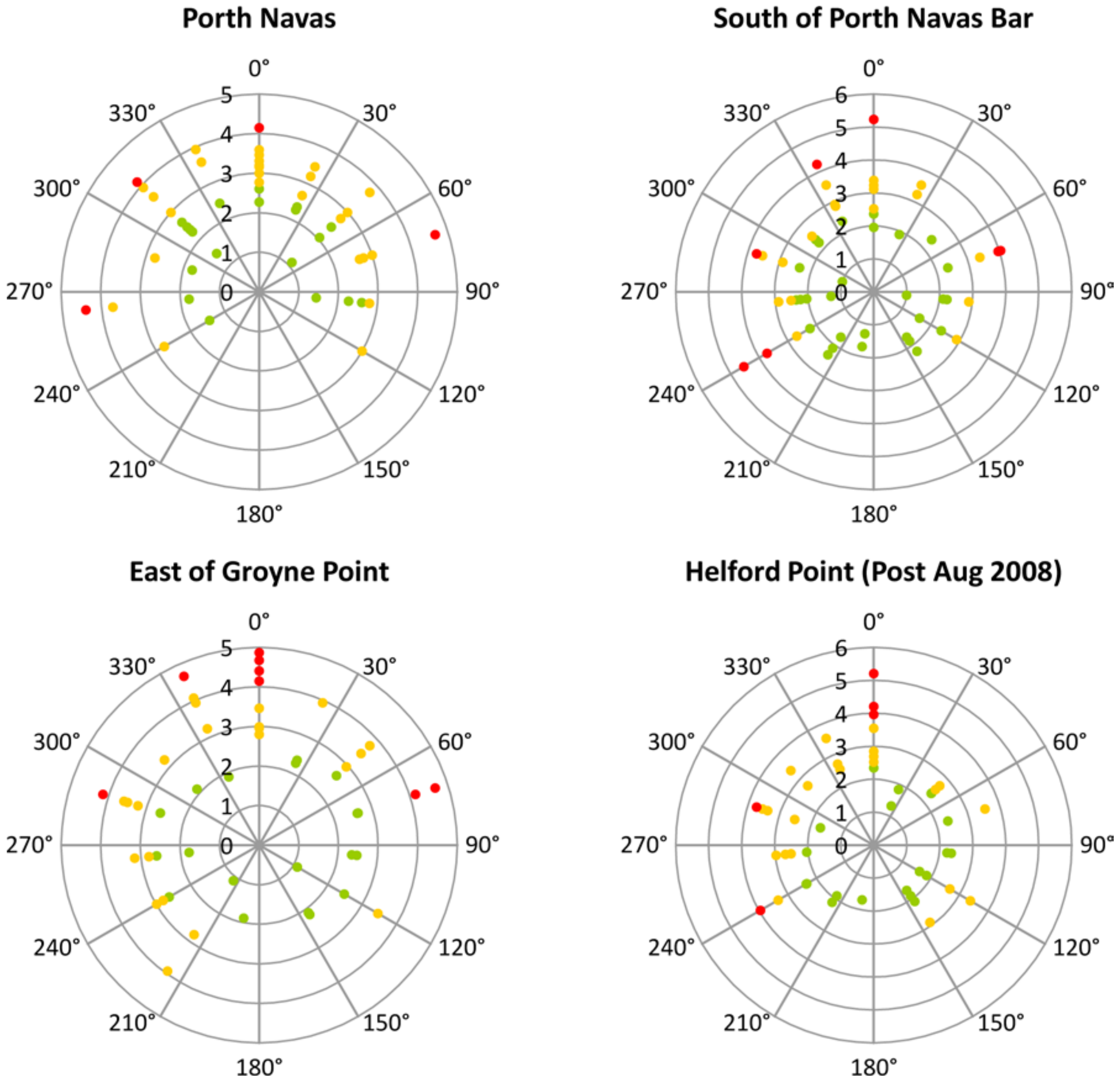

Figure 8.15: Polar plots of log10 *E. coli* results (MPN/100g) at mussel RMPs against spring/neap tidal state

At the Porth Navas, South of Porth Navas, East of Groyne Point and Helford Point mussels RMPs, higher results tended to occur as the tidal range was increasing. This may be due to contamination deposited on the shoreline during low tidal ranges being washed into the estuary, or contamination sources from further away reaching the mussels due to the larger tidal excursion.

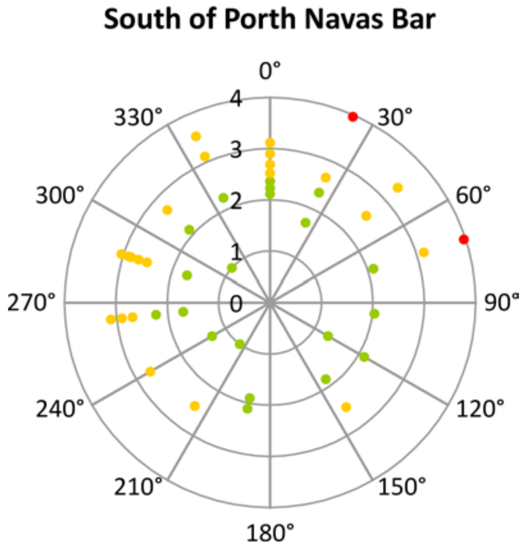

Figure 8.16: Polar plots of log10 *E. coli* results (MPN/100g) at native oyster RMPs against spring/neap tidal state

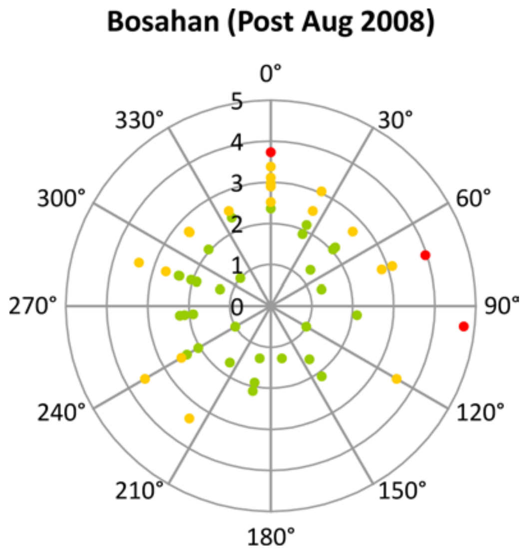

Figure 8.17: Polar plots of log10 *E. coli* results (MPN/100g) at Pacific oyster RMPs against spring/neap tidal state

As with mussel RMPs, in the South of Porth Navas native oyster RMP and the Bosahan Pacific oyster RMP higher results tended to occur as the tidal range was increasing.

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Appendices

Appendix I. Shoreline survey report

Date (time):
24th September 2013 (06:30-14:30)

Cefas Officers:
Simon Kershaw
Rachel Parks
Louise Rae
David Walker

Area surveyed:
Foot survey: Cliff tops at Parson's Beach to The Bar (north shore) and Little Dennis to Helford Point (south shore)
Boat survey: Perimeter of estuary from Passage Cove (north shore) and Helford Point (south shore) to Gweek. Including Porthnavas Creek, Polwheveral Creek, Polpenwith Creek, Mawgan Creek, Ponsontuel Creek, Vallum Tremayne Creek and Frenchman's creek.

Weather:
24th September 12:00, overcast, 22°C, wind bearing 046° at 3.2 km/h.

Tides:
Admiralty TotalTide© predictions for Helford River Entrance (50°05'N 5°05'W). All times in this report are BST.

24/09/2013		
High	08:39	5.0 m
High	20:53	4.9 m
Low	03:08	0.9 m
Low	15:24	1.0 m

I.1. Objectives:

The shoreline survey aims to obtain samples of freshwater inputs to the area for bacteriological testing; confirm the location of previously identified sources of potential contamination; locate other potential sources of contamination that were previously unknown and find out more information about the fishery. A full list of recorded observations is presented in Table I.1 and the locations of these observations are shown in Figure I.1.

I.2. Description of fishery

During the shoreline survey, it was possible to meet with the harvesters at the Duchy Oyster Farm. The details of the Pacific oyster operation in the Helford Estuary were discussed, the details of which are outlined in section 2 (Shellfishery).

Mussels were observed growing on rocks at observations 35 and 40. These mussels are not harvested currently, and those at observation 35 fall just outside the current classification area. The harvester has expressed an interest in harvesting those mussel at observation 35.

I.3. Sources of contamination

Sewage discharges

The location of one sewage discharge from the EA discharge consent database was confirmed (Helford STW, observation 37). Observations 21 and 26 were possible discharges from private package treatment plants no sample could be taken at observation 26, but a sample taken at observation 21 (F04) returned a relatively high *E. coli* concentration of 5,300 MPN/100 ml. At observation 10, someone was seen emptying a potty overboard from a boat. Owing to the number yacht moorings and in the estuary overboard discharges may represent a significant source of contamination to the estuary at least on a seasonal basis. At observation 29 there was an iron pipe with a missing valve and terracotta pipe. One of these may have been the discharge from the Shipwright PS. However, neither was flowing and may be relics of the old sewage system used before the Helford STW was installed, and now abandoned.

Freshwater inputs

Several small streams were observed flowing into the estuary. Of these streams, Helford Brook (observation 38) returned the highest *E. coli* concentration (1,500 cfu/100 ml) equivalent to a loading of 7.58×10^9 cfu/day.

Livestock & wildlife

Cattle and cow faeces were noted at several points throughout the survey (observations 4, 16, 19 and 23) and horses were noted in a field adjacent to the seal sanctuary at Gweek (observation 5). In the upper estuary flocks of gulls were noted (observations 1 and 11, where around 40 gulls were seen in each case.

Other sources

The Gweek Seal sanctuary has seven piped discharges, five of which were confirmed in the shoreline survey (observations 5, 6, and 7). One of these discharges (observation 7) had a relatively high flow rate (not measured, Figure I.10), but only had an *E. coli* concentration of <10 cfu/100 ml. In contrast another discharge (observation 5) had a low flow rate, but an *E. coli* concentration of 3,200 cfu/100 ml (Figure I.8).

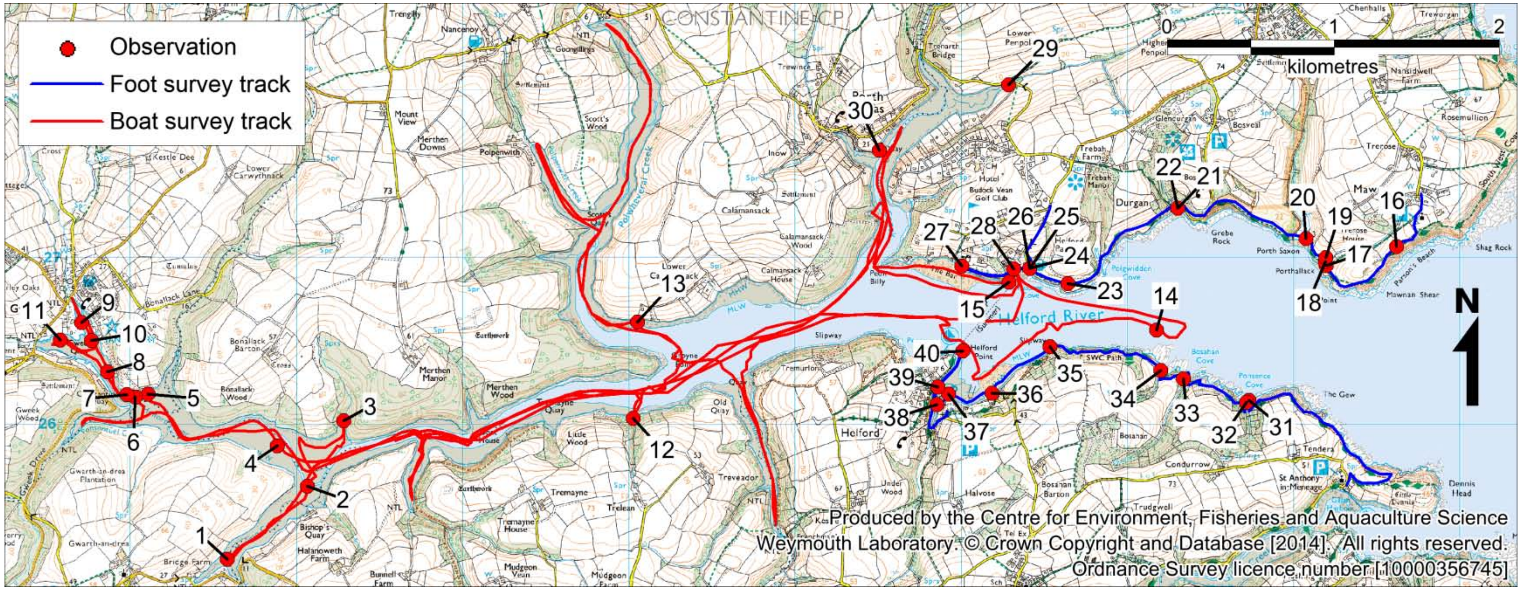


Figure I.1: Locations of shoreline observations (Table I.1 for details).

Table I.1: Details of Shoreline Observations.

Observation no.	NGR	Time	Description	Photo
1	SW7158125194	06:30	40 gulls.	
2	SW7206225629	06:41	Evidence of fishing.	Figure I.5
3	SW7228226021	06:51	Stream - No flow.	Figure I.6
4	SW7188125871	06:58	15 cattle on shore.	
5	SW7110526181	07:04	2 pipes from Seal Sanctuary dripping and horses in field behind (sample HB04).	Figure I.7 & Figure I.8
6	SW7102926164	07:12	2 pipes from Seal Sanctuary - Not flowing.	Figure I.9
7	SW7097626178	07:13	Fast flowing pipe from seal sanctuary (strong chlorine smell, sample HB05).	Figure I.10
8	SW7086026315	07:18	Fuegro Sea Core industry - with 2 pipes in sea wall - Not flowing.	Figure I.11
9	SW7070326608	07:22	Person onboard boat seen emptying potty overboard.	
10	SW7076426501	07:32	Houseboats, people living onboard yachts and caravans.	Figure I.12
11	SW7057626504	07:35	40 seagulls.	

Observation no.	NGR	Time	Description	Photo
12	SW7402426037	08:16	Freshwater stream flowing (sample HB09).	Figure I.13
13	SW7404926611	08:30	Pipe under steps - possibly land drainage - not flowing.	Figure I.14
14	SW7717326565	11:12	Oyster operation on barge.	Figure I.15
15	SW7628726851	13:35	Pipe (10 cm diameter, sample HB18).	Figure I.16
16	SW7861827062	07:36	Cow faeces in field.	
17	SW7819426951	07:47	Small boat shed and slip on the shore.	
18	SW7818926971	07:51	Small stream (sample F02).	Figure I.17
19	SW7819326997	07:55	Cow faeces in field.	
20	SW7807427110	07:59	Boat shed and slip on shore. Dog observed swimming in estuary here.	
21	SW7730227293	08:16	Iron manhole near slipway, with iron pipe (15 cm diameter x 2 cm flow depth) discharging near end of slipway (sample F04). Possibly Culverted stream with private package treatment plants.	Figure I.18
22	SW7730227293	08:16	40 boats anchored in bay here.	Figure I.19
23	SW7664026841	08:37	Cow faeces in field.	
24	SW7641026933	08:44	Broken plastic pipe (15 cm diameter). Not flowing. Other smaller pipes not flowing.	Figure I.20
25	SW7641126933	08:44	Dead shell (mussels) on strand line.	Figure I.21
26	SW7641126932	08:45	Black plastic pipe (20 cm diameter). Flow/depth too shallow to take sample. Possibly discharge from private package treatment plant.	Figure I.22
27	SW7600126948	08:53	Possible mussel poaching site - as reported to by passing member of public. Dog being walked on beach.	
28	SW7631426930	09:00	Culverted stream, land drainage flowing under road onto beach (sample F10).	Figure I.23
29	SW7628428031	09:42	Boats moored at edges of creek.	Figure I.24
30	SW7550627640	10:40	Duchy oyster farm holding area in estuary.	Figure I.25 & Figure I.26
31	SW7772926145	12:41	18 cows in field.	
32	SW7771726132	12:48	Stream to Ponsence Cove beach (sample F15).	
33	SW7733626272	13:00	Stream (sample F16).	
34	SW7720026322	13:08	Stream running across footpath soaking into beach. Too small to sample.	Figure I.27
35	SW7653326465	13:23	Mussels on rocks.	
36	SW7618326187	13:36	Concrete culvert onto beach (40 cm x 40 cm). Lots of gutweed observed at outfall (sample F20).	Figure I.28
37	SW7592326181	13:44	Helford STW outfall pipe exposed but not flowing.	Figure I.29

Observation no.	NGR	Time	Description	Photo
38	SW7585226119	13:50	Stream (sample F22).	Figure I.30
39	SW7585626223	13:55	Iron pipe with missing valve cover (under concrete slipway) and terracotta pipe (10 cm diameter). Neither flowing. Possibly discharge from Shipwright PS.	Figure I.31
40	SW7601226439	14:00	Mussels on rocky shoreline	

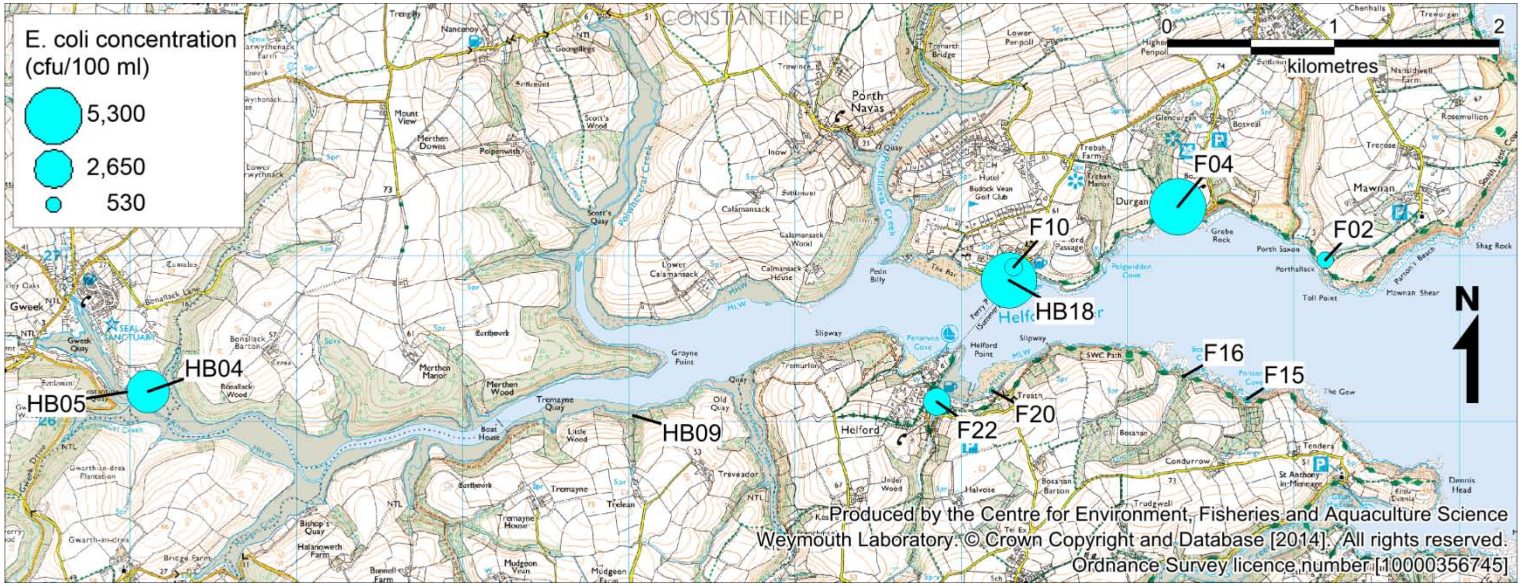


Figure I.2: Water sample results (Table I.2 for details).

Figure I.3: *E. coli* loadings (Table I.2 for details).

Table I.2: *E. coli* results, spot flow gauging results and estimated stream loadings (where applicable).

Sample ID	Observation number	Time	Description	Flow (m^3/s)	E. coli concentration (CFU/100 ml)	E. coli loading (CFU/day)	NGR
HB04	5	07:04	Pipes from Seal Sanctuary	3.51×10^{-5}	3,200	9.69×10^{7}	SW7110526181
HB05	7	07:13	Pipe from Seal Sanctuary		<10		
HB09	12	08:16	Stream	8.57×10^{-5}	<10	3.70×10^{5}	SW7402426037
HB18	15	13:35	Pipe	2.08×10^{-4}	5,200	9.36×10^{8}	SW7628726851
F02	18	07:51	Stream	3.30×10^{-3}	640	1.83×10^{9}	SW7818926971
F04	21	08:16	Pipe	1.18×10^{-3}	5,300	5.39×10^{9}	SW7730227293
F10	28	09:00	Stream		680		
F15	32	12:48	Stream	2.67×10^{-3}	100	2.31×10^{8}	SW7771726132
F16	33	13:00	Stream	1.89×10^{-3}	30	4.89×10^{7}	SW7733626272
F20	36	13:36	Culvert	1.54×10^{-5}	100	1.33×10^{6}	SW7618326187
F22	38	13:50	Stream	5.85×10^{-3}	1,500	7.58×10^{9}	SW7585226119

I.4. Bacteriological survey

To determine the background level of contamination across the estuary, several water samples were taken from the estuary (i.e. not from freshwater inputs or pipes) throughout the survey area. The *E. coli* results of these samples are shown in Table I.3 and their locations in Figure I.5.

Table I.3: *E. coli* results for water samples taken throughout the estuary

Sample	Time	*E. coli* concentration (cfu/100ml)	Time since high tide (hours)	NGR
B01	06:30	840	10.0	SW7158125194
B02	06:43	50	10.2	SW7210925681
B03	06:48	40	10.3	SW7226125914
B04	07:24	1,800	10.9	SW7063826734
B05	07:40	870	11.2	SW7081726384
B06	08:07	130	11.6	SW7273125840
B07	08:33	80	12.1	SW7370226779
B08	08:44	510	12.2	SW7385628386
B09	08:58	120	0.2	SW7366327257
B10	09:03	10	0.3	SW7430826361
B11	09:19	50	0.6	SW7467426308
B12	09:40	50	0.9	SW7545326948
B13	12:07	140	3.4	SW7258625878
B14	12:25	40	3.7	SW7563127746
B15	07:47	40	11.3	SW7819426951
B16	07:59	30	11.5	SW7807427110
B17	08:19	120	11.8	SW7729427286
B18	08:44	580	12.2	SW7641126933
B19	08:53	40	0.1	SW7600126948
B20	09:42	1,800	0.9	SW7628428031
B21	10:39	320	1.9	SW7550627649
B22	10:40	70	1.9	SW7550627640
B23	12:41	220	3.9	SW7772926145
B24	13:02	100	4.3	SW7737026299
B25	13:23	50	4.6	SW7653326465
B26	13:31	20	4.8	SW7634126354
B27	13:44	50	5.0	SW7592326181
B28	14:00	50	5.2	SW7601226439

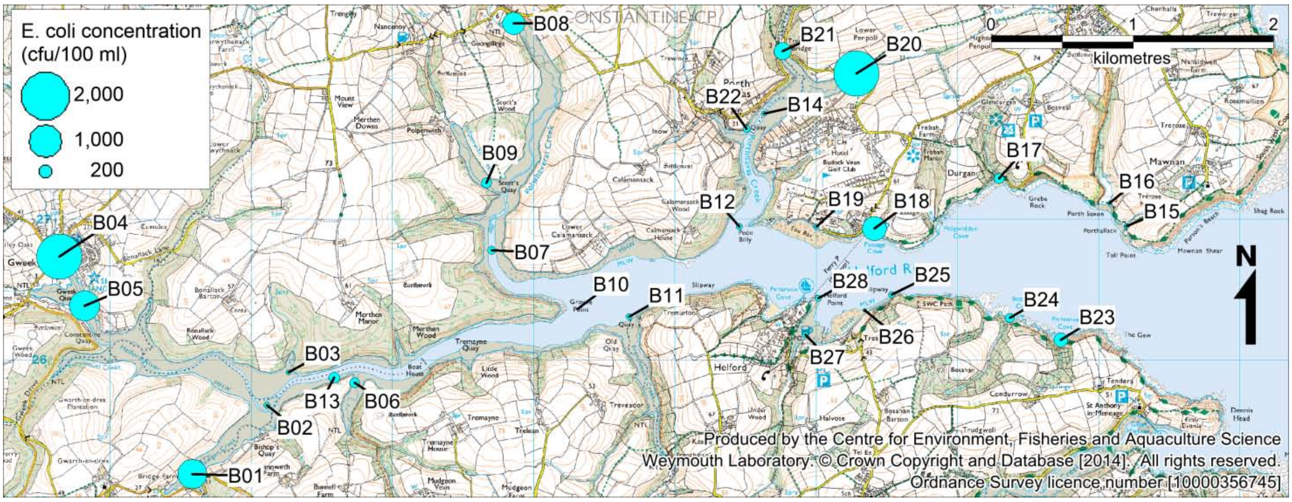
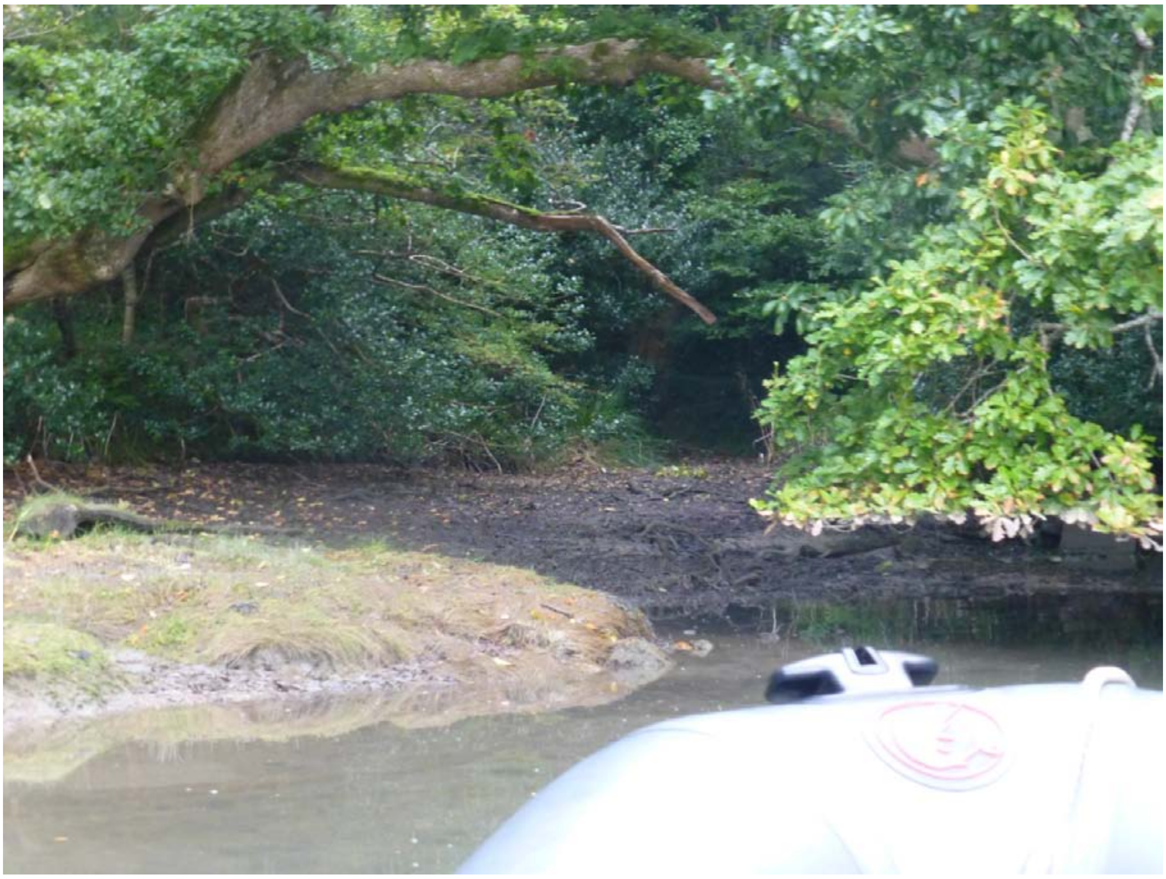


Figure I.4: Bacteriological survey (Table I.3 for details)

The results from the bacteriological survey show that the levels of *E. coli* are generally higher at the tops of the creeks. This would be expected due to the close proximity to freshwater inputs bringing contamination from across the catchment. Sample B18, which had an *E. coli* concentration of 580 cfu/100 ml was not taken from a creek. The close proximity to samples HB18 and F10 (Table I.2) a pipe and a stream respectively probably contribute to the relatively high *E. coli* concentration in sample B18.

