EC Regulation 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SANITARY SURVEY REPORT
West Mersea

2013

Cover photo: South shore of Mersea Island

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STATEMENT OF USE: This report provides a sanitary survey relevant to bivalve mollusc beds at West Mersea, as required under EC Regulation 854/2004 which lays down specific rules for official controls on products of animal origin intended for human consumption. It provides an appropriate hygiene classification zoning and monitoring plan based on the best available information with detailed supporting evidence. The Centre for Environment, Fisheries & Aquaculture Science (Cefas) undertook this work on behalf of the Food Standards Agency (FSA).

CONSULTATION:

Consultee	Date of consultation	Date of response
Environment Agency	18/02/2013	25/03/2013
Maldon DC	18/02/2013	25/03/2013
Colchester BC	18/02/2013	25/03/2012
Kent & Essex IFCA	18/02/2013	25/03/2013
Anglian Water	18/02/2013	25/03/2013

DISSEMINATION: Food Standards Agency, Colchester Borough Council, Maldon District Council, Environment Agency, Kent and Essex IFCA.

RECOMMENDED BIBLIOGRAPHIC REFERENCE: Cefas, 2013. Sanitary survey of West Mersea. 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 of EC Regulation No. 854/2004.

CONTENTS

1. INTRODUCTION

1.1 LEGISLATIVE REQUIREMENT

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

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

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

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

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

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

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

(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 cycle in the production area; and

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

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

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

This report documents the information relevant to undertake a sanitary survey for Pacific oysters (*Crassostrea gigas*) and native oysters (*Ostrea edulis*) at West Mersea. The area was prioritised for survey in 2012-13 by a shellfish hygiene risk ranking exercise of existing classified areas.

1.2 AREA DESCRIPTION

SITE DESCRIPTION

The area considered in this report is situated on the Essex coast, between the Colne and Blackwater estuaries. It consists of the intertidal and subtidal area south of Mersea Island, and three creeks at the west of Mersea Island (Strood Channel, Salcott Channel and Tollesbury Fleet). This production area lies immediately adjacent to the Colne production area to the east, and the Blackwater production area to the south and west.