Figure I.5



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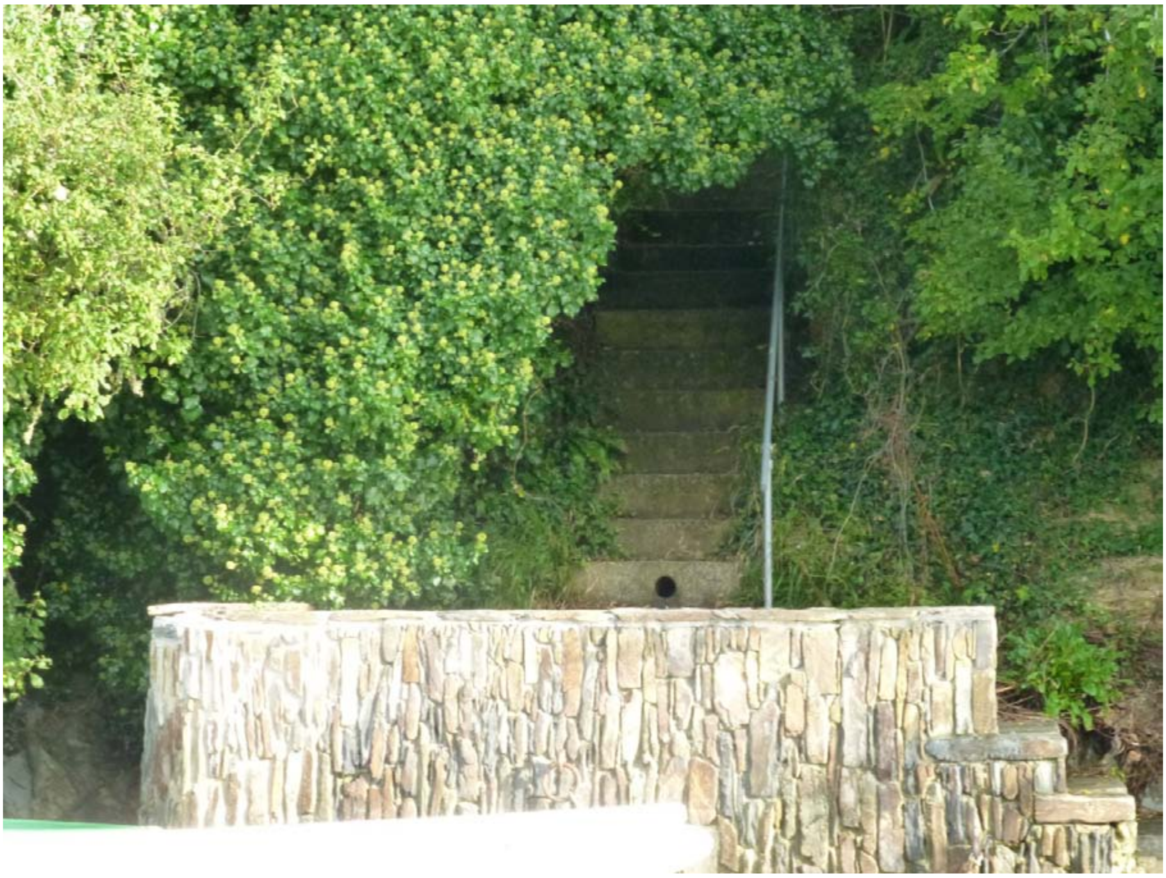

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Figure I.28

Figure I.29

Figure I.30


Figure I.31

Appendix II. Helford Estuary sanitary survey report 2008

Regulation (EC) No 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SANITARY SURVEY REPORT

Helford Estuary – Cornwall

2008

Cover photo: Mouth of the Helford Estuary.

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STATEMENT OF USE: This report provides information from a desk study evaluation of the information available relevant to perform a sanitary survey of bivalve mollusc production areas in the Helford Estuary. It also presents information acquired from a shoreline survey focused on the area of a new aquaculture fishery for *Crassostrea gigas* at Bosahan Cove. Its primary purpose is to demonstrate compliance with the requirements for classification of bivalve production areas, laid down in Regulation (EC) No 854/2004 of the European Parliament and of the Council. The Centre for Environment, Fisheries and Aquaculture Science (Cefas) undertook this work on behalf of the Food Standards Agency (FSA).

DISSEMINATION: Food Standards Agency, Falmouth and Truro port Health Authority, Environment Agency.

CONTENTS

EXECUTIVE SUMMARY

Under Regulation (EC) No 854/2004[1], there is a requirement for competent authorities intending to classify bivalve mollusc production and relaying areas (BMPAs) to undertake a number of tasks collectively known (in England and Wales) as ‘sanitary surveys’. The main purpose of these surveys is to inform the sampling plans for the microbiological monitoring programme and classification of BMPAs. Other wider benefits of these surveys include the potential to improve identification of pollution events and the sources of those events such that in the future remedial action can be taken to the benefit of the fisheries.

This report documents the qualitative assessment made of the levels of microbiological contamination in bivalves from the Helford Estuary, Cornwall and presents the recommended sampling plan as a result of a sanitary survey undertaken by Cefas on behalf of the Food Standards Agency (FSA).

The assessment is supported by published relevant information for the Helford catchment area and new information obtained from a shoreline survey performed in the estuary. The sampling plan presents information on location of monitoring points, sampling frequency and depth of sampling for the new Pacific oyster harvesting area at Bosahan Cove and all the other existing production areas of Native oysters, Pacific oysters and mussels in the estuary.

In general, it was concluded that the main sources of pollution likely to impact on the BMPAs are sewage discharges at Gweek, Constantine and Helford and non point sources associated with agricultural land use in the wider catchment. There are also seasonal fluctuations in the proportion of microbiological sources of contamination from wildlife (birds), boats (moored yachts) and the human population (as a result of tourism).

The margins and tributaries of the middle reaches and the upper reaches of the estuary are the areas potentially most vulnerable to contamination having less available dilution due to restricted water depth and being subject to potential sources of contamination from both upstream and downstream.

The central channel of the outer estuary, off Bosahan Cove, is potentially vulnerable to intermittent episodes of microbiological contamination via either wind driven or tidally advected pollution from further up the estuary. However, significant dilution is available in this area and there are no large point source inputs immediately upstream. Small streams entering the coast in the vicinity of the Bosahan and Ponscence coves represent a localised, potential significant, intermittent source of contamination in the south of the proposed harvesting area.

[1] See Section 6, Annex II of the Regulation.

Statistical analysis performed on historical data from the Shellfish Hygiene monitoring programme evidenced differences between species in their abilities to retain and accumulate contaminants, thus highlighting the importance of monitoring more than one species (or the one most vulnerable) in mixed shellfisheries.

The locations of existing representative monitoring points at Groyne Point, Port Navas and Helford Point were reviewed and new monitoring points were defined at Bosahan Cove and Port Navas Quay, in order to adequately reflect the impact of pollution sources across all the bivalve mollusc production areas.

1 INTRODUCTION

This report documents information arising from a sanitary survey relevant to BMPAs in the Helford Estuary. The sanitary survey was prompted by an application for monitoring and classification of farmed Pacific oysters at Bosahan Cove, in the outer Helford Estuary. This is a new operation being developed adjacent to an existing production area. A desk based assessment of existing relevant information has been made and the results of this are presented in Section 2. The results of a shoreline survey, undertaken in the vicinity of the proposed new production area are presented in Section 3. In Section 4, the results of the desk study and shoreline survey are drawn together in an overall assessment of the pollution sources likely to affect the levels of microbiological contamination in the BMPAs, along with recommendations in respect of the monitoring programme. A sampling plan, derived from an evaluation of the above information, is set out in the Appendix. This includes the location of representative monitoring points (RMPs) and required frequency of sampling for each species across the Helford production areas.

Filter feeding, bivalve shellfish (e.g. oysters, clams, cockles, mussels) retain and accumulate a variety of microorganisms from their natural environments. Since filter feeding promotes retention and accumulation of microorganisms, the microbiological safety of bivalve molluscs 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 in humans. Infectious disease outbreaks are more likely to occur in coastal areas where bivalve mollusc production areas (BMPAs) are impacted by sources of human and or animal microbiological contamination.

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 shellfish with pathogens is assessed through the microbiological monitoring of shellfish. This assessment results in the classification of BMPAs, which determines the level of treatment (eg purification, relaying, cooking) required before human consumption of bivalves (Lee and Younger, 2002).

Under Regulation (EC) No 854/2004[2] of the European Parliament and of the Council, competent authorities are required to undertake a number of activities collectively known (in England and Wales) as a 'sanitary survey' in and around BMPAs and their associated hydrological catchments and coastal waters in order to establish the appropriate representative monitoring points (RMPs) for the monitoring programme.

[2] See Section 6, Annex II of the Regulation.

The Centre for Environment Fisheries and Aquaculture Science (Cefas) is performing sanitary surveys for new BMPAs in England and Wales, on behalf of the Food Standards Agency (FSA). The purpose of these sanitary surveys is to demonstrate compliance with the requirements stated in Regulation (EC) No 854/2004, whereby ‘if the competent authority decides in principle to classify a production or relay area it must:

a) make an inventory 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 released during the different periods of the year, according to the seasonal variations of both human and animal populations in the catchment area and environmental factors e.g. rainfall, river flow, level of 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 shellfish 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.

Regulation (EC) No 854/2004 also specifies the use of *Escherichia coli* as an indicator of microbiological contamination in bivalve molluscs. This bacterium is present in animal and human faeces in large numbers and is therefore indicative of contamination of faecal origin. Both sewage and agricultural inputs to river systems upstream of estuaries are thought to significantly impact on a number of coastal and estuarine BMPAs in England and Wales (Younger *et al*., 2003). However, the standard test[3] used to enumerate *E. coli* does not differentiate between contamination of animal or human origins. Animal manure containing microbiological pathogens can pose a potential health risk, for example, the enterohemorrhagic serotype *E. coli* O157 can be present in cattle faeces at concentrations of 10^6 CFU g^{-1} (Omisakin *et al.*, 2003).

In addition to better targeting the location of RMPs and frequency of monitoring, it is believed that sanitary surveys may serve to help to target future water quality improvements within a BMPA. 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 specific point source discharge improvements or as a result of proactive changes in land management practices.

[3] ISO TS 16649-3: Microbiology of food and animal feeding stuffs – Enumeration of β-glucuronidase positive *Escherichia coli* – part 3: Most Probable Number (MPN) technique using 5-bromo-4-cloro-3-indolyl-β-D-glucuronide acid. International Organization for Standardization, Geneva.

2 DESK STUDY

2.1 GENERAL DESCRIPTION OF THE COASTAL AREA

The Helford Estuary is almost entirely undeveloped, with no heavy industry. It is situated in Cornwall, on the south coast of England (50° 05.85'N, 5° 08.25'W; Figure 1). The estuary has been categorised as a Type 3b Ria (drowned river valley without spits). The mouth is fairly narrow and deep. It faces east and is sheltered. The estuary is long and narrow with many small tributary creeks. The relative depth to width ratio is high, which is typical of a ria, whereas the intertidal ratio is low at 0.33, indicating that the estuary is capable of further sedimentation. The mouth width is about average in relation to the channel length (Halcrow Group Ltd, 2002).

The estuary covers an intertidal area of 186 ha and includes approximately 47 km of shoreline at the level of extreme high water spring tides (Davidson *et al*., 1991). Clay, shale and slate dominate in the river valley. Granite batholiths are represented in the northern region, whereas conglomerate and breccia, gneiss and schist, and basic and ultrabasic intrusions are represented in the southern region. The most significant hydro-geological units in the area are alluvium, granite and killas, which provide groundwater transport by their low primary permeability (Environment Agency, 2006).

The estuary contains a diversity of habitats, which are reflected in the range of communities present from the limit of the saline influence out to the sea. The bed of the estuary consists of mudflats, sand and shingle and there are rocky areas at the opening. Inter-tidal areas at the heads of the creeks are comprised of mud with gravel and sand (Halcrow Group Ltd, 2002). In its middle and lower portions, the fringing intertidal areas are generally narrow rocky shores with some areas of sedimentary and mixed substratum habitats. Extensive areas of sediment flats occur at The Bar, Passage Cove and around Helford Point (Figure 1). Shale and shingle shores, often replaced by deep mud towards low water are present at Groyne Point and Calamansack (Figure 1). The most extensive mud banks occur towards the head of the estuary near Gweek. Ancient woodlands dominate many areas in the lower river valley.

The estuary has been designated an Area of Outstanding Natural Beauty and is a marine Special Area of Conservation noted for its large shallow inlets and bays, mudflats and sand flats not covered by seawater at low tide, and those that are slightly covered by seawater at all times (Langston *et al.*, 2006). Gweek and Constantine form an Area of Great Landscape Value (Cornwall County Council, 2007).

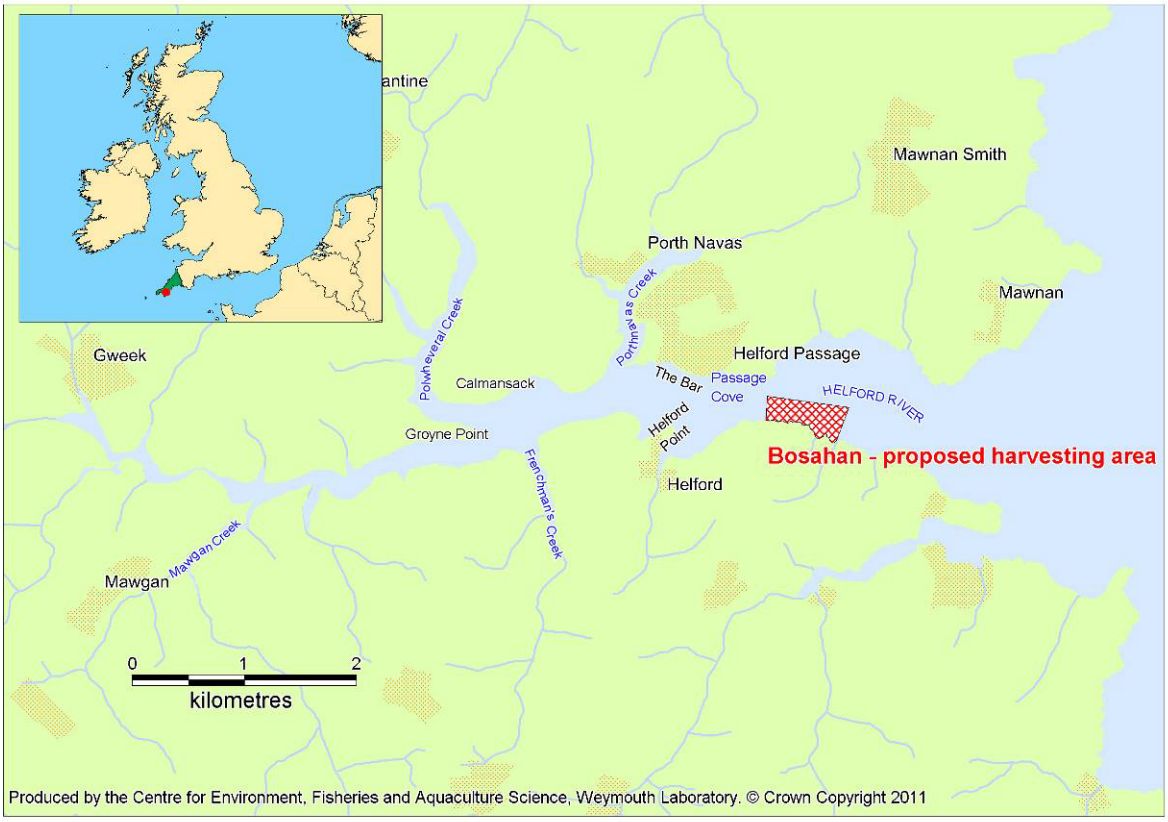


Figure 1. Location of the Helford Estuary showing its main localities and tributaries.

2.2 DESCRIPTION OF BIVALVE MOLLUSCAN SHELLFISHERIES

2.2.1 Bivalve Molluscan Species, Location and Extent

The harvesting of the native oyster *Ostrea edulis* and mussels *Mytilus* spp. is a century old activity in the Helford Estuary (see Neild, 1995; Helford Voluntary Marine Conservation Area, 2006). Both species are widely distributed within the estuary. Mussels occur in a wide range of depths and grow in dense banks. An aquaculture operation for growing the Pacific oyster *Crassostrea gigas* is being established in the outer estuary at Bosahan Cove.

Banks of the common cockle *Cerastoderma edule* occur at Helford Point area. Although this is one of the main species harvested in recreational (casual) harvesting at this site (see Section 2.2.6), the species is not subject to commercial exploitation.

The American hard shell clam *Mercenaria mercenaria* was brought from the Solent to the Helford Estuary for relaying (Rostron, 1989). Records indicate the first appearance of this species in the estuary in 1932 (Cole and Hancock, 1956 *in* ICES, 2005). However, there is no current commercial exploitation of this species in the Helford.

2.2.2 Growing Methods

In the past, oysters, clams and mussels were brought to the estuary for growing in cages deposited on the river bed (Helford Voluntary Marine Conservation Area, 2006). Currently, the commonly used farming method for mussels is bottom culturing. Juvenile mussels and oysters are collected from wild beds and placed in sheltered areas for growing to a marketable size (Figure 2). Native oyster seeds are also brought from the Fal and Solent estuaries for growing on beds (Helford Voluntary Marine Conservation Area, 2006).

Figure 2. Native oysters in bags ready for marketing at Porth Navas Quay.

The current application for classification of *C. gigas* cultivation at Bosahan Cove proposes the use of cages as a growing technique. Cages will be deposited on the seabed in one single layer (Ben Wright, pers. com.)

2.2.3 Capacity of Area

General
The estuary is considered to be under-utilised in terms of shellfish exploitation (MacAlister, Elliott & Partners Ltd, 1999).

Native oysters
Rostron (1989) reported an annual oyster production of over one million oysters in the Helford Estuary during the 1970s. Oyster stocks were largely affected by the protozoan parasite *Bonamia ostreae* during the 1980s, which caused the dramatic decline of production (Helford Voluntary Marine Conservation Area, 2006; Laing and Spencer, 2006). Whilst this

parasite is still one of the most important factors limiting the production of native oysters in the UK (Laing *et al*., 2005), it is not detrimental to human health. The oyster drill *Ocenebra erinacea* was reported to be an important predator of oysters in the Helford Estuary (Laing and Spencer, 1997). Being in the southwest region, the estuary has the advantage of higher winter seawater temperatures, giving an extended growing season and a reduced risk of winter mortalities (Laing and Spencer, 1997).

Cockles

It is estimated that an average of 65 kg of cockles are harvested from in the vicinity of The Bar, in the middle section of the estuary, each Good Friday (Tompsett, 2006).

Pacific oysters

Capacity for the new production area at Bosahan Cove is estimated to be around 200 tonnes per year (Ben Wright, pers. com.)

2.2.4 Existing Production/Relaying Areas

Bivalve beds occur throughout the estuary (Figure 3). The main area for harvesting bivalves covers approximately 336 ha. The main estuarine area together with Porth Navas Creek and Frenchman's Creek constitute the current production areas for mussels and oysters. The current classification status of these production areas is shown in Figures 4–6.

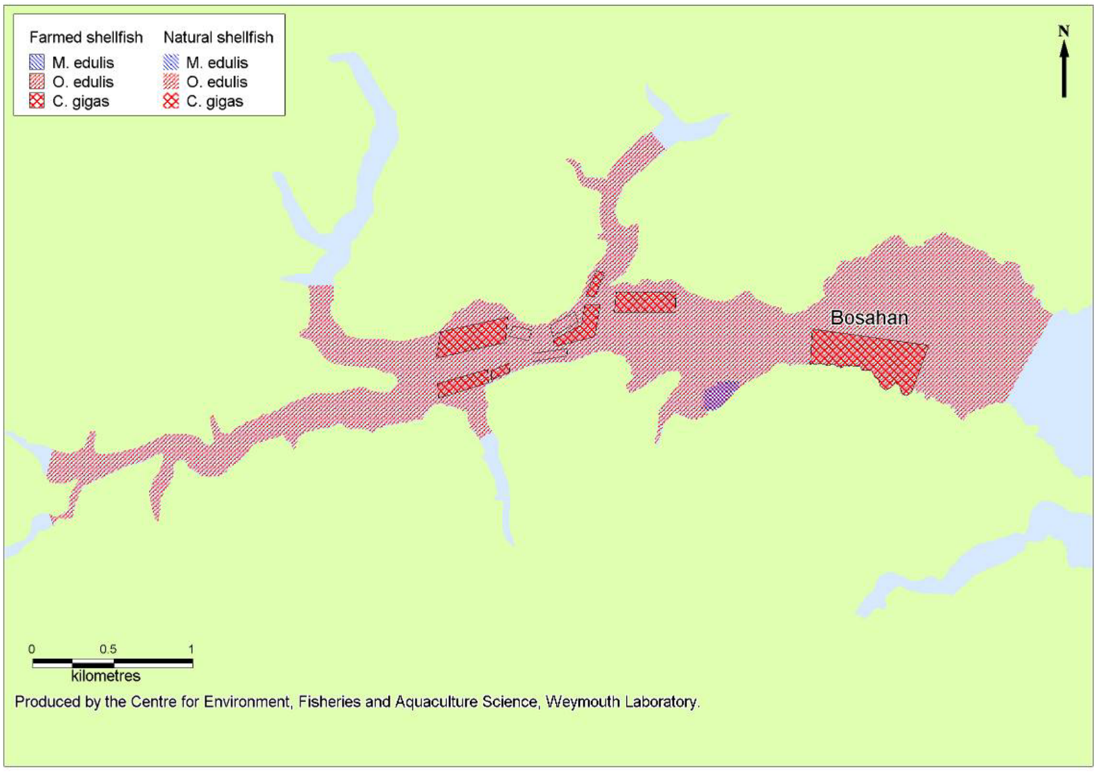


Figure 3. Existing natural and farmed shellfish beds and intended production area for* C. gigas *at Bosahan Cove in the Helford Estuary.

Classification of Bivalve Mollusc Production Areas: Effective from 1 September 2007

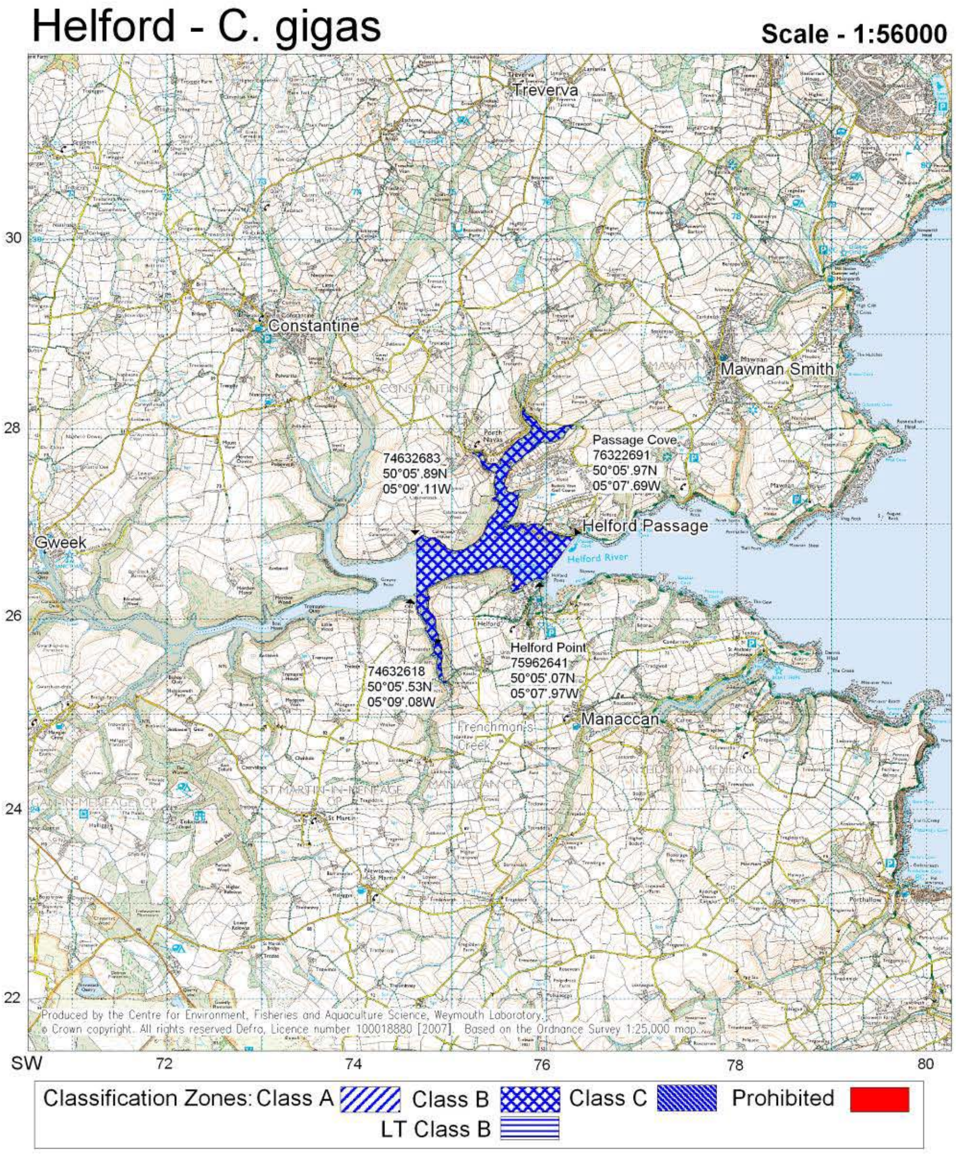
The areas delineated above are those classified as bivalve mollusc production areas under EU Regulation 854/2004.

Further details on the classified species and the areas may be obtained from the responsible Food Authority. Enquiries regarding the maps should be directed to: Shellfish Microbiology, CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB.
(Tel: 01305 206600 Fax: 01305 206601)

N.B. Lat/Longs quoted are OSGB 36
Separate maps available for Ostrea edulis and C. gigas at Helford

Food Authority: Falmouth and Truro Port Health Authority

Figure 4. Existing production area and current classification status of mussels in the Helford Estuary.



Classification of Bivalve Mollusc Production Areas: Effective from 1 September 2007

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N.B. Lat/Longs quoted are OSGB 36
Separate maps available for Ostrea edulis and Mytilus spp. at Helford

Food Authority: Falmouth and Truro Port Health Authority

Figure 5. Existing production area and current classification status of Pacific oysters in the Helford Estuary.

Classification of Bivalve Mollusc Production Areas: Effective from 1 September 2007

The areas delineated above are those classified as bivalve mollusc production areas under EU Regulation 854/2004.

Further details on the classified species and the areas may be obtained from the responsible Food Authority. Enquiries regarding the maps should be directed to: Shellfish Microbiology, CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB. (Tel: 01305 206600 Fax: 01305 206601)

N.B. Lat/Longs quoted are OSGB 36
Separate maps available for C. gigas and Mytilus spp. at Helford

Food Authority: Falmouth and Truro Port Health Authority

Figure 6. Existing production area and current classification status of native oysters in the Helford Estuary.

The oyster fishery is leased to the Duchy of Cornwall Oyster Farm, which has a purification plant and dispatch centre at Porth Navas. A new application also seeks classification for Pacific oysters at Bosahan Cove (Figure 7).

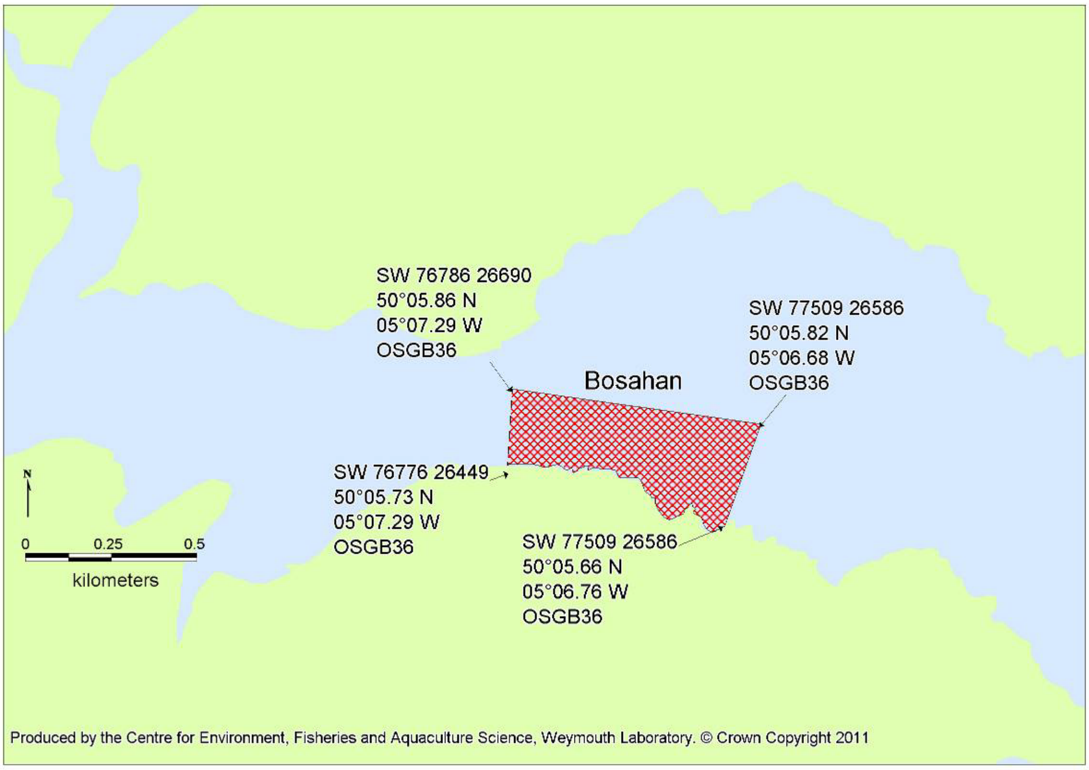

Figure 7. Intended production area for* C. gigas *at Bosahan Cove.

2.2.5 Seasonality of Harvest

In general, native oysters can take four to five years to reach a marketable size (Laing *et al*., 2005). The spawning season occurs between June and August. The harvesting of these oysters starts in August (Helford Voluntary Marine Conservation Area, 2006; see 2.2.7). The other bivalve species are dredged year round. Production of caged Pacific oysters at Bosahan Cove is intended to be undertaken as a year-round harvesting operation (Ben Wright, pers. com.).

2.2.6 'Casual' Gathering of Bivalve Molluscs

Local families harvest shellfish on Good Friday each year around Helford Point and Bar Beach, a tradition known as "trigging" (Tompsett, 2006). Cockles are the main species collected, although winkles, mussels, and limpets are also taken. 'Casual' (non-commercial) gathering activities, such as these, are not subject to the requirements for sanitary survey under Regulation (EC) No 854/2004. However, information from monitoring points in or adjacent to these areas may provide useful information for the local food authority (Falmouth & Truro Port Health Authority) to base public health decisions on.

2.2.7 Harvesting Techniques

Harvesting of native oysters is carried out using iron-frame dredges from boats (Figure 8) that can collect up to 100 oysters each pull (Helford Voluntary Marine Conservation Area, 2006). However, a significant proportion of bivalve harvesting within the estuary is done by hand. Pacific oysters at Bosahan are to be recovered by hand from cages hauled aboard a boat.

Figure 8. Boat used for dredging bivalve shellfish in the Helford Estuary.

2.2.8 Conservation Controls

In England and Wales, native oyster fisheries are managed by local Sea Fisheries Committee byelaws. In England and Wales, sea fisheries committees are empowered to make byelaws for the regulation, protection and development of fisheries for shellfish. There is a national closed season, lasting approximately two and a half months, from 14 May to 4 August to protect native oysters during the spawning season, though a dispensation exists for cultivated stocks (Laing *et al*., 2005). In general where no stock is being harvested and placed on the market in a closed season, monitoring may not be necessary during all of the closed period. In terms of public health protection it is necessary to commence monitoring two months prior to the start of the open season and therefore it is not possible to reduce the frequency of monitoring during the relatively short closed season for Native oysters in the Helford.

2.3 CLIMATE IN THE CATCHMENT AREA

2.3.1 Rainfall

The average annual rainfall in the Helford catchment ranges from 1,061 mm to 1,290 mm in the western and southern areas and from 1,291 mm to 1,690 mm in the northern areas (Meteorological Office, 2007a). From a UK perspective, this contrasts with averages of about 5,000 mm in parts of the western highlands of Scotland to about 500 mm in parts of East Anglia and the Thames Estuary (Met Office, 2007b).

Data from several rainfall gauges in and around the Helford catchment have been examined and all have partially incomplete data sets. Figures 9 and 10 show total rainfall by month in Culdrose and St Keverne meteorological stations. Both indicate that October, November and December are the wettest months on average and during these months there may therefore be an increased risk of contamination from land run-off and rainfall associated sewer overflows. The rainfall gauge at St Keverne to the south of the estuary has a continuous data set from June 2002 and has therefore been used for further analysis aiming to evaluate the relationship between this parameter and levels of *E. coli* in bivalves (see 2.4.5.3).

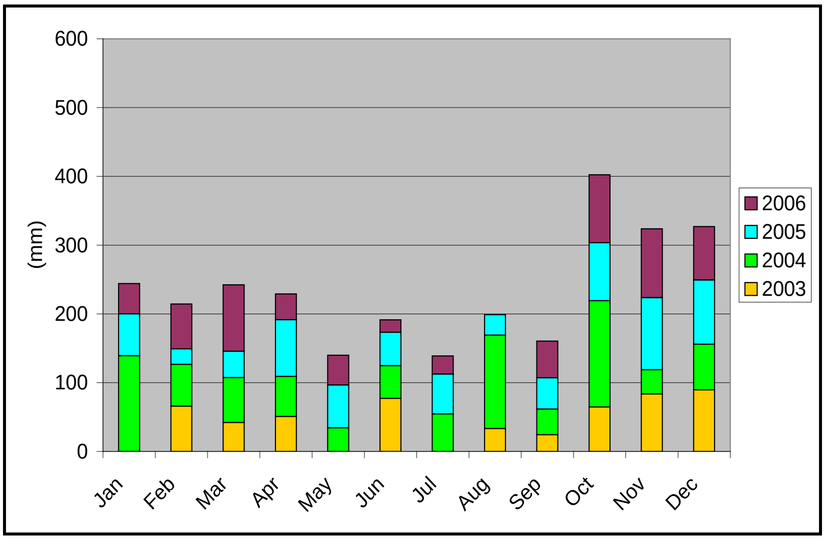

Figure 9. Monthly variation in total rainfall at Culdrose for 2003–2006.

Data provided by the Environment Agency (2007).
No data available for Jan., May and Jul. 2003 and Aug. 2006.

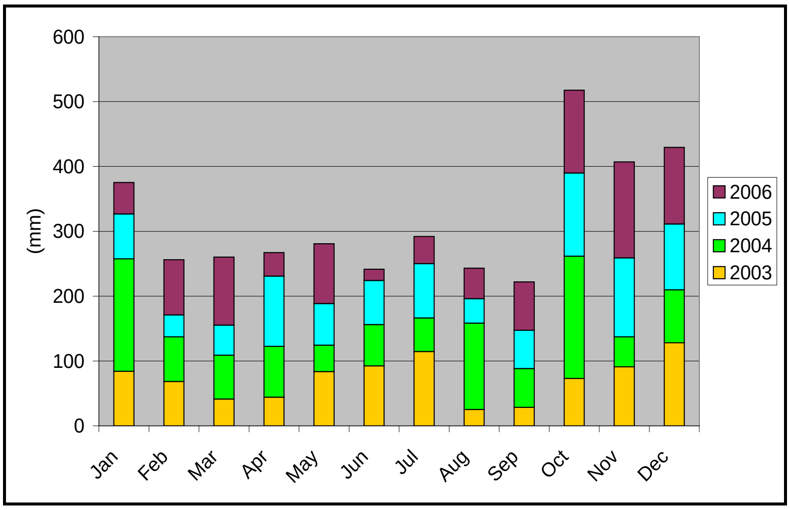

Figure 10. Monthly variation in total rainfall at St. Keverne for 2003–2006.
Data provided by the Environment Agency (2007).

2.3.2 Air Temperature

As in most of the South Western region of the country, the climate is relatively mild. The average annual air temperature in the Helford catchment ranges from 10.2°C to 12°C in most of the western and southern areas and from 9.4°C to 10.1°C in northern areas (Met Office, 2007a). A number of experimental studies demonstrated that temperature is one of the main factors limiting the persistence of pathogenic bacteria and viruses in freshwater and marine waters (see Obiri-Danso *et al*., 2001; Darakas, 2002; Fong and Lipp, 2005). Studies aiming to analyse the effect of temperature on the levels of microbiological contamination in surface waters are complex and beyond the scope of this assessment.

2.3.3 Sunshine

The sunniest parts of the United Kingdom such as along the South coast of England, achieve annual average figures of around 1,750 h of sunshine. The dullest parts of England are the mountainous areas, with annual average totals of less than 1,000 h (Met Office, 2007b). The average annual sunshine duration recorded in the Helford catchment ranges from 1541 h to 1885 h in most of the Western and Southern areas and from 1471 h to 1540 h in the Northern areas (Met Office, 2007a). It is generally accepted that the most rapid die-off or low persistence of bacteria occurs in marine and freshwaters in coastal areas with high sunlight intensities. Studies aiming to analyse the effect of incident solar radiation on the levels of microbiological contamination in specific surface waters are complex and beyond the scope of this assessment.

2.3.4 Wind

Wind data between 1992 and 1998 from Culdrose meteorological station (western limit of the Helford river catchment) have been analysed.
Figure 11 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 10A shows that 16% of winds contained a South-easterly. Together, insets 10A and 10B show that winds from the westerly and South-westerly sectors predominate. The wind rose in Figure 12 shows that the prevailing wind is South-westerly.

Whilst the contours of the land around an estuary will modify the prevailing wind to some extent, in the Helford the potential for wind driven advection of potentially contaminated surface waters is predominately from the head towards the mouth of the estuary. The way that wind can affect surface currents and how these may originate pollution incidents in the Helford Estuary is also considered in Section 2.5.5.

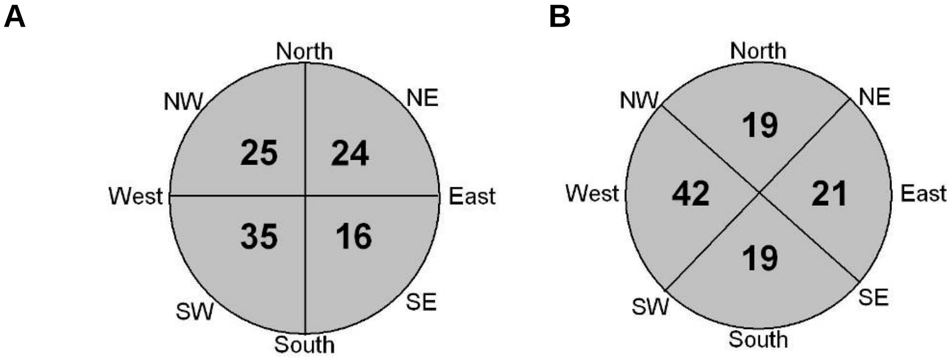

Figure 11. Percentage of wind direction by time for given sectors over the period 01 Jan 1992–31 Dec 1998.
Derived from Culdrose meteorological station.
Data provided by the Environment Agency (2007).

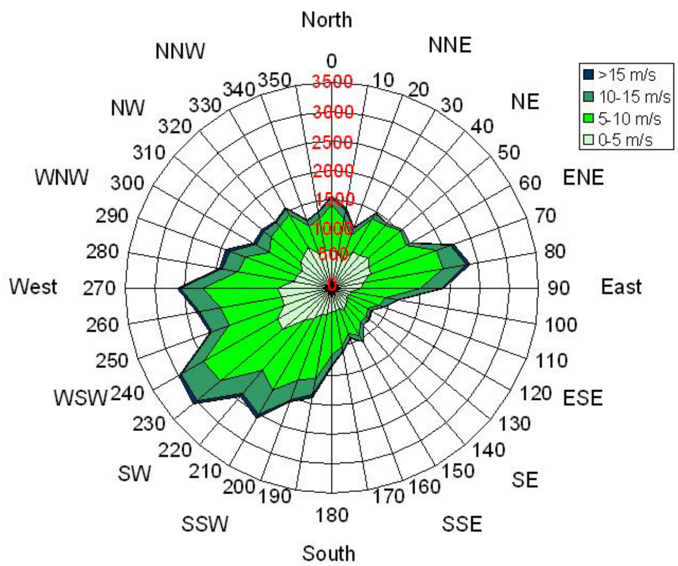

Figure 12. Wind rose showing direction and mean wind speed by hourly count over the period 01 Jan 1992–31 Dec 1998.
Derived from Culdrose meteorological station.
Data provided by the Environment Agency (2007).

2.4. SOURCES OF AND VARIATION IN MICROBIOLOGICAL POLLUTION

2.4.1 Land Use/Land Cover

The river catchment for the Helford Estuary comprises most of the southern half of the Kerrier District. The catchment area, as is the case with all the Kerrier District, is largely rural (Figure 13).

Figure 13. The Helford catchment area.
Reproduced under license from ©Anquet Maps Technology Ltd 2005.

Most of the catchment is utilised for agricultural purposes (Figure 14) and dominated by small holding farms (Figure 15).

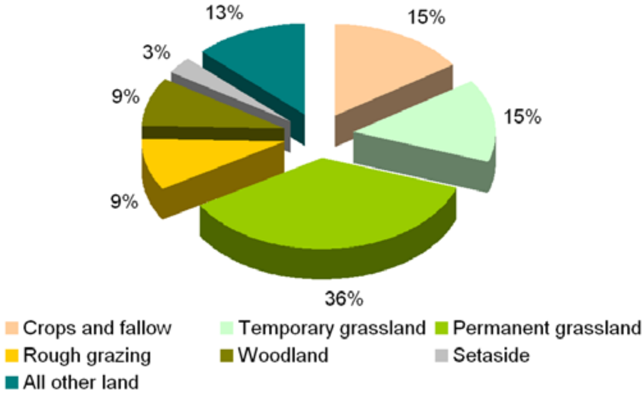

Figure 14. Land use characteristics in Postcode Districts TR10-13 encompassing the Helford catchment area.
Data derived from Defra 2004 June Agricultural Survey.

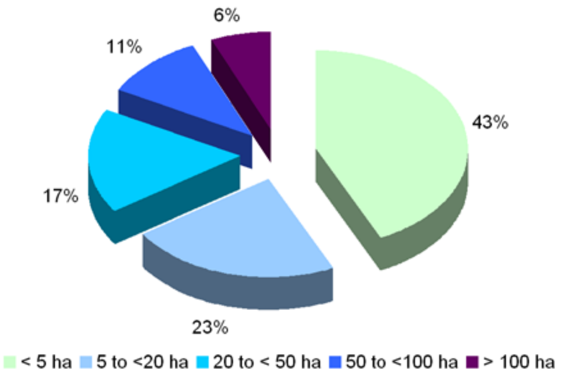

Figure 15. Size groups of farms in land use characteristics in Postcode Districts TR10–13 encompassing the Helford catchment area.
Data derived from Defra 2004 June Agricultural Survey.

There are 1007 farm holdings in the Kerrier District encompassing Postcode Districts TR10-13 (Defra, 2006). 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 (Figure 16).

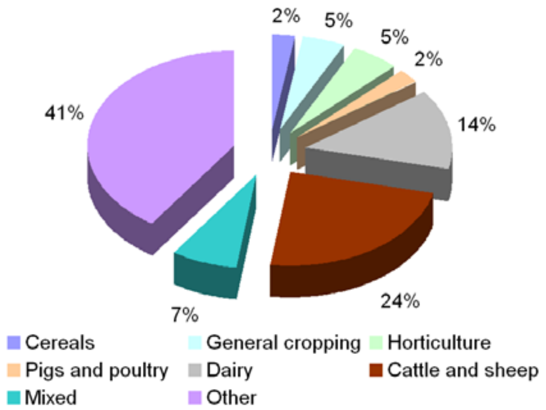

Figure 16. Farm types in Postcode Districts TR10–13 encompassing the Helford catchment area.
Data from derived from Defra 2004 June Agricultural Survey.

Mixed farms include holdings with mixtures of cattle and sheep and pigs and poultry and holdings where one of these groups is dominant, but do not account for more than two thirds of the total standard gross margin[4].

Several studies have documented the strong association between intensive livestock farming areas and faecal-indicator concentrations of microorganisms in streams and coastal waters, especially during high-flow conditions, both from point and non-point sources of contamination (eg Crowther *et al*., 2002 and references therein). The conclusions of investigations undertaken in the Helford catchment area aiming to

[4] Standard gross margin is a financial measure calculated by multiplying the crop areas and livestock numbers by the appropriate Standard Gross Margin coefficient (total output less the variable costs) and then summing the result for all enterprises on the farm.

calculate bacterial loadings from the main tributaries entering into the estuary under dry and wet weather conditions are presented in section 2.6.4.

2.4.2 Human Population and Activities

2.4.2.1 General

Population statistics for the area are collated by administrative ‘ward’ and at the District Council area level (Figure 17, Table 1). The mean population density in the Kerrier District is 203 km^2 (National Statistics, 2007). The south of the district has a dispersed settlement pattern containing over 60 villages, mostly below 2,000 people, and many smaller groups of settlement (Kerrier District Council, 2006). The Kerrier District covers a total area of 47,330 ha (National Statistics, 2007), of which 28,747 ha constitute the Helford catchment.

The population estimate for the Helford, Lizard, Carrick Roads river catchment is 50,755 (National Statistics, 2007). The main population centres in the Helford catchment are Constantine, Gweek and Mawnan, which have a total combined population of 3,740. The catchment also includes the western limit of the town of Helston, with a population of about 9,780 (National Statistics, 2007).

Human population in a given administrative area can be obtained from Census data, however relating this information to the level of microbiological contamination in coastal waters is difficult and is constrained by the geographical boundaries used.

Giving the importance of tourism related activities in the Helford catchment area, section 2.4.5.1 presents results from a simple assessment made on variation of percentage of tourism occupancy in the Kerrier District and geometric means of *E. coli* in bivalves from three beds in the estuary. It is supposed that this could help in giving a general picture of variation of contamination according to the seasonal variations of human population, as stated in the ‘sanitary survey’ requirements in Regulation (EC) No 854/2004 (see Introduction).

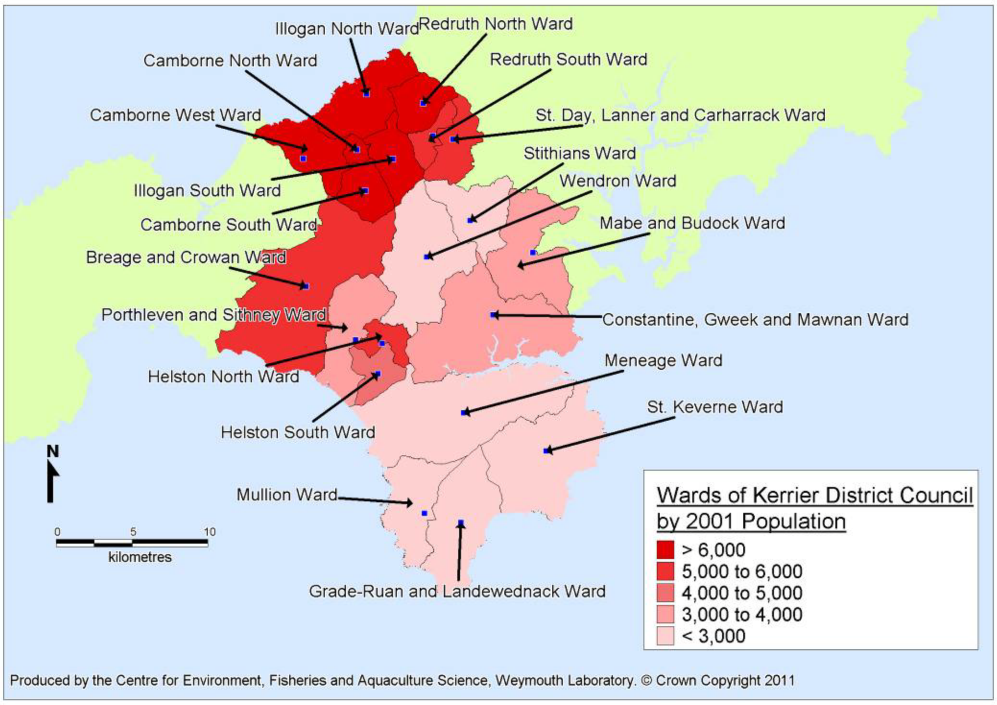

Figure 17. Human population by ward.
Office for National Statistics 2001 Population Census.

Table1. Human population numbers by wards of Kerrier District Council.

Ward Name	Total Population (2001)
Breage and Crowan Ward	5,838
Camborne North Ward	6,661
Camborne South Ward	6,875
Camborne West Ward	6,796
Constantine, Gweek and Mawnan Ward	3,740
Grade-Ruan and Landewednack Ward	1,956
Helston North Ward	5,961
Helston South Ward	4,323
Illogan North Ward	6,922
Illogan South Ward	7,114
Mabe and Budock Ward	3,946
Meneage Ward	2,539
Mullion Ward	1,986
Porthleven and Sithney Ward	3,830
Redruth North Ward	6,501
Redruth South Ward	5,851
St. Day, Lanner and Carharrack Ward	5,438
St. Keverne Ward	2,107
Stithians Ward	2,004
Wendron Ward	2,150

Data from Office for National Statistics 2001 Census.

2.4.2.2 Tourism

As in all the Kerrier District, tourism is one of the main activities taking place in the Helford catchment (see Hewett, 1995). The 2003 Tourism Survey showed 541,000 overnight stays and 1,415,000 day visitors a year in the district (Kerrier District Council, 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). In fact, most of the houses in villages around the Helford Estuary are second homes or holiday cottages, many of which are not connected to the sewerage system.