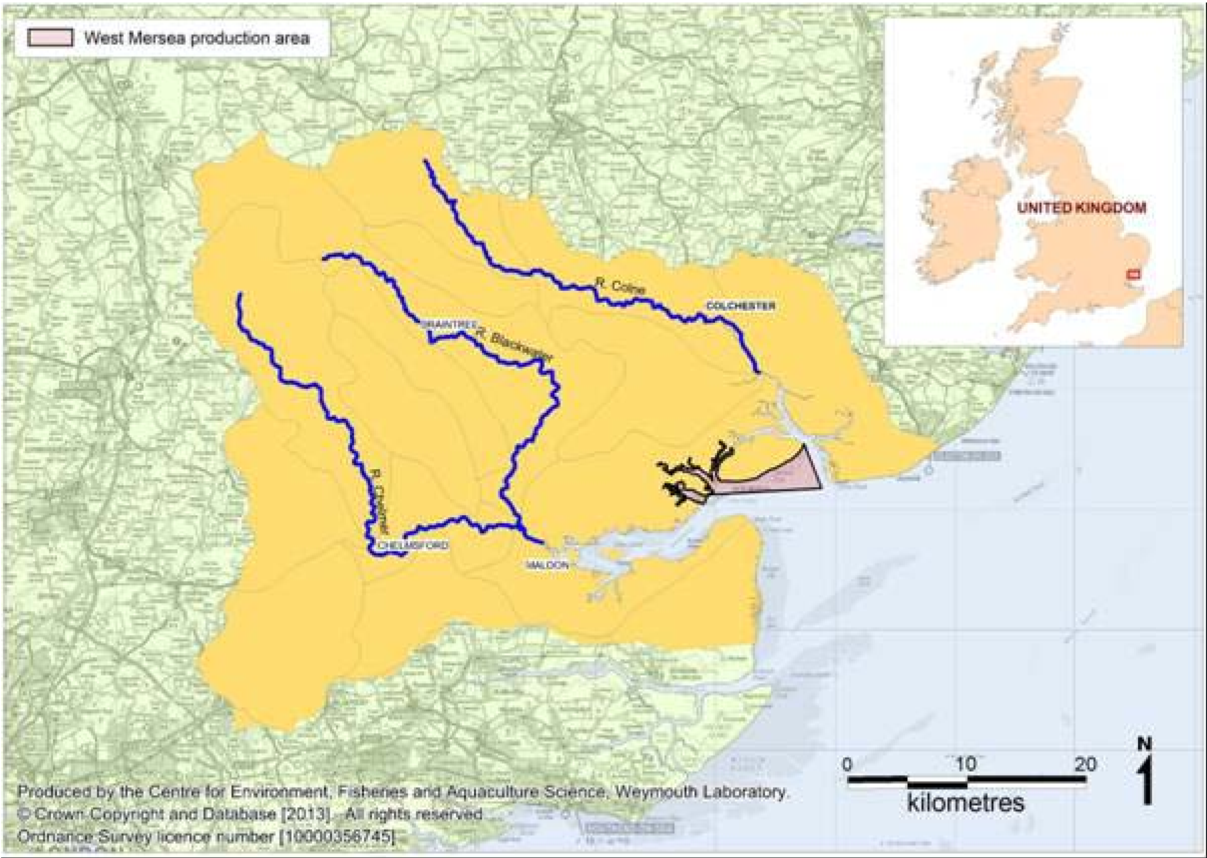


Figure 1.1 Location of the West Mersea production area and the surrounding river basin sub catchments

West Mersea encompasses a rich variety of estuarine habitats; areas of intertidal mudflats which are uncovered at low water, large areas of saltmarsh, shingle banks, and sand flats. The foreshore area is designated under the Essex Estuaries SAC, SSSI, SPA and falls within the Colne Ramsar site. Saltmarsh and mudflats around Mersea Island support large numbers of internationally and nationally important flocks of wading and migratory birds during the winter months. The area is relatively low lying and prone to flooding consequently parts of the coastline are protected by seawalls (Environment Agency, 2010). Boating activity in the West Mersea area is a popular pastime including yachting, dinghy sailing, windsurfing and canoeing. It is an important area for fishing with a large inshore commercial fishing fleet.

The intertidal mudflats sustain a large variety of bivalves and marine invertebrates; a source of food for the birds that frequent the mudflats and providing shellfish for human consumption. The harvesting of native oysters (*Ostrea edulis*) off Mersea Island has taken place since Roman times (West Mersea Town Council, 2012). Today oysters harvested within the West Mersea are shipped all over the world and the rich history of oyster farming attracts a high number of tourists each year, although the fishery is mainly for Pacific oysters now.

CATCHMENT

Figure 1.2 shows the land cover within the hydrological catchment draining to the survey area.