The National Seal Sanctuary is an important and popular tourist attraction at Gweek, operating as a home and hospital for seals and other marine animals rescued from the surrounding seas. In Mawnan Smith, the 26 acre Trebah Gardens receive visitors through the year, with visitor numbers exceeding 100,000 (Plants Info, 2007). Other tourism related activities in the estuary include sailing (see Section 2.4.3.2), windsurfing, kite surfing, kayaking, power boating, fishing, horse riding, dog walking and bird watching. All these activities have the potential to increase background levels of contamination in the estuary.

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 within the Helford catchment. This is considered further in Sections 2.4.3.1 and 2.4.5.1 below.

2.4.2.3 Industry

With the exceptions of the thriving boat construction and repair industry at Gweek and a commercial drilling rig company operating from this area, there are no other relevant industries (e.g. manufacturing, construction) in the catchment (see Hewett, 1995). Industrial discharges are not therefore considered to be significant in determining the location of hygiene monitoring points in the estuary.

2.4.3 Inventory of Pollution Sources of Human Origin

2.4.3.1 Point Source Discharges

The majority of residential properties in the catchment are not connected to main sewer and are served by septic tanks or cesspits or are untreated, although there are small sewage treatment works (STWs) at Constantine, Gweek and Helford Point (Figure 18).

Constantine STWs was improved in 2002, when the existing primary treatment works were upgraded by South West Water Ltd to receive secondary biological treatment followed by ultraviolet (UV) disinfection. The Seal Sanctuary (at Gweek) discharges seal pool water (max. 470 m^3) over approximately 90 minutes each morning. This discharge, which was consented by the EA in 2001, has a microbiological load contributing to background levels of contamination at the head of the estuary. The EA is intending to undertake an impact assessment of discharges in the vicinity of Gweek (P. Jonas, pers. com.).

There are several intermittent sewage discharges in the catchment that are consented to discharge under storm or emergency conditions. Overflow monitoring has been in place at Constantine STW storm tank discharge and Penbothidno Estate CSO since 2002. The current spill frequency of these discharges is described as ‘satisfactory’ (Environment Agency, 2007). In the period April 2005 to March 2006, 20 spills were recorded from Constantine STWs storm tanks, although only five of these spills were of over 1 h duration. Information on the spill frequency of other intermittent sewage discharges in the catchment is not available.

A summary of the most significant continuous and intermittent discharges to the Helford estuary is given in Table 2. This level of significance was established according to the distance of discharges to the estuary and, therefore, those within 10km of distance were considered to have a potentially significant impact on the levels of microbiological contamination in the BMPAs.

The Environment Agency Pollution Reduction Plan (PRP) considers that the continuous discharges from Constantine and Gweek (Bovis) STWs have a significant or potentially significant impact on the Helford Estuary Shellfish Water (Environment Agency, 2007). In addition, the intermittent discharges from Constantine STWs storm tank, Penbothidno Estate Combined Sewer Overflow (CSO) and Constantine Bridge Pumping Station CSO/Emergency Overflow (EO) were classified as having the potential to influence the shellfish water. Gweek STWs and Penbothidno CSO have been identified as priorities for further improvement in relation to shellfish waters.

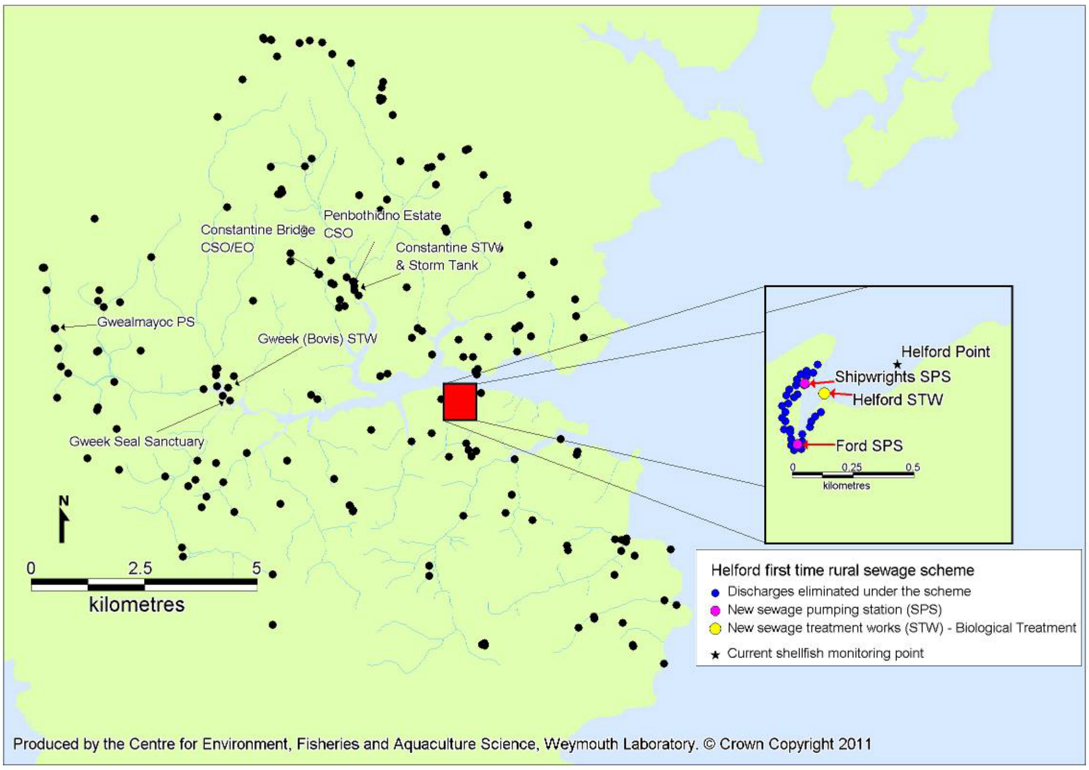

Figure 18. Sewage discharges in the Helford catchment area.
Main sewage discharges labelled.
Inset shows the First Time Rural Sewerage Scheme.
Data from the Cefas database.

Table 2. Significant microbiological discharges to the Helford Estuary.

Name of discharge	Treatment	Dry Weather Flow (m^3 day^{-1})	Distance from nearest BMPA (km)*
Continuous			
Helford STW	Secondary	50	0
Gweek Seal Sanctuary	Tidally phased	470 (maximum)	1.4
Gweek (Bovis) STWs	Secondary	25 (estimated)	1.8
Constantine STWs	Tertiary (UV)	150	2.1
Intermittent			
Shipwrights Arms PS	N/A	N/A	0
Ford PS	N/A	N/A	0
Constantine STWs storm tank	N/A	-	2.1
Penbothidno Estate CSO	N/A	-	2.3
Constantine Bridge CSO/EO	N/A	-	2.5
Gwealmayoc PS	N/A	-	6.5

STW - *sewage treatment works*
CSO - *combined sewer overflow*
PS - *pumping station*
EO - *emergency overflow*
** Distance is measured as a fluvial distance following the river/estuarine channel as appropriate.*
N/A - *data not available.*

In 2007, under a 'First Time Rural Sewerage Scheme', up to 43 small crude sewage discharges in the Helford Estuary were connected to sewer and transferred to a new STWs at Helford Point. This provides secondary level treatment by biological filtration plus tidal storage, restricting the discharge to high water ± 3 h. Associated with the scheme are storm and emergency overflows from the interconnecting Shipwrights Arms and Ford sewage-pumping stations, which discharge directly into part of the existing BMPAs. The locations of these discharges in relation to the nearest current RMP are shown in the inset in Figure 18.

2.4.3.2 Boats and Shipping

The estuary is not of national or regional significance for commercial shipping.

There are yacht clubs operating at Porth Navas and Helford River. The Helford River Sailing Club has about 1,300 members (Hewett, 2006). A survey in 1994 identified sixteen boatyards and 240 moorings in the estuary (Hewett, 1995). Since then, the number of moorings has increased and the main river has now about 600 moorings for use by locals during the peak season. The location of these moorings was confirmed during a shoreline survey performed on the 4 April 2007 (see Section 3). In a Google Earth image, more than 200 boats could be identified between Helford Point and Helford Passage (Figure 19). There are about 50 visiting yachts per night (Robert Hewett, pers. com.). Most of these appear to be located on either side of the fairway in an area from north of Helford Creek to south of The Bar.

The 1994 survey identified a total of 52 boats related to boat hire and charter activities in the estuary, most of them were sailing dinghy (19) and motorboats (21) (Hewett, 1995). Ferries between Helford and Helford Passage operate from the 1 April to 31 October (Imray, 2000). The annual Henri-Lloyd Regatta sees numerous sailing boats passing through the estuary and over to Falmouth.

The potential pollution of BMPAs by recreational boats is an issue that has received a great deal of attention (see Milliken and Lee, 1990). In the Helford Estuary boats are certainly potential sources affecting the background levels of microbiological contamination. Guillon-Cottard *et al*. (1998) investigated the contribution of boats as a source of microbiological contamination for mussels. This study was undertaken in a recreational harbour with a capacity for 650 boats, without any sewage discharge in its vicinity and under stable environmental conditions. The authors concluded that the increased levels of faecal coliforms in bivalves collected from the harbour were directly linked to sewage discharges from toilets flushing straight into the seawater. Similarly, Sobsey *et al*. (2003) found faecal coliform levels exceeding the standards for bivalves for human consumption in water samples taken a distance of 305 m from boats on a busy holiday weekend. The possible effects from this pollution source deserve further investigations outside the scope of this assessment.

Figure 19. Boats moored between Helford Point and Helford Passage.
Google Earth ™ mapping service, 2007.

2.4.4 Inventory of Pollution Sources of Animal Origin

2.4.4.1 Domestic animals

There are approximately 53,000 farmed animals in the Helford catchment. Cattle represent more than 50% in terms of animal numbers in the catchment (Table 3).

Table 3. Numbers of farmed animals in the Helford catchment.

Animals	Number
Dairy	7,383
Beef	3,311
Cattle	27,345
Pigs	1,015
Sheep	9,165
Ewes	4,296
Goats	108

Data from June 2006 Agricultural Census (Defra, 2007).

In addition to farm animals, dog faeces could conceivably contribute to background levels of contamination in water bodies receiving run-off from urbanised catchments (see Leeming *et al*., 1996; Whitlock *et al*., 2002). Dogs defecating on the foreshore in the vicinity of harvesting areas may be also present a potential health hazard in some instances. However, we have not seen any evidence to suggest this is a particular problem in the Helford catchment.

2.4.4.2 Birds

The catchment supports a variety of wildfowl and shore, woodland and farmland species of birds (Table 4). The most recent records indicate a better representation of woodland species in the Helford Estuary. The estuary supports a nationally important population of the shorebird black-tailed godwit (*Limosa limosa*) and water birds, such as the black-necked grebe (*Podiceps nigricollis*) and the slavonian grebe (*P. auritus*) (Langston *et al*., 2006). The numbers of birds in the estuary increase from early autumn and peak in mid-winter. The most abundant species in the estuary are the Curlew (*Numenius* sp.), the Grey Heron (*Ardea cinerea*) and the Little Egret (*Egretta garzetta*), with recent increasing numbers of this species in upper regions of the estuary (The Helford River, 2007). Birds usually concentrate around Helston, Helford Passage and northern areas of Mawnan.

Table 4. Abundance and seasonality of some important bird species in the Helford catchment.

Common name	Scientific name	Abundance	Seasonality
Black-headed Gull	*Larus ridibundus*	C:U	m/w:bs
Carrion Crow	*Corvus corone*	C	r
Collared Dove	*Streptopelia decaocto*	FC	r
Fieldfare	*Turdus pilaris*	FC	m/w
Garden Warbler	*Sylvia borin*	FC:U	bs:m
Goldfinch	*Carduelis carduelis*	FC	bs/m/w
Great Spotted Woodpecker	*Dendrocopos major*	FC	r
House Martin	*Delichon urbica*	C	bs/m
Jay	*Garrulus glandarius*	FC	r
Linnet	*Carduelis cannabina*	C:FC	bs/(a)m:w
Marsh Tit	*Parus palustris*	FC	r
Mute Swan	*Cygnus olor*	U	r
Nuthatch	*Sitta europaea*	FC	r
Redwing	*Turdus iliacus*	C	m/w
Rook	*Corvus frugilegus*	C	r
Skylark	*Alauda arvensis*	C	r
Starling	*Sturnus vulgaris*	VC:C	w:r
Willow Warbler	*Phylloscopus trochilus*	C	Bs

Data from the Environmental Records Centre for Cornwall and the Isles of Scilly (2007).
Abundance of non-breeding individuals):
VC - very common: >100,000.
C - common: 10,001-100,000.
FC - fairly common: 1,001-10,000.
U - uncommon: 101-1,000.
Notes on seasonality: r-resident; m-migrant; s-summer visitor; (a)m-migrant mainly in autumn; w-winter visitor; b-breeds.

2.4.5 Quantities of Microbiological Pollutants

2.4.5.1 Variation According to Human Population

Human population in the Helford catchment area, as in the entire Kerrier District Council district, increases during the holiday season. It is estimated that population temporarily double in average years during the peak season, which lasts from Easter to the end of September, with a sharp peak during the national school holidays in July and August (Kerrier District Council, 2002), when the percentage of tourism occupancy exceeds 80% (Figure 20).

The levels of microbiological contamination in shellfish production areas located in developed catchments frequently correlate with human population and land uses in adjacent shorelines and uplands (Mallin *et al*., 2001). In the Helford Estuary, weak positive correlations or no correlation were found between the percentage of tourism occupancy (see Section 2.4.2.2) and monthly geometric means of *E. coli* in shellfish from sampling points from which there are more than 50 microbiological results. Correlation coefficients were low, ranging between 0 (no correlation) in Native oysters from Calamansack Bar (Bed ID reference B034A) and 0.24 in mussels from Groyne Point (B034H).

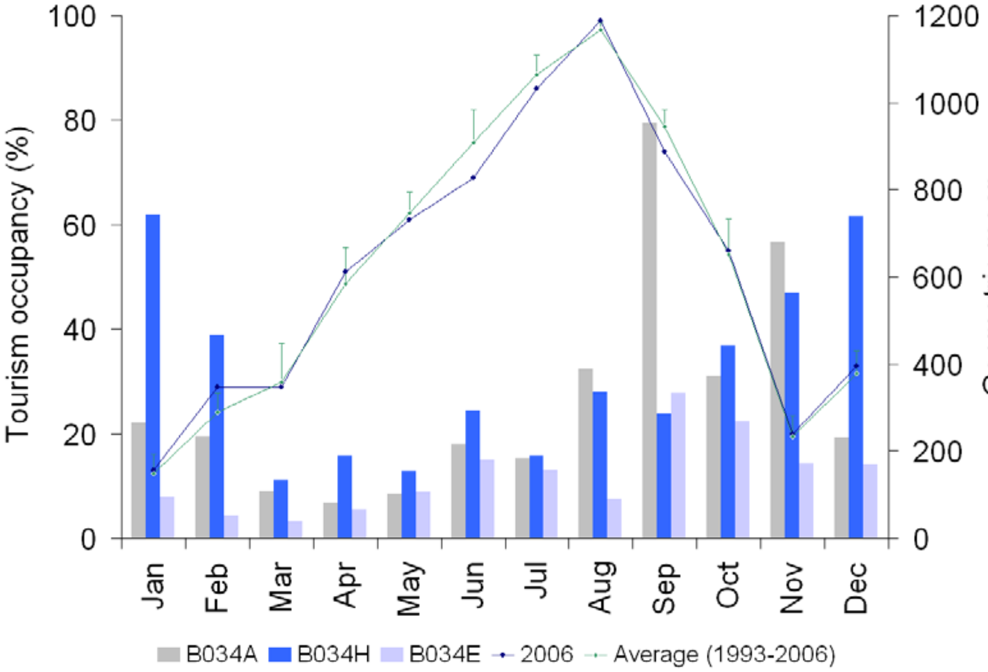

Figure 20. Monthly variation of percentage of tourism occupancy (2006 values and average ± Standard Deviation values between 1993 and 2006) in the Kerrier District and monthly geometric means of* E. coli *in native oysters from Calamansack Bar (B034A), mussels from Groyne Point (B034H) and native oysters from Porth Navas (B034).

Data on percentage of occupancy from Cornwall Tourist Board (2006).

2.4.5.2 Variation According to Animal Population

No information is available on seasonal variations in farmed animals. Information on manure application (rates/seasonality) in the catchment was requested from the Defra Catchment Sensitive Farming Officer. However, it transpires that no such information is currently available for the Helford catchment area.

The significant numbers of birds in the estuary especially over the autumn and winter months are likely to affect the background levels of microbiological contamination in the estuary at these times.

2.4.5.3 Variation According to Rainfall

Rainfall readings from St Keverne were checked for correlation with the levels of *E. coli* in shellfish from six sampling points for 24-hour periods up to seven days prior to the day of sampling. In all the sampling points, no correlation or weak positive (p=<0.05) correlations were obtained up to seven days before sampling (Table 5).
These results did not show a strong association between the levels of contamination in the Helford Estuary and rainfall. It is hypothesized that this is due to the well mixing hydrodynamic conditions in the estuary (see Section 2.5), promoting dispersion and dilution of contaminants in the vicinity of pollution sources.

Table 5. Spearman rank correlation coefficients (r_s) between daily rainfall averages (mm) and monthly levels of MPNs of E. coli 100g^{-1} FIL[5] in bivalves from six beds in the Helford Estuary.

Rainfall (mm) preceding sampling	MPN of E. coli 100g^{-1} FIL											
	B034A		B034D		B034E		B034G		B034H		B034J	
	Calamansack Bar (*O. edulis*)		Groyne Point (*O. edulis*)		Porth Navas (*O. edulis*)		Calamansack Bar (*M. edulis*)		Groyne Point (*M. edulis*)		Porth Navas (*M. edulis*)	
	r_s	*P*-value	r_s	*P*-value	r_s	*P*-value	r_s	*P*-value	r_s	*P*-value	r_s	*P*-value
One day	0.08	0.08	0.04	0.22	0	0.95	0.12	0.02*	0.08	0.07	0.06	0.15
Two days	0.19	0*	0.04	0.21	0	0.91	0.19	0.003*	0.25	0.001*	0.11	0.04*
Three days	0.19	0.01*	0.06	0.13	0.001	0.89	0.15	0.01*	0.21	0.003*	0.15	0.02*
Four days	0.14	0.02*	0.06	0.14	0.02	0.38	0.11	0.03*	0.17	0.01*	0.13	0.03*
Five days	0.13	0.03*	0.03	0.26	0	0.77	0.08	0.07	0.11	0.04*	0.09	0.08
Six days	0.09	0.06	0.03	0.3	0.01	0.51	0.03	0.32	0.11	0.04*	0.11	0.05
Seven days	0.06	0.13	0.02	0.41	0.01	0.65	0.04	0.20	0.07	0.10	0.10	0.06

* significant at the 0.05 level.
The test statistic, r_s, ranges from -1, through 0, to 1, indicating 'perfect negative correlation', 'no correlation' and 'perfect positive correlation', respectively.
Derived from St Keverne meteorological station data 01 Jan. 1992 to 31 Dec. 1998. Provided by the Environment Agency (2007).

[5] FIL = Bivalve mollusc flesh and intravalvular fluid.

2.4.5.4 Variation According to Waste-Water Treatments

Information from process engineering calculations used for the design of the new Helford STWs indicates that summer flows are approximately 30% greater than winter flows (South West Water, 2005) and background levels from sources of continuous discharges would therefore be expected to be higher at this time. Other than this there we are not aware of any other seasonal differences in the level of sewage treatment applied (eg seasonal disinfection) that would have significance for the classification microbiological monitoring programme.

2.4.6 Significant Pollution Events

Over the winter of 2006–2007, the Duchy of Cornwall Oyster Farm witnessed contamination of Porth Navas creek. On one occasion, discoloured surface water run-off was observed to originate from one particular field and flood across the road adjacent to the Creek. On other occasions subsequently visible discolouration of the water in the Creek was also observed. These events were not reflected in the results from monitoring of Native oysters at Porth Navas (B034E) and may have been due to silage with little or no faecal bacteria content.

2.5 HYDROGRAPHY AND HYDRODYNAMICS

2.5.1 General

The Helford estuary is a well-mixed estuary both on a tidal and seasonal basis and because of the relatively low freshwater input it is fully saline most of the time (Rostron, 1989). Salinity values obtained between February 2002 and December 2006 under the Shellfish Waters Directive monitoring programme ranged between 24.8 ppt and 35.2 ppt (Environment Agency, pers. com.). The estuary appears to be flood dominant. Surface water temperature varies between 8°C in January and 19°C in June and surface salinity varies between 24.4 ppt in January and 34.1 ppt during summer months (Boyden *et al*., 1979 *in* Rostron, 1989). These well mixed conditions are likely to favour the physical dispersion and dilution of microbiological contamination from point-source discharges. However, the salinity range indicates that these conditions might not be prevalent at certain times of the year.

2.5.2 Freshwater Inputs

The Helford Estuary receives freshwater inputs from several small tributaries (Figure 20). No continuous flow monitoring is undertaken on these watercourses, however there is an established spot flow gauging site (NGR SW70422650) on the Helford river at Gweek (Environment Agency, 2006).

The mean and range of flows derived from data collected by the Environment Agency as part of the Cycleau Project (Cycleau Project,

2006b; see 2.6.4) are shown in Table 6 and the location of the collection points is shown in Figure 21.
Helford and Gweek rivers together with Polwheveral Creek contribute 55% of the mean average flow on the basis of these readings (see 2.6.4). Monitoring points should be established at the nearest shellfish beds in order to assess the influence of the main freshwater inputs that also receive point source sewage discharges.

Table 6. Summary of monthly spot gaugings (m^3s^{-1}) undertaken by the EA between August 2005 and May 2006.

Location in Figure 20	Site	Minimum	Maximum	Mean
1	Mawnan Smith Brook at Lower Penpoll	0	0.04	0.02
2	Porth Navas Stream (Roskellan Bridge)	0	0.18	0.07
3	Trewince Stream (D/S Slipway)	0	0.08	0.03
4	Polwheveral Creek (D/S Constantine STW)	0.03	0.66	0.25
5	Cavedras Stream (at Nancenoy)	0	0.05	0.02
6	Gweek River (at Gweek Bridge)	0.05	0.56	0.24
7	Helford River U/S Gweek Mill	0.04	0.37	0.18
8	Rosevear River U/S Road Crossing	0.02	0.24	0.08
9	Tributary of Mawgan Creek at Bridge Farm	0	0.10	0.03
10	Mawgan Creek at Trelowarren Mill Bridge	0.01	0.35	0.09
11	Frenchmans Pill at Carnbarges Bridge	0	0.05	0.02
12	Helford Brook D/S Helford Ford	0	0.05	0.01
13	Manaccan Stream above Gillan Creek	0.04	0.42	0.17

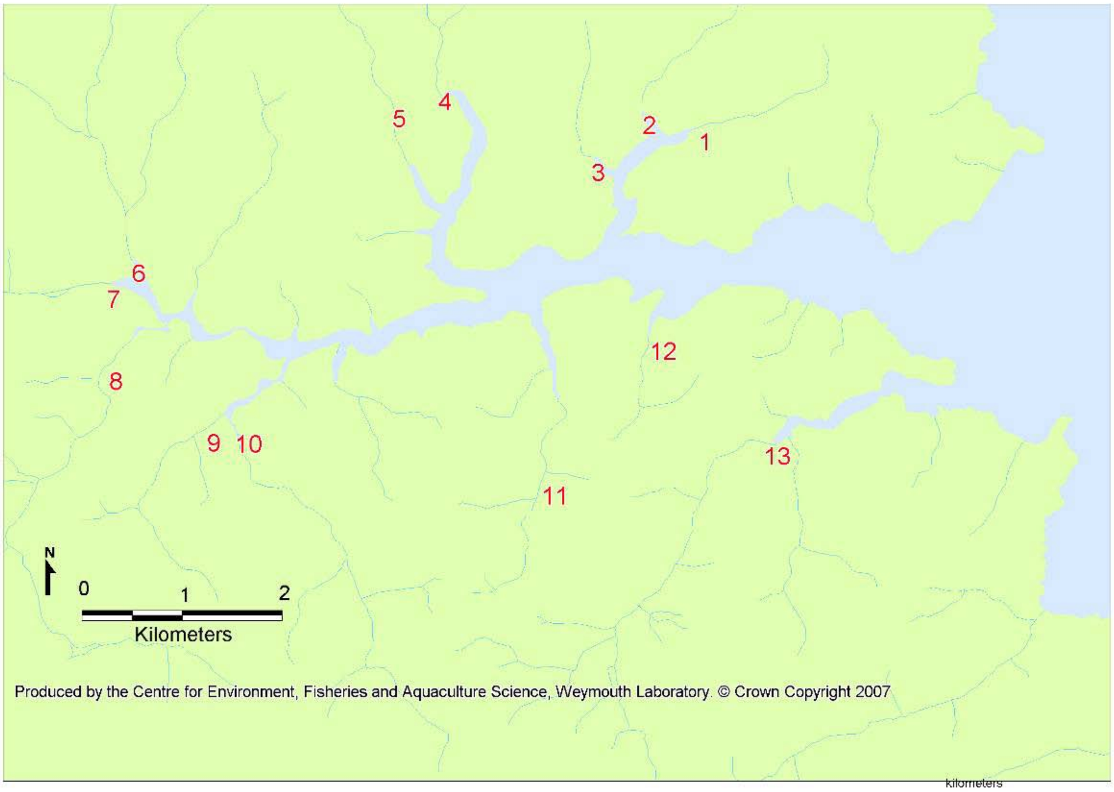

Figure 21. Helford river spot flow gauging sites.

2.5.3 Bathymetry

The estuary is a flooded river valley with intertidal drying areas along its margins and tributaries. There is a deep pool, with 15 m depth below chart datum (CD) in its deepest area (Figure 22), between Helford Point and Helford Passage.

The area between Bosahan Cove and Durgan Bay (see Figure 22) is generally between 2 m and 4 m below CD. These variations in bathymetry lend themselves to a range of habitats for bivalve molluscs. Both hand gathering and dredging of shellfish is carried out in order to commercially harvest shellfish and collect samples for hygiene monitoring purposes. From a practical point of view, this may limit the opportunity to access samples at certain states of tide.

2.5.4 Tidal range

The mean tidal range varies between 2.3m on mean neap tides to 4.7m on mean spring tides (Table 7).

Table 7. Predicted tide levels at the Helford Estuary entrance.

Level		Level (m)
Mean High Water Springs	MHWS	5.3
Mean High Water Neaps	MHWN	4.2
Mean Low Water Neaps	MLWN	1.9
Mean Low Water Springs	MLWS	0.6

Data from Imray (2000).

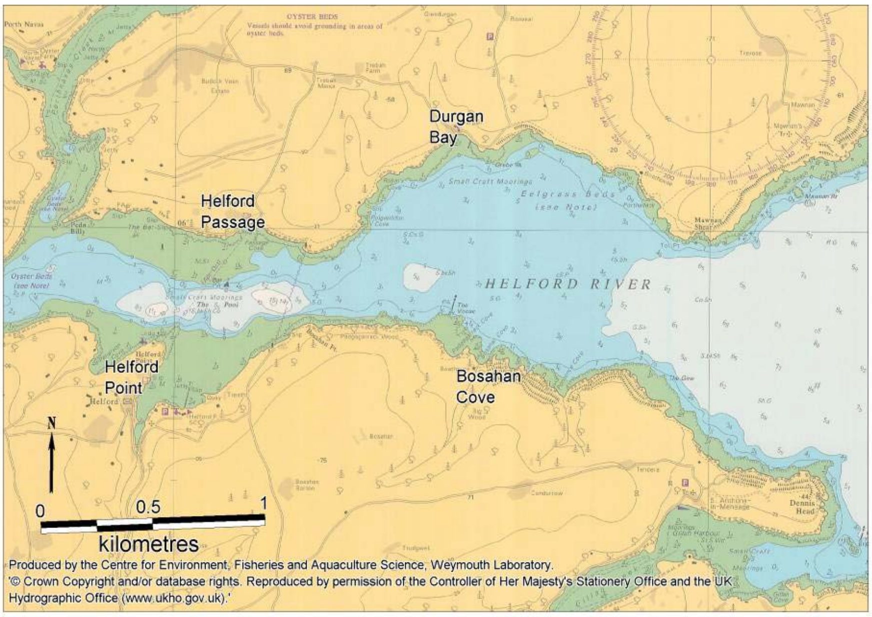

Figure 22. Bathymetry (depths in metres) in the Helford Estuary.

2.5.4 Tidal range

The mean tidal range varies between 2.3 m on mean neap tides to 4.7 m on mean spring tides (Table 7).

Table 7. Predicted tide levels at the Helford Estuary entrance.

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Mean High Water Springs	MHWS	5.3
Mean High Water Neaps	MHWN	4.2
Mean Low Water Neaps	MLWN	1.9
Mean Low Water Springs	MLWS	0.6

Data from Imray (2000).

2.5.5 Tidal flow and circulation

At springs, streams reach up to 2 knots (The Helford River Moorings, 2007). The east facing aspect of the estuary sheltered from the predominantly westerly winds means that the effects of wave action are limited to the mouth of the estuary (Rostron, 1989).

In 2005, tidal flow measurements were obtained in the mouth of the Helford Estuary (see Figure 23). This work was undertaken by Cornwall County Council in partnership with Triskel Marine Ltd. under an ‘Acute Pollution Action’, as part of the ‘Cycleau Project’. This project was conceived to improve pollution protection for estuaries through oil spill boom design and optimal placement, through the use of novel free floating GPS data logging drogues developed by Triskel Marine (Cycleau Project, 2005). Surface (top 1 m) water movements in the mouth of the estuary were recorded in October 2005. Data was collected and analysed in relation to peak flood tide conditions (K. Wittamore, Triskel Marine, pers. com.). Surface water vector plots for various combinations of tide and wind are shown in Figure 23. The study highlighted that:

(a) Surface water flows in the river mouth are strongly affected by the wind.

(b) Above 15 knots (7.7 m s^{-1}) of SW wind, the Helford is unlikely to be at risk from a pollution incident from seaward surface currents.

A strong back eddy was also noted to occur off the headland at Mawnan Shear, to the north of the entrance during peak flood tide (K. Wittamore, pers. com.).

To the best of our knowledge there has not been any other significant water movement studies or hydrodynamic modelling undertaken in relation to microbial dispersion in the estuary.

Given that the estuary is unlikely to be at risk of contamination from seaward and that advection of contaminants down the estuary with the prevailing south-westerly winds is likely to be more significant (particularly on the ebb tide), monitoring points need to be located that reflect dominant upstream sources of contamination.

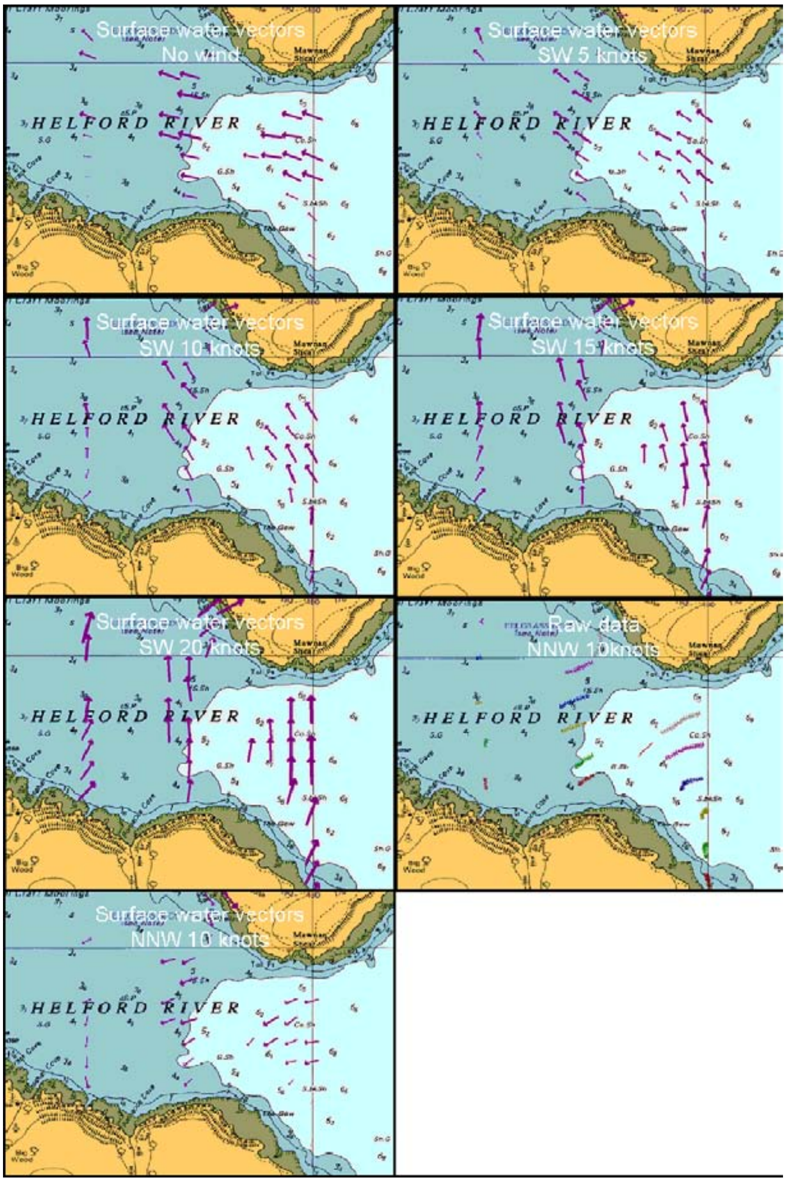

Figure 23. Peak flood tide surface water vectors.
Modified with the permission of Triskel Marine Ltd.

2.6 MICROBIOLOGICAL DATA

2.6.1 Historical *E. coli* data from the shellfish hygiene-monitoring programme

Following the implementation of the first statutory controls in England and Wales stipulating microbiological monitoring requirements for shellfish in 1992 consistent sampling effort has been maintained for native oysters at Calamansack Bar (Bed ID reference B034A) and Groyne Point (B034D). Regular sampling of native oysters and mussels in Porth Navas (B034E and B034J) commenced in 1993. Sampling of Pacific oysters for ongoing microbiological monitoring started in Calamansack Bar (B034M) and Porth Navas (B034N) in 2006.

The microbiological monitoring programme currently undertaken in the Helford Estuary to classify mussel and oyster beds has thirteen identified representative monitoring points (RMPs), though not all are currently required for the purposes of hygiene monitoring (see Figure 24). The numbers of samples by year collected in the ten shellfish beds, for which long term or recent data are available, are given in Table 8.

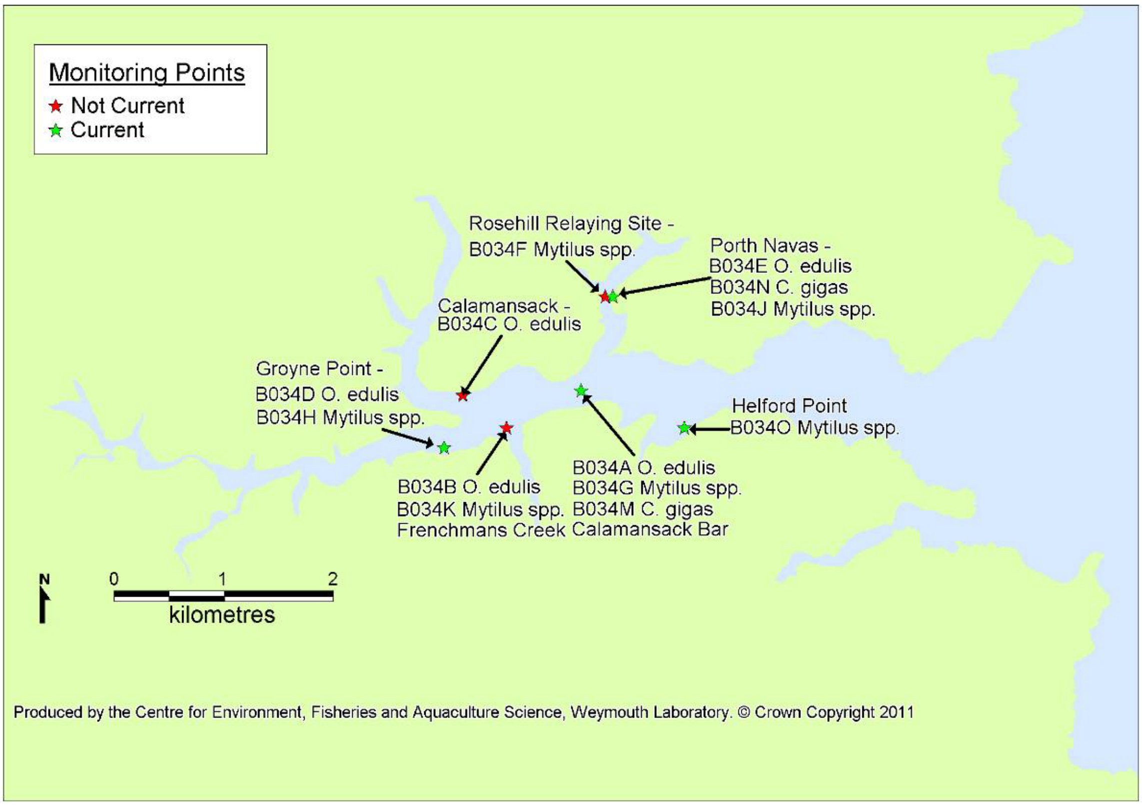

Figure 24. Location of representative monitoring points and bivalve species sampled in the Helford Estuary.

Table 8. Numbers of samples by year collected in ten shellfish beds in the Helford Estuary between 1992 and 2007.

	B034A	B034G	B034M	B034D	B034H	B034E	B034J	B034N	B034F	B034O
Number of samples	Calamansack Bar			Groyne Point		Porth Navas			Rosehill Relaying Site	Helford Point
	O. edulis	*Mytilus* spp.	*C. gigas*	*O. edulis*	*Mytilus* spp.	*O. edulis*	*Mytilus* spp.	*C. gigas*	*Mytilus* spp.	*Mytilus* spp.
Total	175	112	14	179	111	172	148	13	48	12
1992	21	1	0	20	0	0	0	0	0	0
1993	13	1	0	15	0	16	15	0	0	0
1994	12	1	0	12	0	11	2	0	0	0
1995	13	0	0	13	0	10	13	0	0	0
1996	9	0	0	10	0	12	11	0	0	0
1997	11	11	0	5	6	18	16	0	0	0
1998	12	10	0	15	16	14	13	0	0	0
1999	9	7	0	11	12	13	10	0	0	0
2000	8	9	0	11	11	15	10	0	5	0
2001	10	11	0	10	10	7	8	0	13	0
2002	11	12	0	11	12	11	9	0	7	0
2003	12	12	0	13	9	10	7	0	10	0
2004	8	10	0	8	9	10	9	0	9	0
2005	10	10	0	10	10	10	10	0	4	0
2006	10	11	8	10	11	10	10	8	0	8
2007 (Jan-Jun)	6	6	6	5	5	5	5	5	0	4

2.6.1.1 *E. coli* data statistical summary

A summary of descriptive statistics for *E. coli* data monitored in shellfish from ten beds between 1992 and 2007 is presented in Table 9.

The data for individual beds with longer-term data sets are presented, under the relevant site sub-headings below, as time series representations of levels of *E. coli*, including 12 sample moving average trend lines (Figures 25–31).

Variations of annual geometric means of *E. coli* for shellfish beds that have at least six samples per year from year 2000 to date are presented in Figure 32.

Table 9. Statistics of historical* E. coli *data monitored in ten shellfish beds in the Helford Estuary between 1992 and 2007.

	B034A	B034G	B034M	B034D	B034H	B034E	B034J	B034N	B034F	B034O
	Calamansack Bar (*O. edulis*)	Calamansack Bar (*Mytilus* spp.)	Calamansack Bar (*C. gigas*)	Groyne Point (*O. edulis*)	Groyne Point (*Mytilus* spp.)	Porth Navas (*O. edulis*)	Porth Navas (*Mytilus* spp.)	Porth Navas (*C. gigas*)	Rosehill Relaying Site (*Mytilus* spp.)	Helford Point (*Mytilus* spp.)
Date of first sample	23/03/92	21/12/92	13/02/06	23/03/92	25/03/97	18/01/93	19/01/93	13/02/06	07/11/00	08/08/06
Date of last sample	12/06/07	12/06/07	12/06/07	09/05/07	09/05/07	18/06/07	18/06/07	15/05/07	09/05/05	11/06/07
Minimum MPN *E. coli* 100g^{-1} FIL	<20	<20	20	<20	<20	<20	<20	<20	<20	40
Maximum MPN *E. coli* 100g^{-1} FIL	>18,000	16,000	2,200	>18,000	>18,000	>18,000	16,000	1,300	5,400	3,500
Median MPN *E. coli* 100g^{-1} FIL	200	220	310	220	310	110	220	220	370	70
Geometric mean MPN *E. coli* 100g^{-1} FIL	177	280	270	165	293	93	156	186	374	171

Calamansack Bar

The levels of *E. coli* in native oysters (B034A) and mussels (B034G) from Calamansack Bar are presented in Figures 25 and 26 below.

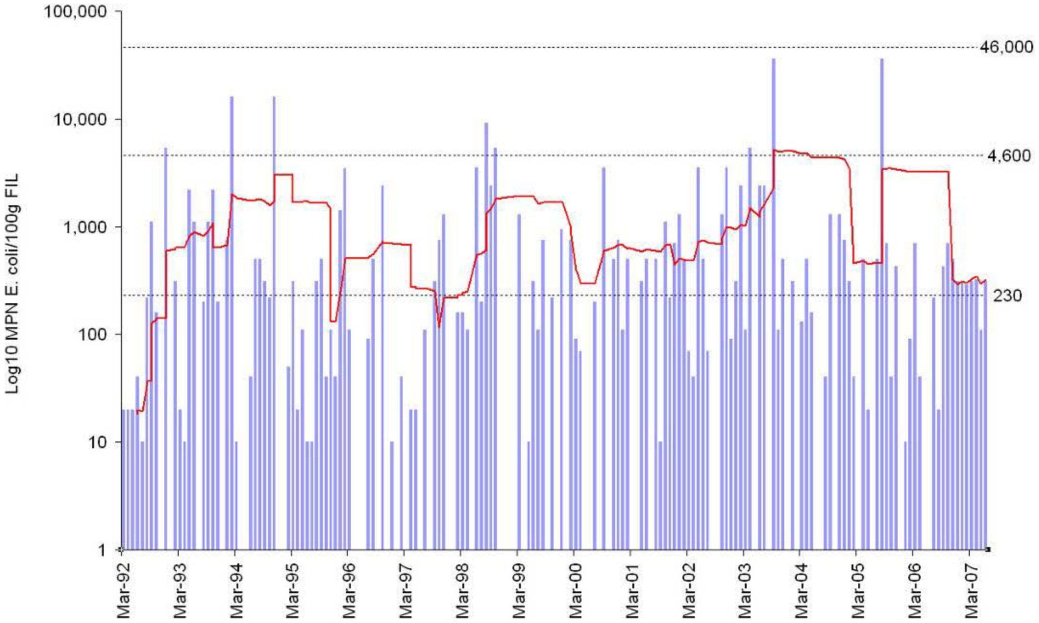

Figure 25. Time series of levels of* E. coli *and 12 sample moving average (red line) in native oysters from Calamansack Bar (B034A).

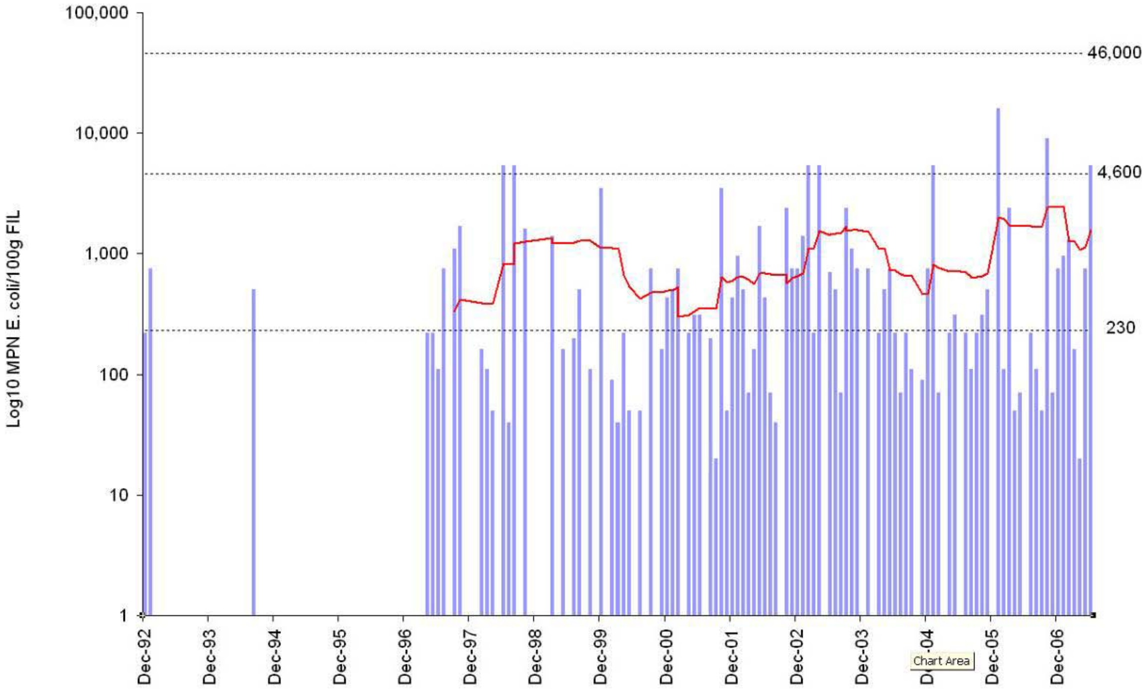

Figure 26. Time series of levels of* E. coli *and 12 sample moving average (red line) in mussels from Calamansack Bar (B034G).

Pacific oysters from Calamansack Bar (B034M) have also been monitored for *E. coli* since February 2006, results ranging between 20 MPN 100 g^{-1} FIL (in May 2006) and 2,200 MPN 100 g^{-1} FIL (in March 2006) (graph not shown).

Groyne Point

The levels of *E. coli* in native oysters (B034D) and mussels (B034H) from Groyne Point are presented in Figures 27 and 28 below.

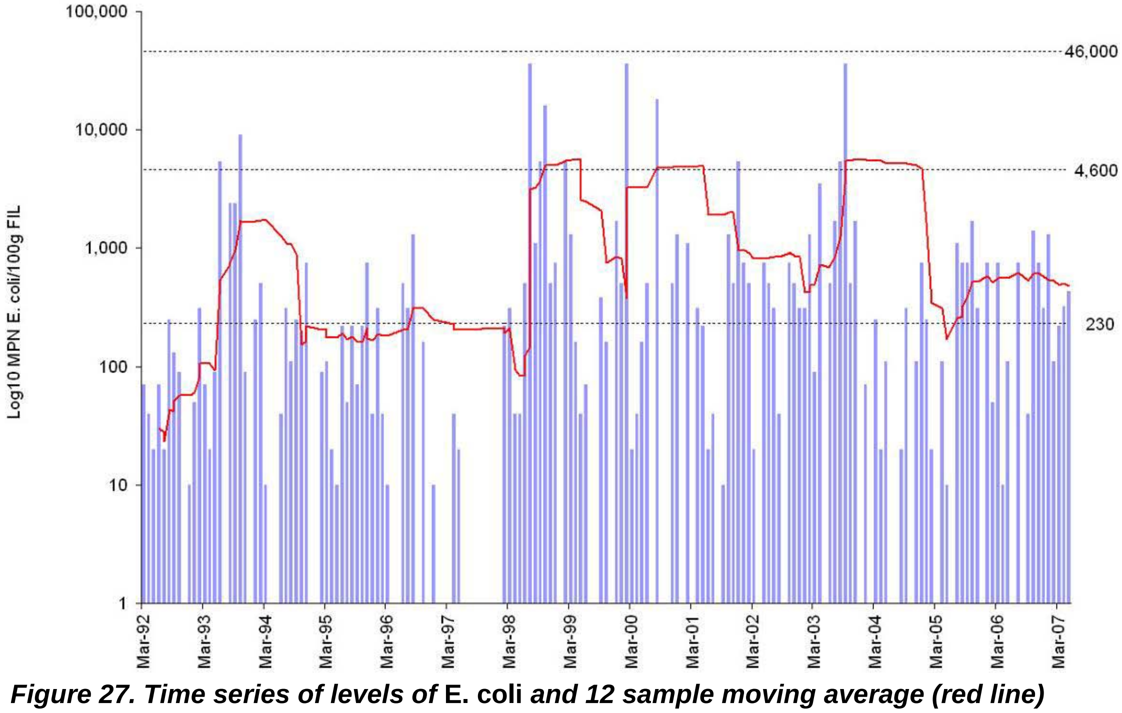

Figure 27. Time series of levels of* E. coli *and 12 sample moving average (red line) in native oysters from Groyne Point (B034D).

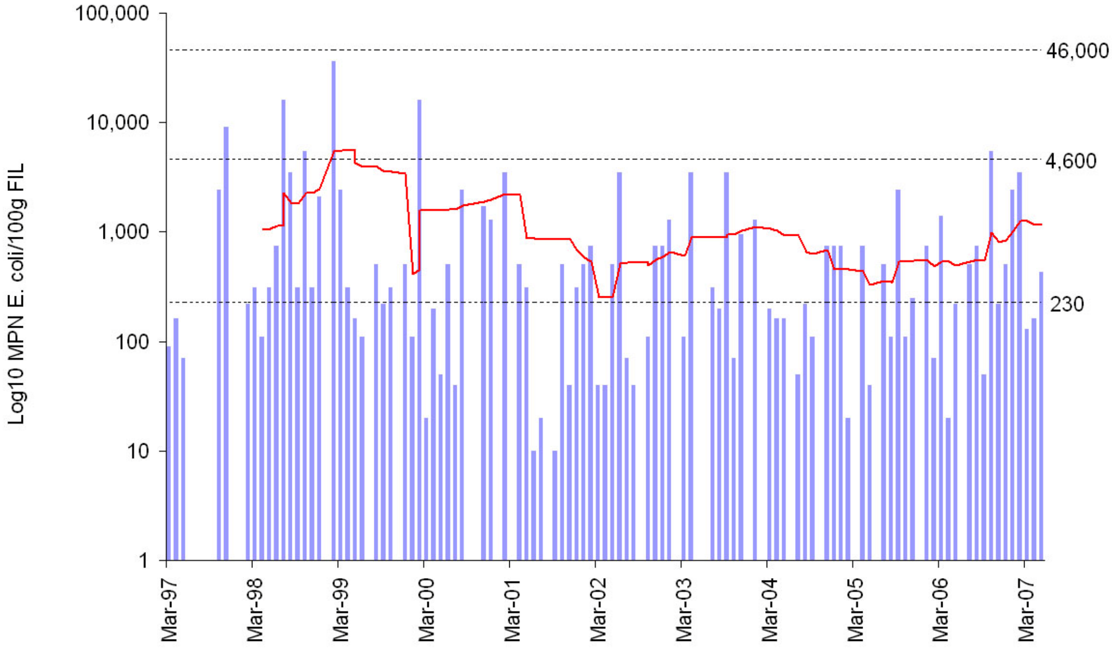

Figure 28. Time series of levels of* E. coli *and 12 sample moving average (red line) in mussels from Groyne Point (B034H).

Porth Navas

The levels of *E. coli* in native oysters (B034E) and mussels (B034J) from Porth Navas are presented in Figures 29 and 30 below.