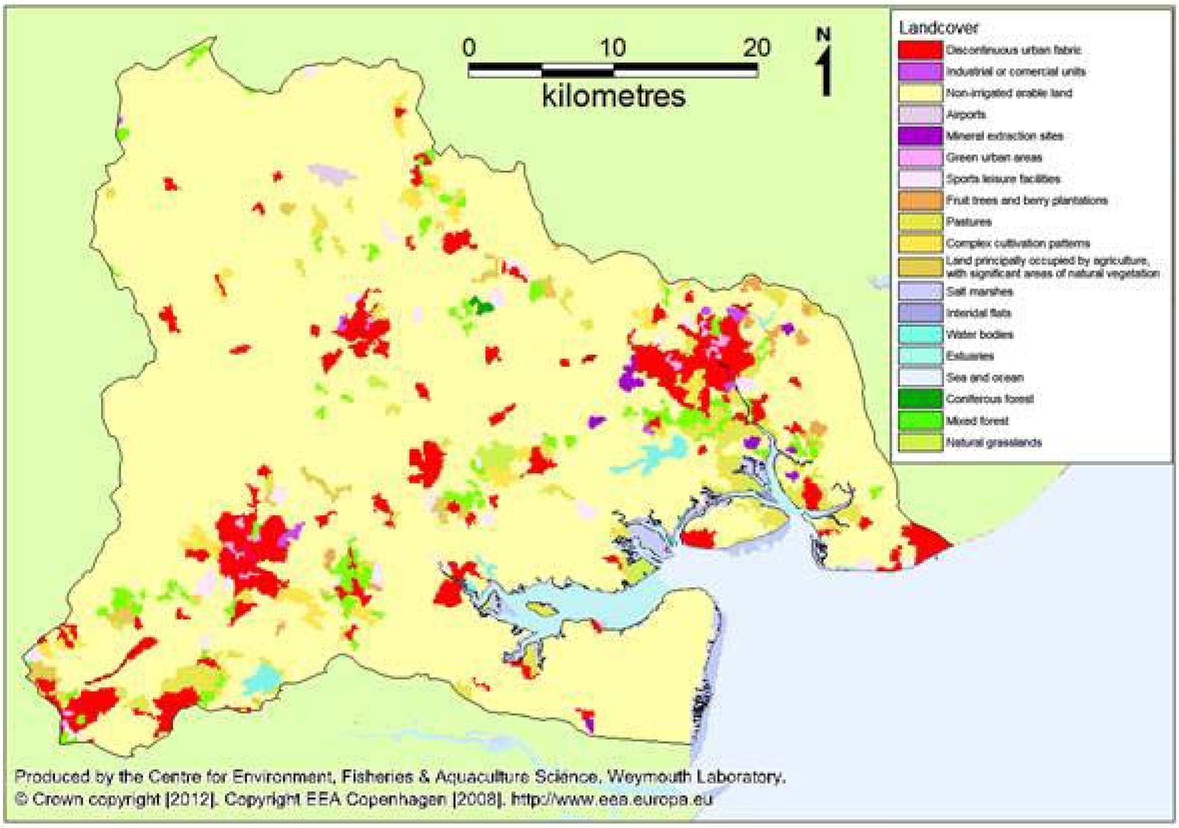


Figure 1.2 Land Cover in the West Mersea wider catchment

The catchment for the West Mersea including the Blackwater and Colne covers an area approximately 1800km². The predominant land cover within the catchment is arable with significant clusters of mixed forest, pasture and complex cultivation (Figure 1.2). The main urbanised regions, represent the towns of Chelmsford, Colchester, Maldon, Braintree, Witham, Brightlingsea and part of Clacton on Sea. There are smaller clusters of sports and leisure facilities close to the outskirts of the urban areas and industrial and mineral extraction sites. Land cover adjacent to the Mersea estuary is mainly arable and saltmarsh, there is a small area of urbanised land on the south west tip of Mersea Island where the village of West Mersea is located.

There are no major rivers that flow directly into the area although there are a few smaller streams. There are significant rivers entering the Blackwater and Colne estuaries either side which may influence the microbiological levels within West Mersea. The rivers Chelmer and Blackwater flow through the Blackwater catchment, and receive sewage discharges from a total population of around 450,000. The River Colne contributes the main freshwater input into the Colne estuary and carries the sewage discharges from a population of approximately 300,000.

Highest faecal coliform contributions arise from developed areas, with intermediate contributions from the improved pastures and lower contributions from the other land cover types (Kay *et al*. 2008a). The contributions from all land cover types would be expected to increase significantly after marked rainfall events, particularly for improved grassland which may increase up to 100 fold.

London clay and chalky boulder clay, sand and gravel constitute the main surface geology within the catchment. Fine to medium sediments are characterised within the intertidal estuary which has led to the development of vast areas of mudflats. Mersea Island is an isolated island of London Clay (Environment Agency, 2010).