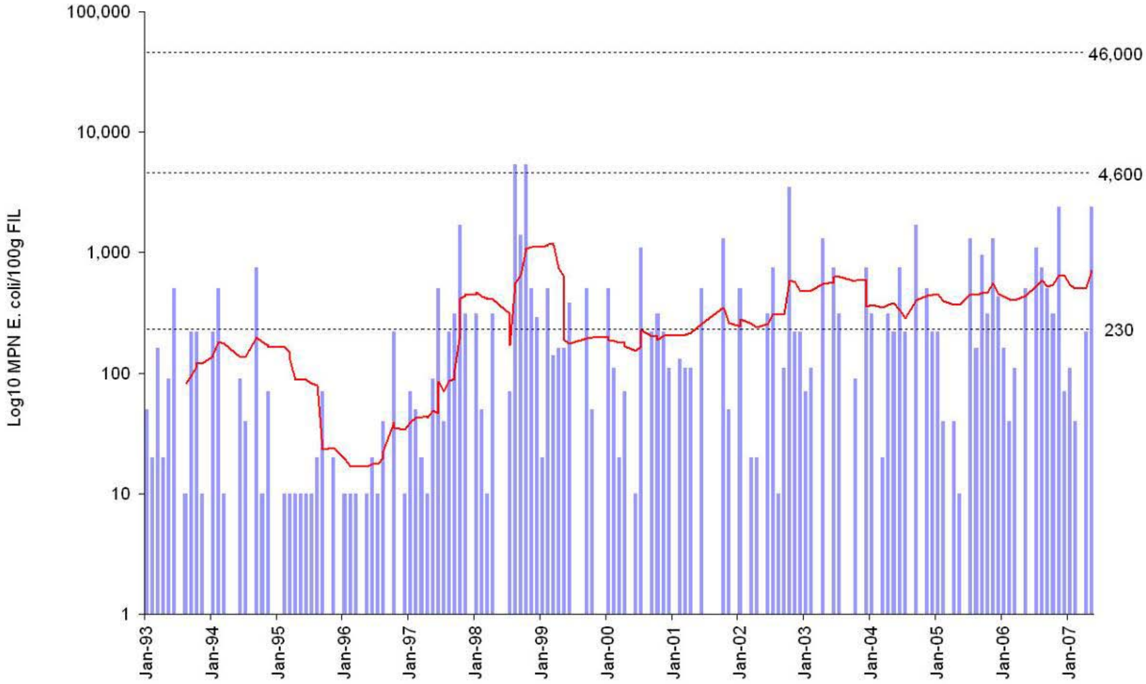

Figure 29. Time series of levels of* E. coli *and 12 sample moving average (red line) in native oysters from Porth Navas (B034E).

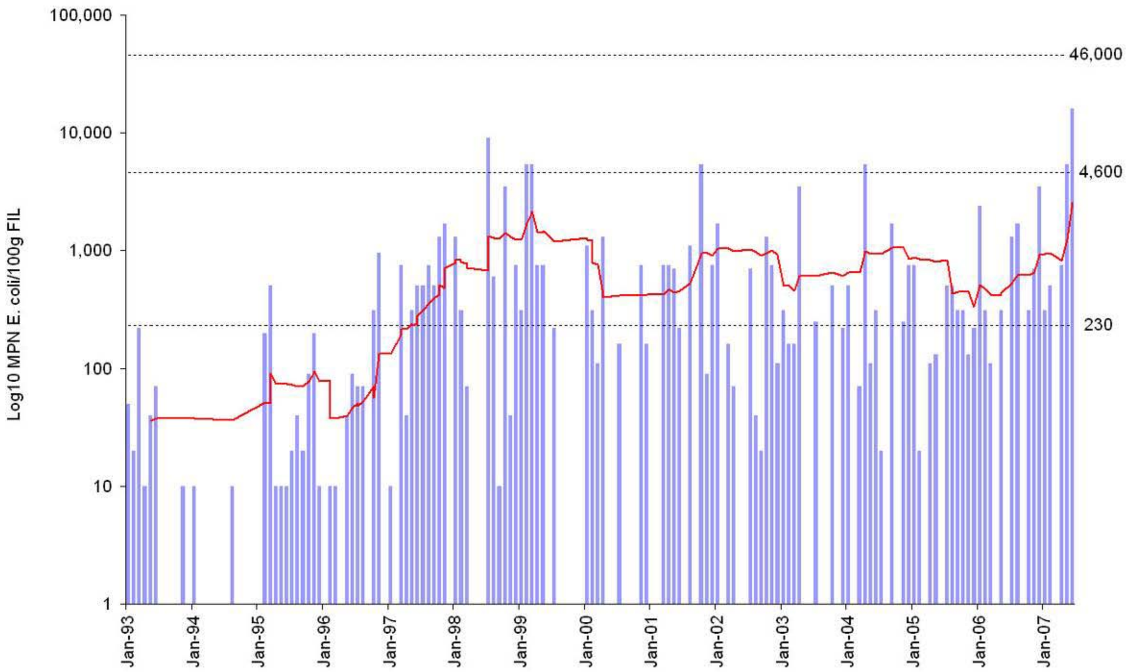

Figure 30. Monthly variation and 12 sample moving average (red line) in the levels of E. coli in mussels from Porth Navas (B034J).

The moving averages for the Porth Navas beds show an increasing tendency in the levels of contamination during the last 10 years. Pacific oysters from Porth Navas (B034N) have been monitored since February 2006, *E. coli* ranging between <20 MPN 100 g^{-1} FIL and 1,300 MPN 100 g^{-1} FIL (May 2007).

Rosehill

The levels of *E. coli* in mussels (B034F) from Rosehill Relaying site are presented in Figure 31 below.

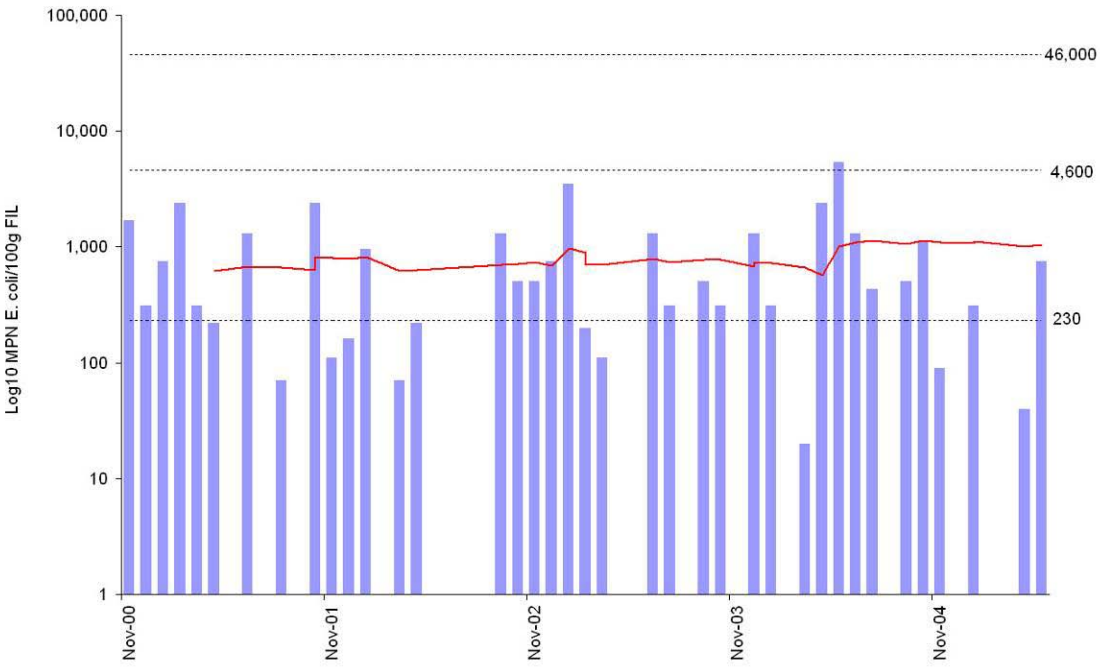

Figure 31. Time series of levels of* E. coli *and 12 sample moving average (red line) in mussels from Rosehill Relaying site (B034F).

Variation in geometric means

With reference to Figure 32 below, in general annual geometric means of *E. coli* from all sites are below 1,000 MPN 100^{-1} FIL with the exception of mussels at Porth Navas (B034J) in 2007, which has a geometric mean of 1,586 MPN 100^{-1} FIL (based on data from the first six months of 2007 only). Geometric means for the last two complete years of data (2005 and 2006) for all sites currently monitored in the Helford were all below 310 MPN 100^{-1} FIL for oysters and 470 MPN 100^{-1} FIL for mussels.

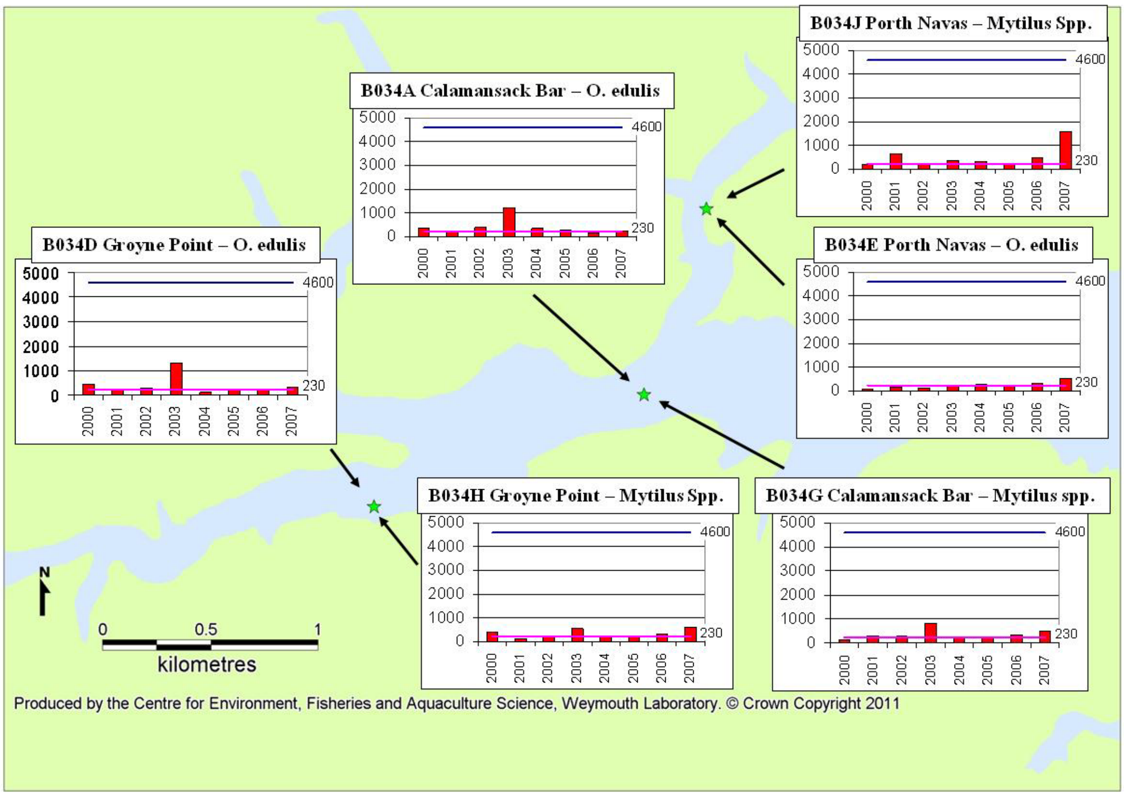

Figure 32. Variation of annual geometric means of* E. coli *in shellfish from Calamansack Bar between 2000 and 2007.

2.6.1.2 Classification Status

The historical classification status of shellfish beds between 1993 and 2007 are summarised in the Table 10. All beds classified in the last three years, with the exception of Native oysters at Groyne Point, have been classified as B_{LT} (long term category B)[6], reflecting a relatively stable range in the results from monitoring at these sites and hence levels of contamination at these locations within the harvesting areas. Native oysters at Groyne Point showed an improving trend from category C to B^{LT} over this period.

[6] As from 1st September 2006 there are two classification systems in place in England and Wales. The first is the annual or 'temporary' classification system. The second is the long-term (LT) classification system, which applies to class B sites only. New areas will initially be given annual classification until they meet criteria for a long-term classification.

The current production areas and classification status of mussel and oyster beds have been given in Figures 4–6. All beds are classified as category B and as such require a post-harvest treatment by means of depuration, relaying or cooking by an approved method before being sold for human consumption.

Table 10. Historical classification status of shellfish production beds in the Helford Estuary between 1993 and 2007.

Bed ID		B034A	B034G	B034D	B034H	B034E	B034J	B034F
Bed name		Calam-ansack Bar	Calam-ansack Bar	Groyne Point	Groyne Point	Porth Navas	Porth Navas	Rosehill Relaying Site
Species		*O. edulis*	*Mytilus* spp.	*O. edulis*	*Mytilus* spp.	*O. edulis*	*Mytilus* spp.	*Mytilus* spp.
	1993	B	B	–	A	A	–	–
	1994	B	–	B	–	A	A	–
	1995	B	–	B	–	A	A	–
	1996	B	–	B	–	A	A	–
	1997	B	–	B	–	A	A	–
	1998	B	–	B	–	B	B	–
	1999	C/B	C/B	C	C	B	C	–
Year	2000	B	B	C	C	B	B	–
	2001	B	B	C	C	B	B	–
	2002	B	B	B	B	B	B	–
	2003	B	B	B	B	B	B	–
	2004	B	B	C	B	B	B	–
	2005	B^{LT}	B^{LT}	C	B^{LT}	B^{LT}	B^{LT}	B
	2006	B^{LT}	B^{LT}	B	B^{LT}	B^{LT}	B^{LT}	n/c
	2007	B^{LT}	B^{LT}	B^{LT}	B^{LT}	B^{LT}	B^{LT}	n/c

^{LT}-Long Term. n/c-not classified.

One-way Analysis of Variance (ANOVA) was performed on *E. coli* results from six RMPs in the Helford Estuary to test for seasonality. Data for complete years with more than six samples from 2003 onwards was analysed by month and by grouping data by season. Seasons were selected by grouping results from the following periods: spring (March–May); summer (June–August); autumn (September–November); winter (December–February). The defined null hypothesis was that there are no differences in the levels of contamination by month or by season.

Figure 33 presents box-plots after grouping data by season. These graphs are frequently used to assess and compare sample distributions of microbiological data and are generally composed by a median line or the middle of the data, the bottom box, which indicates the first quartile value (25% of the data values are less than or equal to this value), the top box, which indicates the third quartile (75% of the data values are less than or equal to this value), the lower whisker or lower limit and the upper whisker or the highest data value within the upper limit. Outliers (unusual large or small values) are represented as asterisk.

Median values of Log_{10} MPN of *E. coli* in Native oysters from Calamansack Bar (B034A) increased from 1.9 [number of samples (N) = 38)] in spring months to 2.7 (N = 40) in autumn months. This difference was higher in Native oysters from Porth Navas, where median values of Log_{10} MPN of *E. coli* increased from 1.3 (N = 41) to 2.3 (N = 43) in the same period and in Native oysters from Groyne Point, where median values of Log_{10} MPN of *E. coli* increased from 2 (N = 26) to 3.2 (N = 24) in the same period.

In both the seasonal and monthly ANOVA analysis, the calculated F test values were higher than critical F tabulated ones at the 95/99% level of confidence for native oysters from Calamansack Bar (B034A) and Porth Navas (B034E), thus leading to the rejection of the null hypothesis (data not shown). Similarly, calculated F test values were higher than critical F tabulated ones in native oysters from Groyne Point (B034D). Therefore, statistically significant higher levels of contamination were observed in the summer, autumn and winter months compared to spring in these beds.

Monthly geometric means were also calculated by grouping *E. coli* levels. The number of samples with MPN *E. coli* $100g^{-1}$ FIL > 4,600 were plotted with monthly geometric means for reference. The results are consistent with ANOVA results undertaken for Native oysters from Calamansack Bar (B034A) and Porth Navas (B034E) (not presented here). Both representations corroborate the seasonal increasing trend in the levels of contamination in oysters from spring to autumn detected in the seasonal analysis (Figure 34). In addition, months with the highest number of results > 4,600 *E. coli* 100 g^{-1} FIL are coincident with the highest geometric means of *E. coli* in beds presenting seasonality in the levels of contamination.

Whilst seasonal differences are evident from both analyses, they are restricted to Native oysters. The closed season for this species (see Section 2.2.8) generally corresponds to an intermediate period between the lowest and highest levels of contamination. The closed season lasts approximately two and a half months. Whilst in principle consideration could be given to reducing the sampling frequency during a closed period, in practise monitoring would need to recommence two months prior to the start of the harvesting season to be protective of public health and therefore would not be worthwhile in this instance.

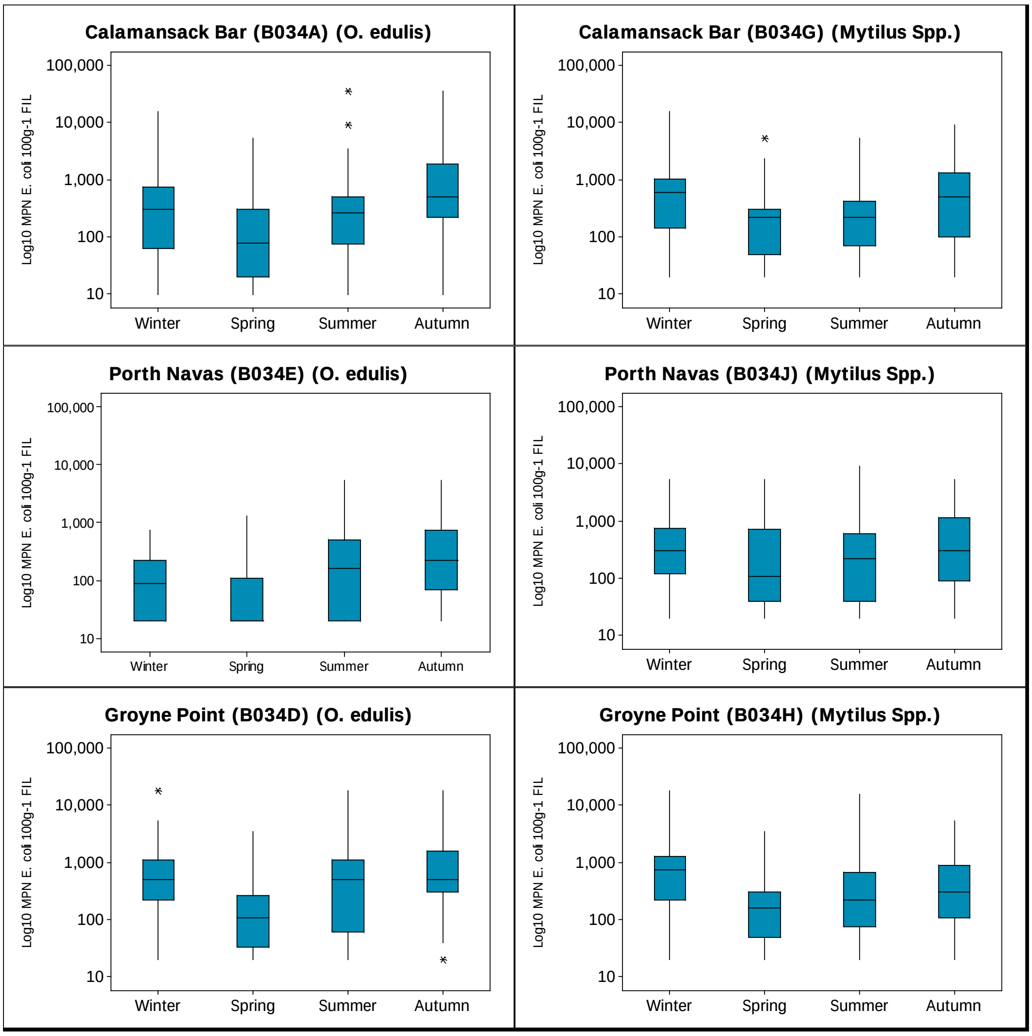

Figure 33. Seasonal variation of* E. coli *in shellfish from three beds in the Helford Estuary.

See Table 11 for the date periods relevant to each bed.

Table 11. Data periods used for analysis of seasonal variation of* E. coli *in shellfish in six monitoring points in the Helford Estuary.

Bed Name	RMP ID	Species	Data Date Period
Calamansack Bar	B034A	*O. edulis*	1993-2006
Calamansack Bar	B034G	*M. edulis* spp.	1997-2006
Groyne Point	B034D	*O. edulis*	1998-2006
Groyne Point	B034H	*M. edulis* spp.	1998-2006
Porth Navas	B034E	*O. edulis*	1993-2006
Porth Navas	B034J	*M. edulis* spp.	1995-2006

Only years yielding at least six samples were selected.

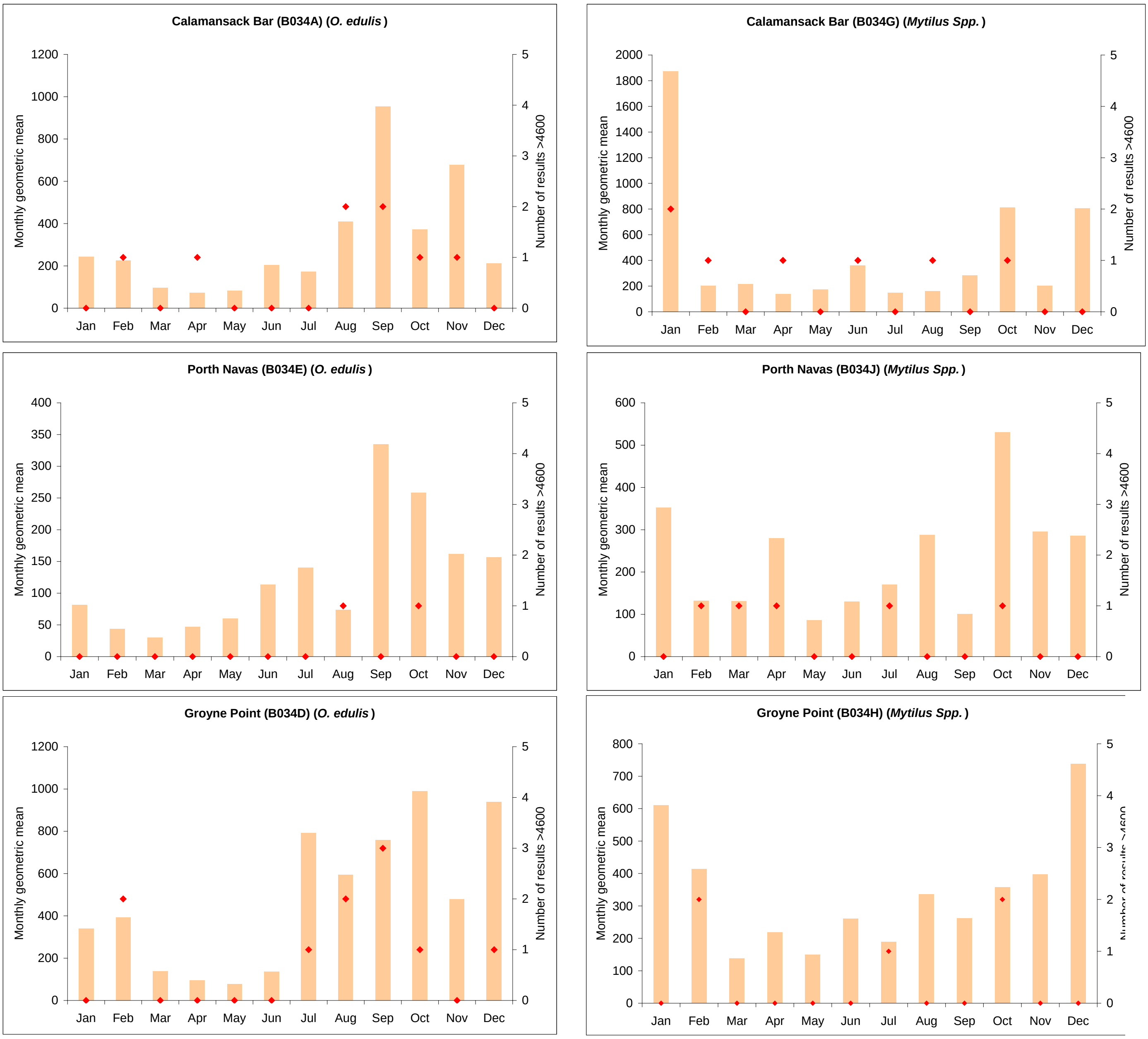

Figure 34. Monthly geometric mean variation of* E. coli *in shellfish from three beds in the Helford Estuary.
See Table 11 for the date periods relevant to each bed.

2.6.2 Microbiological data from the Shellfish Waters Directive monitoring programme

Monitoring points for surface water and shellfish flesh samples undertaken for the purposes of the Shellfish Waters Directive are shown in Figure 35.

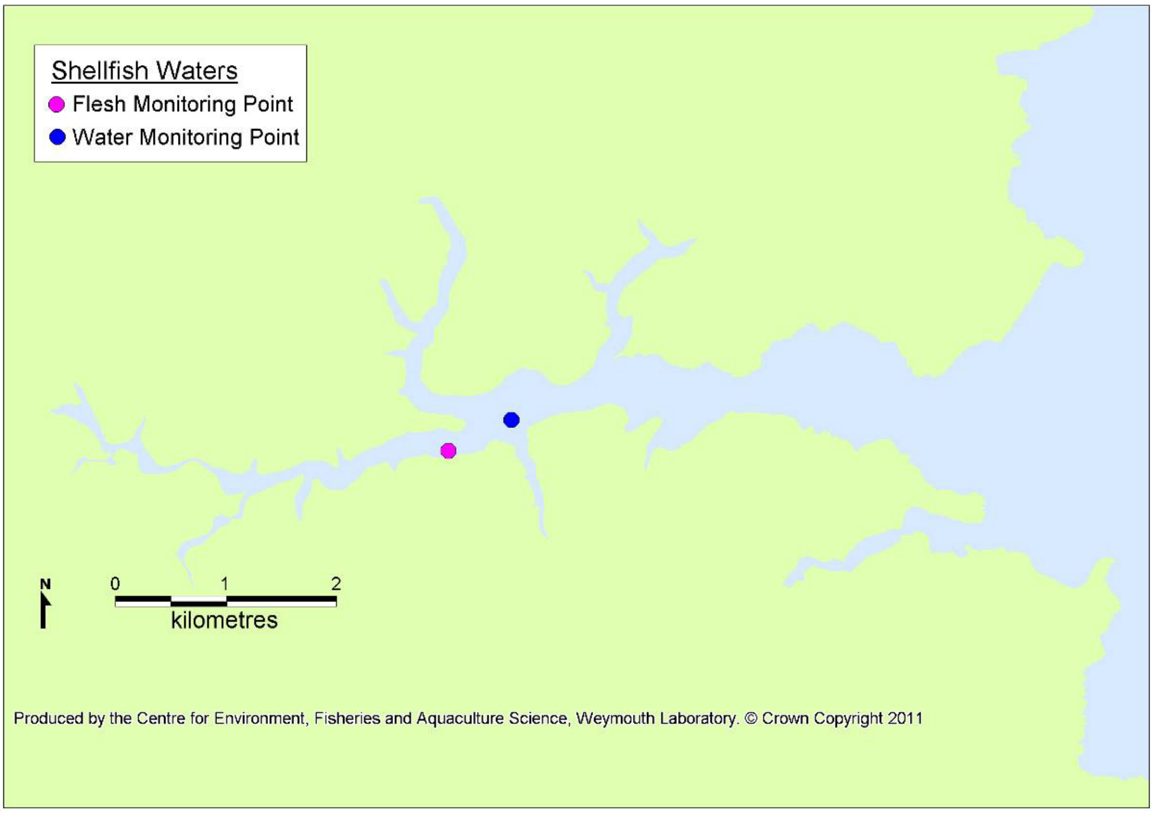

Figure 35. Monitoring points for Faecal coliform water and flesh under the Shellfish Waters Directive in the Helford Estuary.

Faecal coliforms in shellfish flesh are monitored by the EA against a guideline standard of 300 CFU 100 ml^{-1} (in 75% samples) in the Shellfish Waters Directive. However, only a very limited amount of flesh data is available. A comparison between levels of faecal coliforms in shellfish flesh for the purposes of shellfish waters monitoring and *E. coli* for the purposes of shellfish hygiene monitoring is presented in Table 12. There is some inconsistency in the results observed between these monitoring programmes in some sample analyses. Faecal coliform results undertaken for the purposes of the Shellfish Waters Directive were higher than the corresponding *E. coli* analyses required under the hygiene legislation, whilst in other samples no differences were observed.

The EA have also collected some faecal coliform data from the water monitoring point, although this is not required for Directive reporting purposes. These data are presented in Figure 36. The results indicate relatively low levels of contamination at the water sampling point with over 50% of the results less than 10 CFU 100 ml^{-1}. Salinity values recorded simultaneously at the monitoring point are typically within the range 30 ppt to 35 ppt indicating that, at the time of sampling, there is little freshwater influence on levels of contamination.

Table 12. Comparison of levels of faecal coliforms (shellfish waters monitoring) and* E. coli *(hygiene monitoring) in bivalve samples collected from Groyne Point between February and November 2002.

Date	Shellfish Species	CFU faecal coliforms 100g^{-1}	MPN *E. coli* 100g^{-1}
12 Feb 02	*Mytilus* spp.	750	50
12 Feb 02	*O. edulis*	1300	500
11 Jun 02	*O. edulis*	3500	500
21 Aug 02	*Mytilus* spp.	70	40
21 Aug 02	*O. edulis*	40	40
19 Nov 02	*Mytilus* spp.	750	750
19 Nov 02	*O. edulis*	500	500

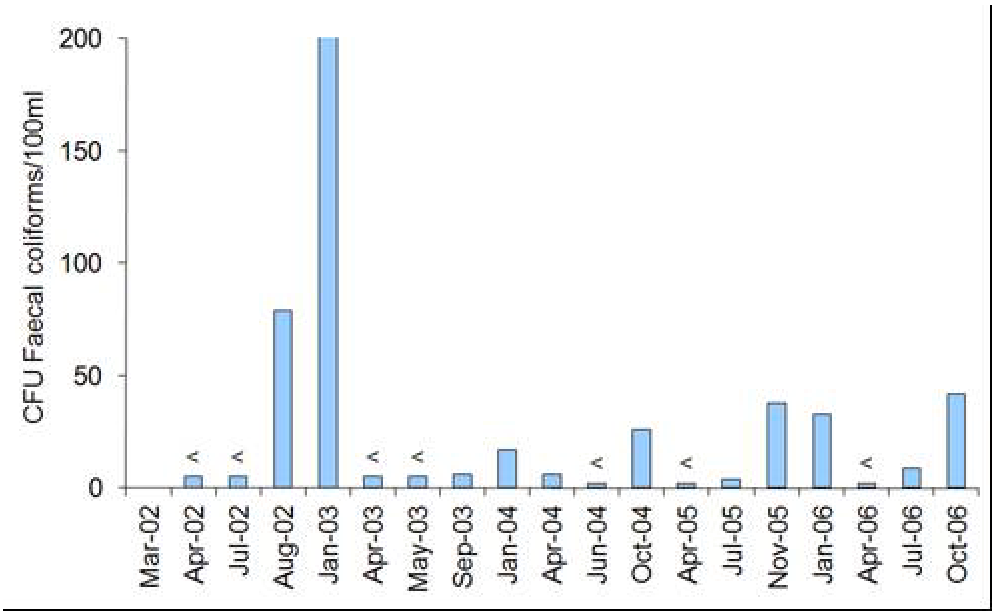

Figure 36. Variation of faecal coliform levels at the shellfish waters monitoring site in the Helford Estuary (< indicates that the result was less than 10 CFU per 100 ml).

2.6.3 Microbiological data from the bathing waters monitoring programme

There are no bathing waters within the Helford Estuary. The nearest bathing waters are at Mawnan Smith to the north and Maenporth (Figure 1) to the north and Porthallow to the south of the estuary mouth. Both these sites have reflected 'Excellent'[7] surface water quality from monitoring undertaken in the bathing season[8] from 2000 to 2007. Concentrations of microbiological indicators obtained in the 2006-bathing season at Maenporth Beach for three microbiological indicators were below 100 CFU 100 ml^{-1} in most of the peak season (Table 13). These results highlight the low likelihood of significant contamination inputs from seaward, reflected in the bathing water 'excellent' classifications over the longer term.

[7] Excellent- 80% compliant with the Shellfish Waters Directive, faecal coliform guideline standard of =/< 100 per 100ml and 90% compliant with a UK *Faecal streptococci* standard of =/< 100 per 100ml.

[8] The bathing season runs from the 15 May to 30 September.

Table 13. Variation of concentrations (CFU 100 ml^{-1}) and statistics for bacteriological indicators quantified in seawater from Maenporth Beach in 2006.

Month	Total coliforms			Faecal coliforms			Faecal streptococci		
	Min-Max	Median	Geometric mean	Min-Max	Median	Geometric mean	Min-Max	Median	Geometric mean
May	<10-27	10	14	<2-20	2	4	<2-23	10	8
June	<10-27	10	13	<2-15	7	5	<2-32	2	4
July	<10-220	72	59	6-126	34	32	4-64	10	12
August	<10-81	19	21	2-36	26	12	<2-52	9	10
September	126	–	–	94	–	–	82	–	–

2.6.4 Microbiological data from bacteriological surveys

Under the Cycleau Project, the EA and the University of Exeter undertook a comprehensive characterisation of water quality in the Helford Estuary catchment. All major tributaries were routinely monitored (sampled on a monthly basis) between June 2004 and May 2006 (Figure 37). A number of surveys were also carried out during wet weather conditions. Water samples were analysed for four faecal indicator microorganisms (total coliforms, faecal coliforms, *E. coli* and faecal streptococci). Total bacteriological loadings from the major tributaries of the Helford Estuary were estimated based on river flow data presented in section 2.5.2 (cf. Table 6; Figure 21).

In most of the sites sampled during routine monitoring, the bacterial loadings of faecal indicator microorganisms were bellow 10^{12} CFU d^{-1}, whereas bacterial loadings in the same sites were above that level during wet weather conditions. The results from routine monitoring also indicated that Gweek River is the main contributor of faecal indicator microorganisms to the estuary. The total bacteriological loadings varied between 7 x 10^{10} CFU d^{-1} (Mawnan Smith Brook at Lower Penpoll) and 9 x 10^{12} CFU d^{-1} (Gweek River at Gweek Bridge) for total coliforms, 5 x 10^{10} CFU d^{-1} (Mawgan Creek at Trelowarren Mill Bridge and Mawnan Smith Brook at Lower Penpoll) and 8 x 10^{12} CFU d^{-1} (Gweek River at Gweek Bridge) for faecal coliforms, 3 x 10^{10} CFU d^{-1} (Mawnan Smith Brook at Lower Penpoll) and 1 x 10^{12} CFU d^{-1} (Gweek River at Gweek Bridge) for *E. coli* and between 6 x 10^{9} CFU d^{-1} (Helford Brook at D/S Helford Ford) and 2 x 10^{11} CFU d^{-1} (Gweek River at Gweek Bridge and Gweek River at U/S Gweek) for faecal streptococci (Figure 38).

Water samples from Gweek River at Gweek Bridge showed the highest difference between faecal coliforms and the more specific indicator of faecal contamination *E. coli*. However, water samples taken from the same river at U/S Gweek showed no differences between those faecal indicator microorganisms. This indicates that sources of contamination of faecal origin are located up river, where contamination from agricultural areas prevails. However, these differences were not apparent during wet weather conditions, in which Gweek River (both at Gweek Bridge and U/S

Gweek) and Helford River showed similar high bacterial loadings. The *E. coli* loadings in these tributaries were higher than 10^{13} CFU d^{-1} during wet weather. It is therefore not surprising that, in past years (1999–2001), native oysters and mussels from Groyne Point achieved class C since this is clearly the result of the cumulative effect of inputs of contamination located at the head of the estuary.

Other tributaries contributing with high bacterial loadings were Rosevear River, Manaccan Stream and, to a lesser extent, Lestraines River and the tributary of Mawgan Creek. Of these tributaries, only Mawgan Creek is not located at the head of the estuary. These results again highlight the main contributions of faecal contamination from the head of the estuary and bivalves in the upper reaches of the estuary could be vulnerable to contamination from these sources. The impact of these sources on the levels of contamination in BMPAs further down the estuary greatly depends on the effect of wind and tide, as discussed in sections 2.3.4 and 2.5.5. Given the effect of prevalent southwesterly winds, there may be the potential for beds further downstream to be affected under certain conditions. Contrarily, giving the pattern of winds and lower resident times of water in Bosahan Cove, it is unlikely that Pacific oysters would be negatively affected by bacterial loadings from Manaccan Stream.

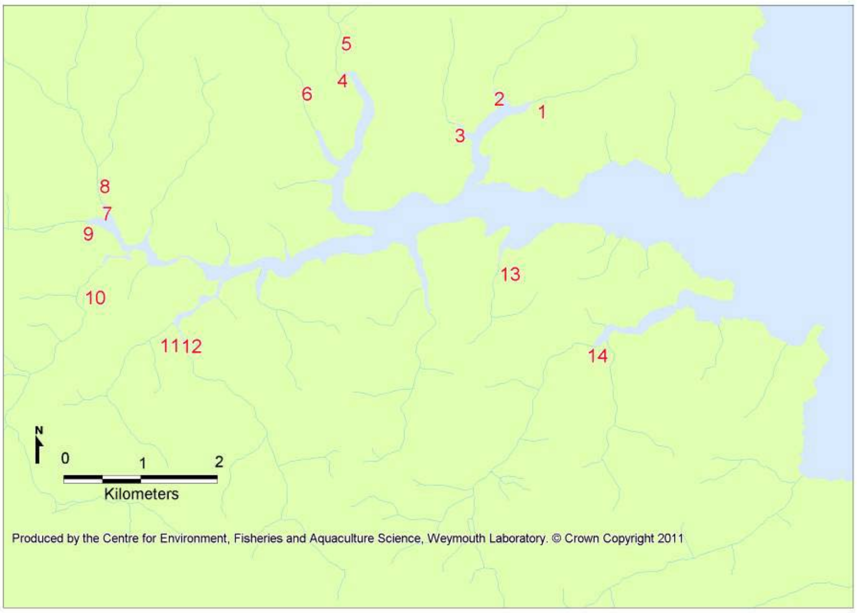

Figure 37. Location of sampling points in the major tributaries of the Helford Estuary.

A microbial source tracking study aimed to estimate the impact of bacterial contamination from Gweek River on the bacteriological quality of shellfish also concluded that Gweek River is the largest contributor of contamination to the estuary (Cycleau Project, 2006). Levels of contamination of this stream with *Bacillus subtilis* dosed on 5 June 2006 varied between 1.27 x 10^{13} CFU and 2.24 x 10^{13} CFU. In oysters, this bacterium reached a maximum concentration of 2,700 CFU $100g^{-1}$ in Frenchman's Creek and Porth Navas.

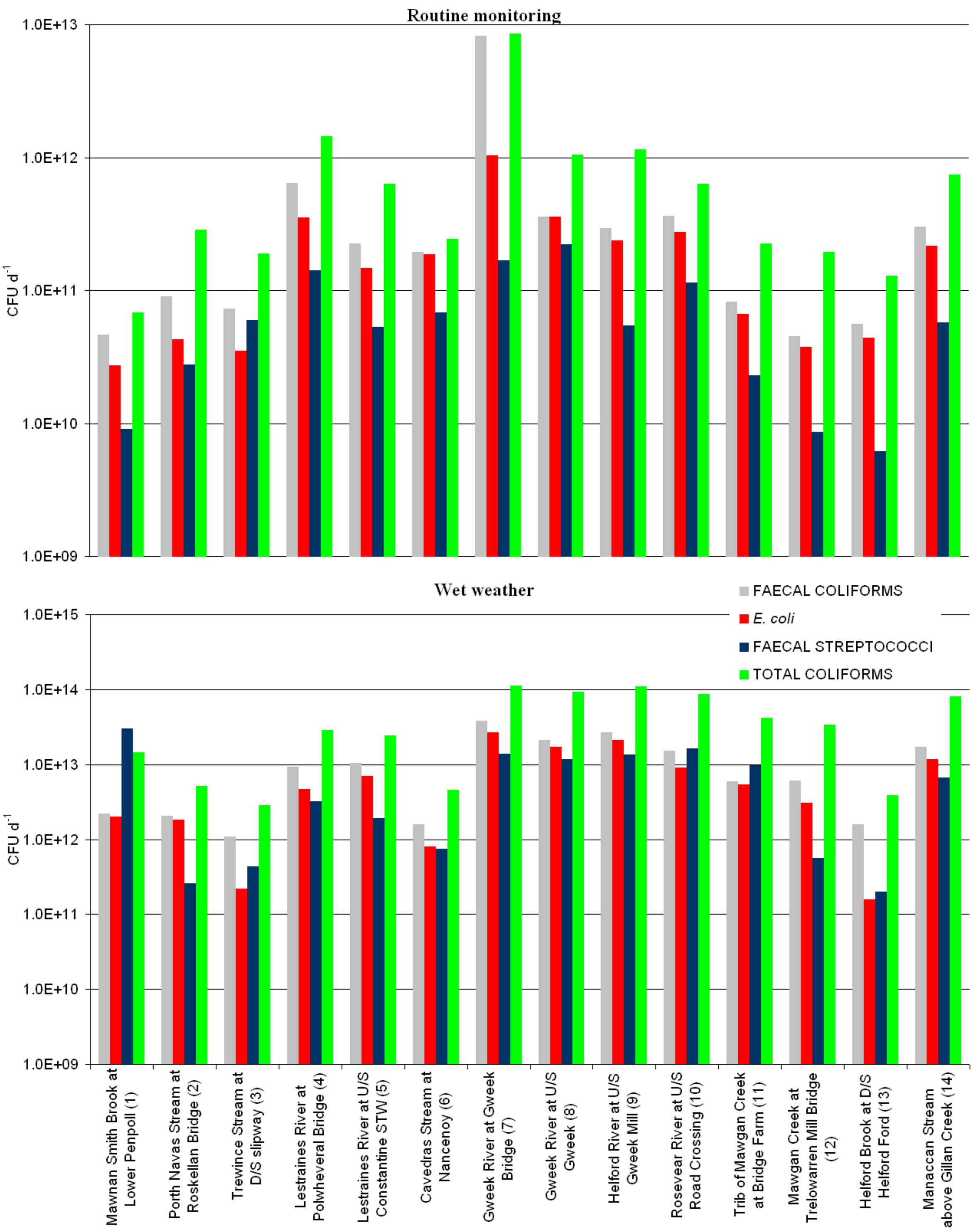

Figure 38. Total bacteriological loadings from the major tributaries of the Helford Estuary.

Scale minimum 1.0E+09 = 1,000,000,000

Scale maximum 1.0E+15 = 1,000,000,000,000,000

Data from the Cycleau Project (2006).

See Figure 36 for locations.

2.6.5 Preliminary sampling results from Bosahan Cove

A bag containing Pacific oysters was suspended from ‘The Voose’ north cardinal mark off Bosahan Cove (Figure 7). Five samples were taken during 2007 for quantification of *E. coli* and the results are shown in Table 14.

Table 14. Results for* E. coli *quantified in Pacific oysters from Bosahan Cove.

Collection date	MPN *E. coli* 100 g^{-1}
22 January	160
13 March	40
09 May	310
12 June	5400
06 August	110

The range of values indicates a low underlying level of contamination. The result of 5,400 on 12 June suggests that this site may be negatively affected by intermittent episodes of microbiological contamination possibly from localized streams.

3 SHORELINE SURVEY

3.1 GENERAL

Date of survey	4th April 2007	
Production Area	Helford Estuary	
Area(s) surveyed	see Figure 39	
Commercial Species	Bosahan Cove	Pacific oysters (*C gigas*)
	Wider estuary	Mussels (*Mytilus* sp.) Pacific oysters (*C. gigas*) Native oysters (*O. edulis*)
Harvester(s)	Duchy of Cornwall Oyster Farm	
Local Authority	Falmouth Port Health Authority	

On the 4 of April 2007, staff from the Cefas Weymouth Laboratory and Falmouth & Truro Port Health Authority performed a shoreline survey in the Helford Estuary. The aim of the survey was to confirm the presence of potential sources of microbiological pollution previously identified as part of a desk study and to identify any additional potential sources of contamination in the area surveyed.

Tidal conditions

The survey took place between 12:10 and 16:00. This period coincided with the lower half of the tidal range according to the tidal curve for the day (Figure 39).

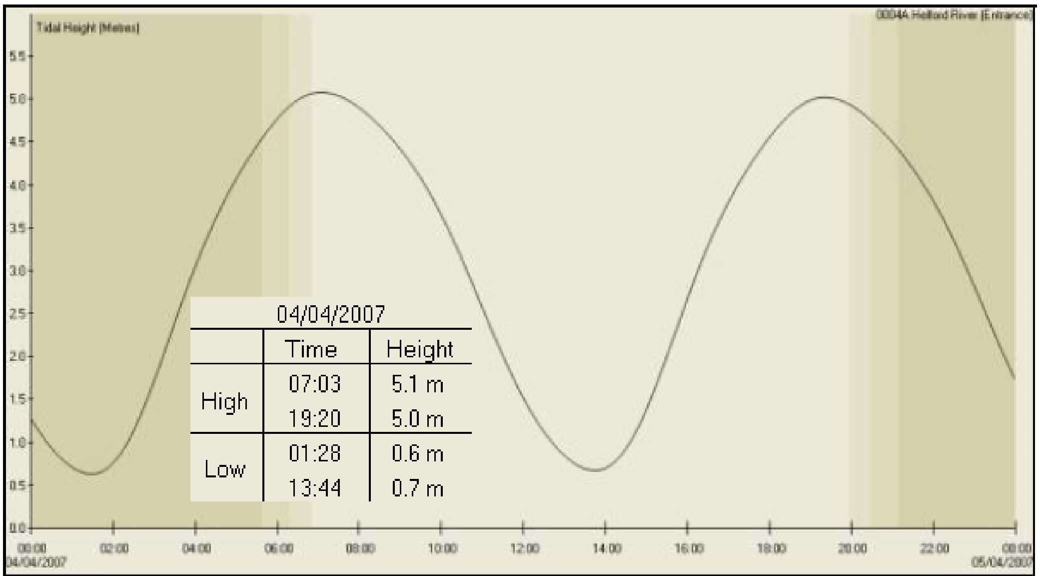

Figure 39. Tidal curve at the entrance of the Helford Estuary on the 4th April 2007. Prediction based on Plymouth (Devonport). Admiralty TotalTide (UKHO, 2007). *Crown copyright and /or database rights. Reproduced by permission of Her Majesty's Stationery Office and the UK Hydrographic Office.*

Area surveyed

The principal focus of the survey was the vicinity of the new shellfish harvesting area at Bosahan Cove. Two main areas were surveyed from Durgan Village to the western limit of Helford Passage, on the northern shoreline and from Helford to the streams at Condurrow, in the southern shoreline (Figure 40).

Figure 40. Area surveyed (red line).

Weather

The weather was dry and sunny with a northwest wind Beaufort force 3–4 from the northwest (13 knots at 13:00).

3.2 RESULTS

Sewage related debris

All the areas surveyed were noted to be very clean, without evidence of sewage related debris.

Boats

Sailing boats were seen to be mostly concentrated between Porth Navas Creek and Helford Passage (Figure 40). Helford Passage is a small village of holiday cottages, from where the Helford River Boats operate for boat hire, ferry services and moorings. More than 60 boats were moored off Helford Passage. There is a small slipway at Durgan. However although there are several moorings could be seen in the bay, no boats were observed moored at the time of the survey. About 20 moored boats were observed in Helford Creek, east of Helford Point (Figure 41).

Figure 41. Moored boats off Helford Passage.

Figure 42. Moored boats in Helford Creek.

Land use and animals

Opposite the proposed Pacific Oyster operation at Bosahan Cove there is a small village at Durgan, surrounded by woodland, grassland and arable land uses, frequently visited by tourists and visitors from the Trebah and Glendurgan Gardens, located within about 500 m of the village centre. Cattle grazing (12 animals) were evident in the field adjacent to the coast above Helford passage (Figure 43).

Figure 43. Cattle grazing above Helford Passage.

A rocky shore limits this grassland to its south and no streams were identified in the area that would connect field runoff directly to the estuary. On the south side of the outer estuary from Threath to Bosahan Cove, fields growing maize and daffodils are separated from the coast by woodland areas. No evidence of manure spreading was observed at the time of survey however there is evidence of previous runoff into the Cove from one of the maize fields via a small gully, Figure 46G1. The presence of woodland birds at Bosahan Cove was noted. No other animal impacts were registered in the vicinity of Bosahan Cove.

Other observations

A line of concentrated foam and detritus extending up the estuary during the early flood phase of the tide was photographed from Bosahan Cove (Figure 44). This feature, a result of converging water masses, evidences the presence of tidal fronts in the Helford Estuary.

Figure 44. View of a tide-line (convergent front) in the Helford Estuary.

Sampling Results

Sampling took place under dry weather conditions. Nine samples of water were collected from selected piped discharges and streams for quantification of *E. coli*. Additional measurements of temperature and conductivity were also made in those sites by using a WTW Cond197i conductivity/salinity meter. No shellfish samples were collected at the time of the survey as it was understood that the local food authority is already collecting samples from bagged oysters established by 'The Voose' north cardinal marker just off the Cove.

The coordinates and descriptions of sites (A-I) sampled are given in Table 15 and the locations are shown in Figure 45.

Table 15. Coordinates and descriptions of sites sampled during the shoreline survey.

Site	Coordinates		Description	Flow
	Eastings	*Northings*		
A	177302	027291	Culverted watercourse under sea wall at Durgan	Trickle
B	176867	027003	Culverted watercourse on beach at Polgwidden Cove	Trickle
C	176416	026938	Pipe in rocks east Passage Cove (dirty)	Trickle
D	176315	026926	Pipe under sea wall at west Passage Cove	Trickle
E	176495	026416	Stream north of Treath	Trickle
F	177201	026326	Stream into Padgagarrack Cove	Trickle
G	177201	026327	Pipe west of Bosahan Cove	Trickle
H	177355	026273	Stream into Bosahan Cove	Trickle
I	177724	026115	Stream at Ponscence Cove	Trickle

Figure 45. Area surveyed including locations of sites sampled in the Helford Estuary.

Samples were taken from piped discharges at Durgan (Figure 46 A), Polgwidden Cove (Figure 46 B) and Passage Cove (Figure 46 C, D). In addition, five streams were sampled between Treath (Figure 45 E) and Ponsence Cove. Three of these streams are in the vicinity of Bosahan Cove. All discharges were noted to have low flows and were clear in appearance with the exception of Site C.

The sampling results are shown in Table 16.

Figure 46. Sites sampled during the shoreline survey.

Table 16.* E. coli *and physico-chemical parameters in samples from watercourses and pipes collected at the time of the shoreline survey.

Site	Name	Temperature (°C)	Conductivity (µS)	MPN E. coli 100 ml^{-1}
A	Pipe under sea wall at Durgan	10.7	369	>10,000
B	Piped watercourse on beach atPolgwidden Cove	11.5	418	10
C	Pipe in rocks east Passage Cove (dirty)	10.3	501	<10
D	Pipe under sea wall at west Passage Cove	11.6	347	5,700
E	Stream north of Treath	–	–	2,600
F	Stream into Padgagarrack Cove	–	–	10
G	Pipe west of Bosahan Cove	9.7	436	10
H	Stream into Bosahan Cove	9.8	446	<10
I	Stream at Ponsence Cove	9.6	601	<10

The piped discharge at Durgan (Site A), despite being of low flow, contained high numbers of *E. coli* (>10,000) and the pipes under the sea wall just in the west of Passage Cove and the stream north of Treath contained relatively high numbers of *E. coli* (5,700 and 2,600 respectively). These could represent septic tank discharges. The stream north of Traeth lies about 0.7 km to the west of Bosahan Cove and discharges in the vicinity of the cockle bed where recreational trigging of bivalves takes place.

Localised streams in the vicinity of Bosahan Cove were not contaminated when sampled in dry weather (Table 16) but could represent a source of contamination in wet weather.

Further considerations and recommendations are given in the overall assessment (see Section 4).

4 OVERALL ASSESSMENT OF POLLUTION SOURCES ON THE MICROBIOLOGICAL CONTAMINATION OF BIVALVE MOLLUSC PRODUCTION AREAS

4.1 Qualitative assessment

4.1.1 The Helford Estuary is located in a rural catchment, mostly used for agricultural purposes. Most of the catchment has a dispersed human settlement pattern of small villages, but with a significant seasonal influx of tourists. The information analysed for producing this report indicates that, in general, the main contributions of pollution likely to be a source of microbiological contamination for BMPAs come from continuous and intermittent discharges concentrated in Constantine, Gweek and Helford and non point sources associated with agricultural land use, notably areas used for livestock production, and tourism activities.

4.1.2 In order to detect possible changes in the levels of contamination in bivalves arising from the sewage treatment works near Helford Point (and associated pumping station discharges), it is proposed to maintain the current RMP at Helford Point.

4.1.3 The geometric means of *E. coli* from the shellfish microbiological monitoring programme in the Helford show a higher frequency of elevated levels of faecal contamination in mussels relative to those in native oysters. This has been observed in other studies but it is not clear if this is due to biological differences, site specific growing conditions or a combination of both.

4.1.4 The extent and seasonality of contamination can vary according to the species of bivalves produced, location of the beds relative to the sources of contamination, water movement characteristics and environmental factors. In this assessment, it was not possible to derive strong correlations between environmental factors and the levels of *E. coli* in bivalves. This reflects the complexity of environmental factors involved and/or lack of detailed information in some cases. The weak correlations obtained between *E. coli* and rainfall limit the use of this parameter in predicting the levels of contamination in the Helford Estuary.

4.1.5 Whilst improvements in the levels of microbiological contamination in mussels were observed following the introduction of tertiary sewage treatments (ultraviolet disinfection) at Constantine STWs in August 2002, no such improvement was observed for native oysters. This highlights the importance of monitoring more than one species for mixed fisheries.

4.1.6 Data from bacteriological surveys performed in the Helford catchment area indicate that the main bacterial inputs affecting the bivalves came from the Gweek River, Mawgan Creek and, to a less extent, Frenchman's Creek. Relatively high results of *E. coli* have been historically quantified in mussels and native oysters from Groyne Point. Whereas the RMP at Trelean has monitored the impact of the first, this is not happening in the case of Frenchman's Creek. Therefore, the sampling plan presented as a result of this assessment (see Figure A1 and Table A1 in the Appendix) proposes the relocation of the RMP at Groyne Point to monitor inputs of microbiological contamination from the catchment area in the vicinity of this creek. In contrast, the intermediate parts of the estuary are geographically well covered by sampling points at Porth Navas, Calamansack Bar and Helford Point. In addition to agricultural runoff, this area is potentially affected by point sources of human origin from the Helford village. In addition to point sources, contamination from boats is more likely to occur in this area, where moorings are concentrated. Further work would be needed to evaluate the relative impact of this source of pollution in the levels of microbiological contamination in bivalves.

4.1.7 Despite the concentration of sources of pollution of human and animal origin between Helford Passage and Helford Point, the bathymetric characteristics and favourable tidal dynamics (these observed locally) are likely to favour the physical dispersion and dilution of contaminants. However, analysis performed on historical *E. coli* data showed an increase in the levels of contamination in Native oysters from Calamansack Bar, Porth Navas and Groyne Point between spring and autumn.

4.1.8 The shoreline survey performed two days before recreational harvesting (trigging) of bivalves, identified a stream discharging freshwater with concentrations of 2,600 *E.coli* 100 ml^{-1} FIL less than 25 m from the mussel bed and in the vicinity of a non-commercial cockle bed at Helford Point. This has potential implications for public health if these bivalves are not adequately cooked prior to consumption.

4.1.9 The new aquaculture operation for Pacific oysters at Bosahan Cove is located towards the mouth of the estuary on its southern side. Woodland areas, small beaches and rocky shores define the coastline in this area. No significant sources of contamination have been identified to the east of Bosahan Cove. The streams running to the estuary at Bosahan were sampled under dry weather conditions on the beaches during the shoreline survey and levels of *E. coli* detected in freshwaters were minimal. However, the shellfish flesh result of 5,400 *E. coli* 100 g^{-1} FIL returned from preliminary monitoring of bagged shellfish close to the Cove indicates there may the potential for these streams to deliver higher levels of contamination under some conditions. Depending on the results of future hygiene monitoring at this point this may require further investigation by the Local Action Group (see glossary).

4.1.10 Given that most sources of identified pollution are concentrated to the West of the proposed production area at Bosahan Cove the most vulnerable part of the area is likely to be the Northwest corner of the site which could be vulnerable to episodes of contamination either wind driven or tidally advected from further up the estuary.

4.1.11 A schematic showing the principal sources of microbiological pollution on the existing production areas and newly proposed production area off Bosahan Cove is presented for reference in Figure 47, along with the locations of the proposed representative monitoring points.

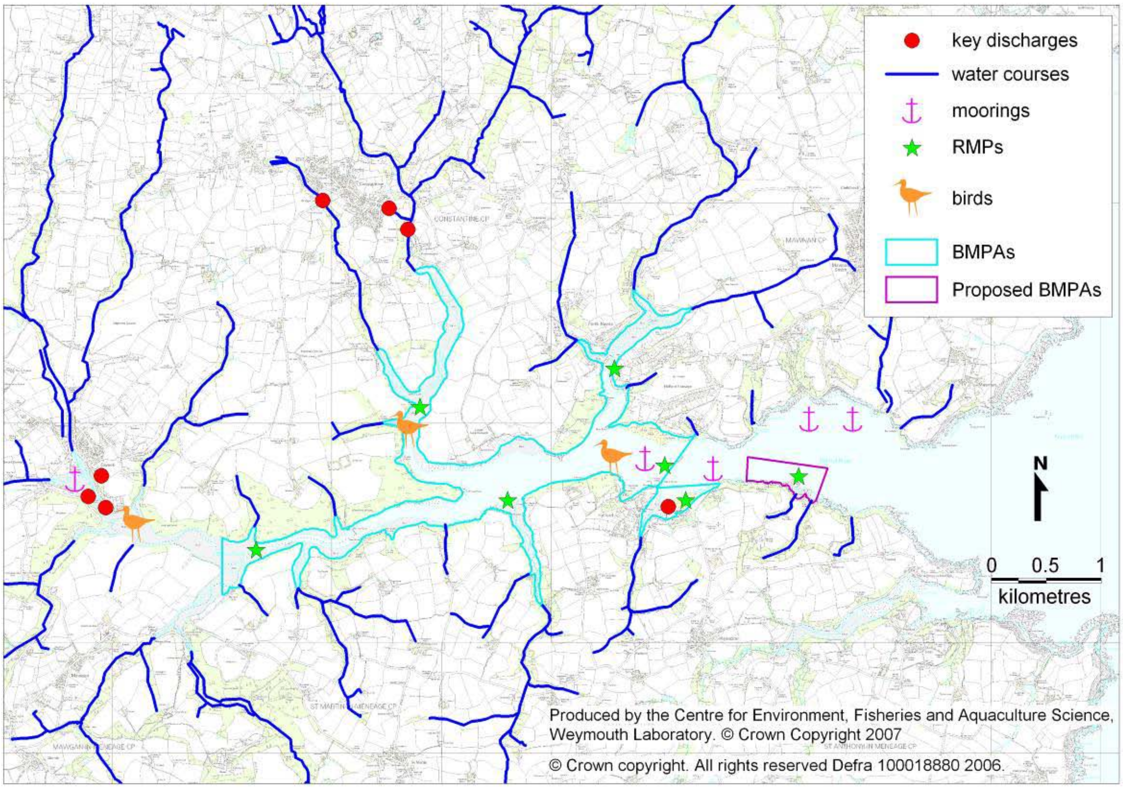

Figure 47. Overview of sources of pollution likely to affect the levels of microbiological contamination in bivalve molluscs in the Helford Estuary.

4.2 Review of bivalve mollusc production area boundaries/recommendation of boundaries for new bivalve mollusc production area

Boundaries for the new production of *C. gigas* at Bosahan Cove are shown in Figure 47 and detailed in the Table 17.

Table 17 . Boundaries for the new production area of C. gigas at Bosahan Cove, Helford Estuary.

	Coordinates (NGR)			
	From		To	
	Easting (m)	Northing (m)	Easting (m)	Northing (m)
Western boundary	177086	26436	177099	26679
Northern boundary	177099	26679	177512	26588
Eastern boundary	177512	26588	177404	26284
Southern boundary (Mean High Water Mark)	177404	26284	177086	26436

Given the information in the above assessment and the general positive assessment that could be made by using the checklist of questions on site suitability for bivalve cultivation defined by Laing and Spencer (2006), there is the potential to expand the production area of *C. gigas* to the East up to Ponsence Cove, in the future interest of the industry. If required, it is recommended that the Eastern and Southern boundaries of the production area could be extended to NGR SW17813626501 (Figure 48), without further assessment and/or definition of additional RMPs for the species.

The boundaries of existing BMPAs are shown in Figures 4–6. On the basis of the information presented in the report the boundaries of the existing areas have been reviewed and new boundaries are recommended which reflect more closely the areas in which harvesting takes place.

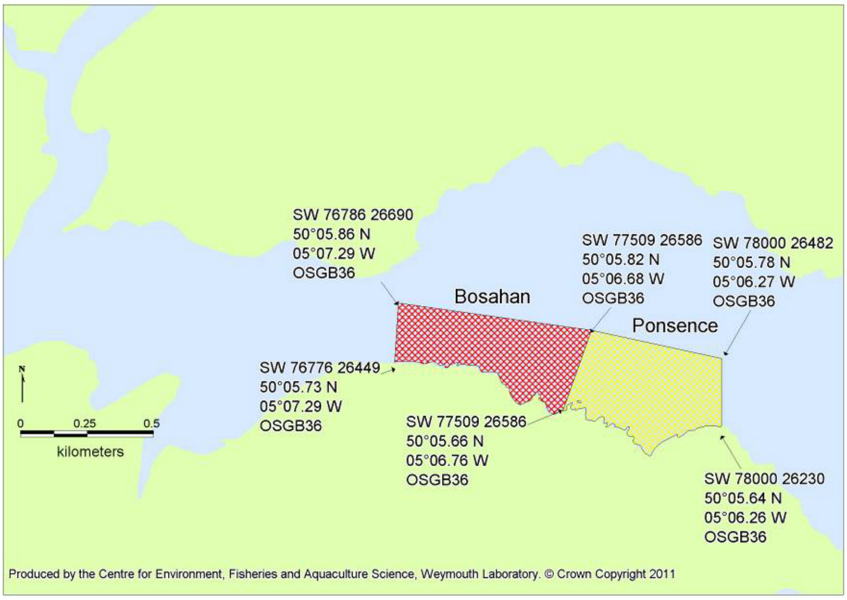

Figure 48. Boundaries for the new production area of C. gigas at Bosahan Cove (red area) and recommendation of boundaries for future expansion of the bed (yellow area).

Boundaries for the revised production areas in the wider Helford Estuary are shown in Figure 49 below. Previously, several of the wild beds were identified as extending into the tributaries of the estuary. These areas are now considered to be either silted up or no longer able to support commercial production (Falmouth Port Health Authority, pers. com.) This therefore has also been taken into consideration in recommending the revised production area boundaries.

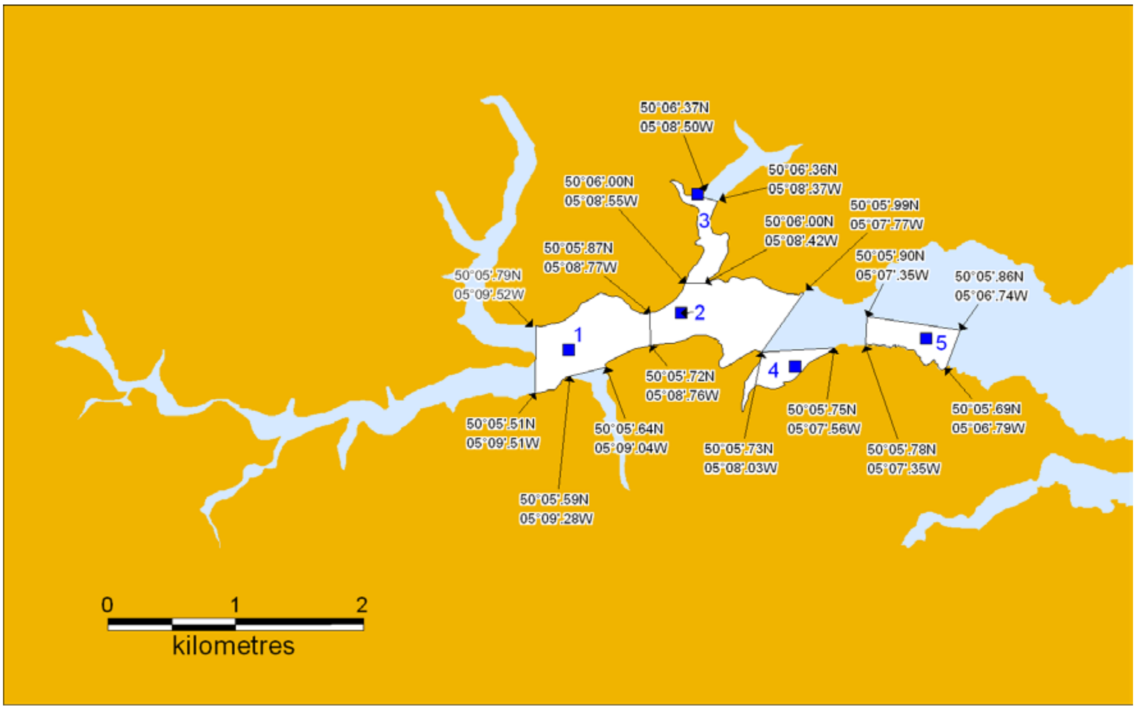

Figure 49. Recommended boundaries for revised production areas in the wider Helford Estuary.

N.B. Boundaries at the interface between water and land follow the Mean high Water (MHW) line.

4.3 Recommendations

- The 'Voose' cardinal marker (Figure 48) is recommended as the Representative monitoring point (RMP) for the new Bosahan aquaculture operation and sampling of Pacific oysters, already initiated by the Falmouth & Truro Port Health Authority, continued to reflect the potential impact from the watercourses entering Bosahan and Ponsence coves.

- Representative monitoring points should be maintained off Helford Point (mussels) and at Porth Navas Quay (mussels, native oysters and Pacific oysters). These points provide monitoring of the harvesting areas closest to the main sewage discharges in Gweek, Constantine and Helford.

- A RMP at South of Porth Navas Bar (mussels, native oysters and Pacific oysters) is necessary to monitor potential pollution from boats and sewage discharges in the central Helford Estuary.

- A RMP at Pylons, on the western edge of the existing production area, is necessary to monitor potential pollution from Gweek and Helford rivers in mussels and native oysters.

- The impact of the new Helford STWs scheme on the levels of microbiological contamination in shellfish needs to be evaluated at the next review (see Appendix, section P3).

- Bagged samples are utilised by LFA in the Helford Estuary (see Table A1 in Sampling Plan), therefore the recommended maximum tolerance for all RMPs is 10 metres. Since there are no difficulties in obtaining sufficient animals for samples from bagged shellfish, particularly in the confined area of Porth Navas Quay, it is considered that this tolerance minimises the effect of spatial variability in the extent of microbiological contamination whilst preserving the fixed location concept. In the case of the new aquaculture operation area at Bosahan, it is considered that this will maximise the opportunity for detecting the influence of freshwater inputs potentially impacting on the BMPA.

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Glossary

Analysis of Variance (ANOVA)	A statistical test which compares the distribution of two or more sample groups to determine if one or more of the groups are significantly different from the others.
Bathing Water	A body of water used for bathing by a significant 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 shellfish harvesting areas	A system for grading harvesting areas based on levels of bacterial indicator organisms (*E. coli*).
Coliform	Gram negative, facultatively anaerobic rod-shaped bacteria that 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 (e.g. on plant material and soil).
Combined Sewer Overflow (CSO)	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.
Discharge Consent	An authorisation issued by the Environment Agency to control the discharge of polluting matter to surface or underground waters.
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.
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. The enterohemorrhagic strain of this bacterium O157:H7 is the cause of infection in humans, such as bloody diarrhoea and occasionally kidney failure.
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.
Geometric Mean	The geometric mean of a series of N numbers is the Nth 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 antilog of that mean. It is often used to describe the typical values of a skewed data such as one following a log-normal distribution.
Guideline (G) values	Values set in European Directives that the Member States have to endeavour to achieve
Habitat	Environmental area that is inhabited by a particular species.

Hydrodynamic modelling	In this context numerical models that approximate the detail of real fluid flow i.e. velocities and water levels as functions of time and space. Output from these models can be used together with a representation of the diffusive process in the water column (Particle Transport Models) to represent the fate and dispersion of bacteria.
Local Action Group	Local Action Groups have been formed to investigate results exceeding prescribed trigger levels in classified harvesting areas and formulate action plans to implemement short term public health proitection measures. Membership of the groups include representatives from the Local Food Authority (LFA), Centre for Environment, Fisheries and Aquaculture Science (Cefas), Environment Agency (EA), Marine Fisheries Agency (MFA), plus the relevant accredited shellfish testing laboratory, water company, harbour authority(ies), local shellfish industry and Food Standards Agency (FSA).
Log-normal distribution	A log-normal distribution is a distribution in which the logarithms of the values have a normal distribution. Environmental monitoring data for a range of bacteria follow a log-normal distribution.
Primary Treatment	Removal of gross sewage solids by settlement process.
Secondary Treatment	Treatment of settled sewage, generally by biological oxidation.
Septic	A term used to describe sewage in which uncontrolled anaerobic decomposition occurs.
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 (STWs)	Facility for treating the wastewater 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.
Sludge	A solid waste fraction precipitated by a water treatment process.
Tertiary Treatment	Treatment applied to the effluent from a secondary treatment process in order to further reduce a component or components of that effluent, e.g. pathogenic micro-organisms or nutrients.
Waste water	Any waste water but see also "sewage".

List of Abbreviations

AOD	Above Ordnance Datum
AONB	Area of Outstanding Natural Beauty
ANOVA	Analysis of Variance
BMPA	Bivalve Mollusc Production Area
BST	British Summer Time
CD	Chart Datum
Cefas	Centre for Environment Fisheries and Aquaculture Science
CFU	Colony Forming Units
CSO	Combined Sewer Overflow
DWF	Dry Weather Flow
EA	Environment Agency
E. coli	*Escherichia coli*
EC	European Community
EO	Emergency Outfall
FIL	Flesh and intravalvular liquid
FSA	Food Standards Agency
h	hour
km	kilometre
LFA	Local Food Authority
LW	Low Water
ml	millilitres
MLWN	Mean Low Water Neap
MLWS	Mean Low Water Spring
MPN	Most Probable Number
NGR	National Grid Reference
PHA	Port Health Authority
ppt	Parts Per Thousand
PS	Pumping Station
RMP	Representative Monitoring Point
SAC	Special Area of Conservation
spp.	Species
STWs	Sewage Treatment Works
SSSI	Site of Special Scientific Interest
SWD	Shellfish Waters Directive
TC	Total Coliforms
TSS	Total Suspended Solids
UK	United Kingdom
UV	Ultraviolet

APPENDIX

Regulation (EC) No 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SAMPLING PLAN

Helford Estuary – Cornwall

2008

P1 GENERAL INFORMATION

Location Reference

Production Area	Helford Estuary
Cefas Main Site Reference	M034
Cefas Area Reference	FDR 2756
Ordnance survey 1:25000 map *Admiralty chart* *Imray chart*	Explorer TM 103 No 147 No 2400.11

Shellfishery

Species/culture	*Crassostrea gigas* *Mytilus* spp. *Ostrea edulis*	caged wild & trestle wild
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 ☎	Colin Bate	01326 211581

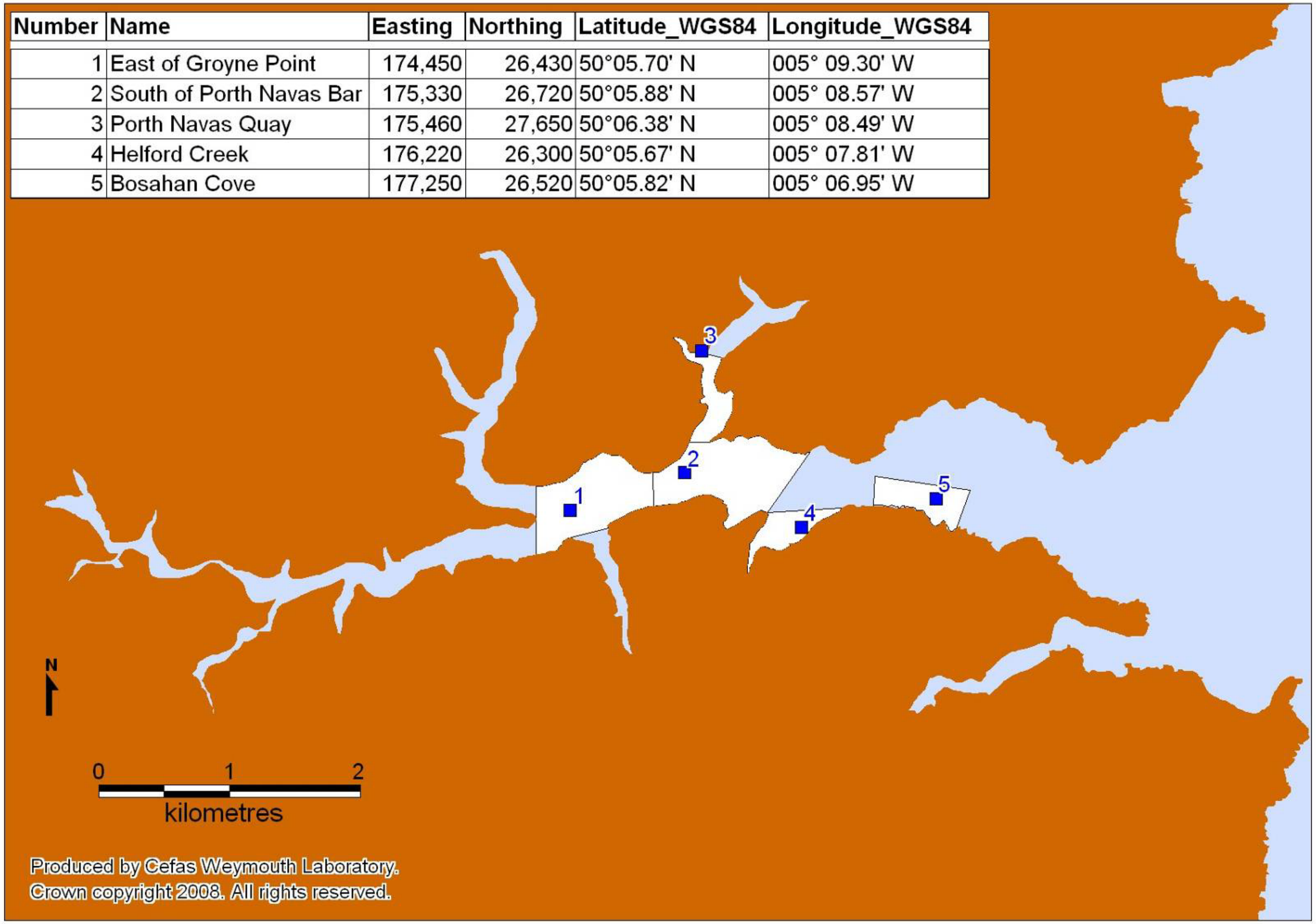
P2 MONITORING POINTS AND FREQUENCY OF SAMPLING

See map and table below.

P3 REQUIREMENT FOR REVIEW

This sampling plan will be reviewed by the competant 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.

At the time of the next review, where more than one species are monitored at a particular sampling point, the results of this parallel monitoring should be assessed with a view to rationalisation of monitoring by reducing the number of species monitored. The LA, subject to industry understanding of the implications and agreement, could consider monitoring of that species shown to be the most protective of public health.



Number	Name	Easting	Northing	Latitude_WGS84	Longitude_WGS84
1	East of Groyne Point	174,450	26,430	50°05.70' N	005° 09.30' W
2	South of Porth Navas Bar	175,330	26,720	50°05.88' N	005° 08.57' W
3	Porth Navas Quay	175,460	27,650	50°06.38' N	005° 08.49' W
4	Helford Creek	176,220	26,300	50°05.67' N	005° 07.81' W
5	Bosahan Cove	177,250	26,520	50°05.82' N	005° 06.95' W

Figure A1. Location of Representative Monitoring Points (RMPs).
For unique RMP identification codes see Table A1.

Table A1. Number and location of Representative Monitoring Points (RMPs) and frequency of sampling.

Map Ref	RMP	RMP/BMPA Name	NGR		WGS84		Species	Sampling Method	Harvesting Method	Frequency/Justification
			Easting	Northing	Latitude (N)	Longitude (W)				
1	B034Q	East of Groyne Point	174450	26430	50°05.70'	5° 09.30'	*C. gigas*	Sampled bags from buoys	Dredged from seabed	At least monthly
1	B034R	East of Groyne Point	174450	26430	50°05.70'	5° 09.30'	*Mytilus* spp.	Sampled bags from buoys	Dredged from seabed	At least monthly
1	B034S	East of Groyne Point	174450	26430	50°05.70'	5° 09.30'	*O. edulis*	Sampled bags from buoys	Dredged from seabed	At least monthly
2	B034T	South of Porth Navas Bar	175330	26720	50°05.88'	5° 08.57'	*C. gigas*	Sampled bags from buoys	Dredged from seabed	At least monthly
2	B034U	South of Porth Navas Bar	175330	26720	50°05.88'	5° 08.57'	*Mytilus* spp.	Sampled bags from buoys	Dredged from seabed	At least monthly
2	B034V	South of Porth Navas Bar	175330	26720	50°05.88'	5° 08.57'	*O. edulis*	Sampled bags from buoys	Dredged from seabed	At least monthly
3	B034W	Porth Navas Quay	175460	27650	50°06.38'	5° 08.49'	*C. gigas*	Hand picked from bags via shore	Hand picked from bags via shore	At least monthly
3	B034X	Porth Navas Quay	175460	27650	50°06.38'	5° 08.49'	*Mytilus* spp.	Hand picked from bags via shore	Hand picked from bags via shore	At least monthly
3	B034Y	Porth Navas Quay	175460	27650	50°06.38'	5° 08.49'	*O. edulis*	Hand picked from bags via shore	Hand picked from bags via shore	At least monthly
4	B034O	Helford Creek	176220	26300	50°05.67'	5° 07.81'	*Mytilus* spp.	Hand picked from bags via shore	Hand picked from bags via shore	At least monthly
5	B034P	Bosahan Cove	177250	26520	50°05.82'	5° 06.95'	*C. gigas*	Hand picked from bags via boat	Cages recovered by boat	Preliminary monitoring: 10 samples taken over at least 3 months (interval between sampling not less than 1 week). Provisional classification: at least monthly over one year.

Tolerance of representative sampling points: 10m.