2. RECOMMENDATIONS

The following seven zones are proposed for both Pacific and native oysters:

Tollesbury North. This zone encompasses the north channel only of Tollesbury Fleet. The South channel is no longer suitable for production. Sources of contamination to Tollesbury Fleet include Tollesbury STW, some minor freshwater inputs, waterbirds, houseboats and a marina at Tollesbury village, and boat moorings in the adjacent south channel. Sources discharging at Tollesbury will primarily impact on the south channel. Little difference was seen between classification monitoring results in the north and south channels, although the south channel RMP was closer to the mouth of Tollesbury Fleet. Most sources are upstream of the fishery.

It is recommended that this zone is restricted to the north channel, and the RMP is located at the upstream end of the zone. Sampling may be via dredge, hand picking, or from a deployment bag. A tolerance of 100m applies for dredging or hand picking, or 10m for bagged samples. If bagged samples are used they must be held *in situ* for at least two weeks to equilibrate. Pacific or native oysters may be sampled to classify both species. The sampling frequency should be monthly and year round. A minimum of 10 samples per year are required to maintain the classification. Sampled stock should be of a market size.

Salcott Channel. This zone encompasses the main (south) Salcott Channel but not the smaller (north) Little Ditch channel. There are significant sewage discharges and freshwater inputs which enter at the head of this channel, and some moorings in its lower reaches. Bathymetry suggests that these sources would mainly impact on the main (south) channel. Classification monitoring results here have shown higher levels of contamination than observed in Little Ditch so separate monitoring is proposed for the two.

It is recommended that the present upstream boundary at Quinces Corner is moved down to the upstream end of the lays as a significant deterioration in water quality is anticipated in the upper reaches of this channel. The RMP should be located at the upstream end of the zone. Sampling may be via dredge, hand picking, or from a deployment bag. A tolerance of 100m applies for dredging or hand picking, or 10m for bagged samples. If bagged samples are used they must be held *in situ* for at least two weeks to equilibrate. Pacific or native oysters may be sampled to classify both species. The sampling frequency should be monthly and year round. Sampled stock should be of a market size.

Little Ditch. This zone encompasses the Little Ditch, the smaller of the two Salcott channels. There are significant sewage discharges to the head of the main Salcott Channel, but the Little Ditch Channel is separate from this at the lower stages of the tide. There is a small watercourse discharging to the head of the little ditch channel and some moorings by its mouth.

An RMP located at the upstream end of the oyster lays should adequately capture contamination from these sources. Sampling may be via dredge, hand picking, or from a deployment bag. A tolerance of 100m applies for dredging or hand picking, or 10m for bagged samples. If bagged samples are used they must be held *in situ* for at least two weeks to equilibrate. Pacific or native oysters may be sampled to classify both species. The sampling frequency should be monthly and year round. Sampled stock should be of a market size.

Ray Creek. This water body forms the western arm of the Strood Channel. Separate monitoring for Ray Creek and the Strood Channel is proposed as they are largely separate and subject to differing sources of contamination. Ray Creek receives freshwater inputs from minor watercourses discharging to its head and to Sampsons Creek. Moorings are present throughout its lower reaches.

An RMP located at the upper end of the lays, where Ray Creek joins the main Strood Channel is at the upstream end of the lays and should adequately capture contamination from these sources. Sampling may be via dredge, hand picking, or from a deployment bag. A tolerance of 100m applies for dredging or hand picking, or 10m for bagged samples. If bagged samples are used they must be held *in situ* for at least two weeks to equilibrate. Pacific or native oysters may be sampled to classify both species. The sampling frequency should be monthly and year round. Sampled stock should be of a market size.

Strood Channel. There are no inputs to the head of this channel, and exchange of water with the Pyefleet channel is minimal limited to high water on spring tides. Sources of contamination include houseboats, extensive areas of moorings (both of which are centred around West Mersea village) as well as some minor surface water outfalls. Those draining urban areas are likely to carry higher concentrations of *E. coli*. Peak levels of contamination are therefore anticipated towards the mouth of the Creek in the vicinity of West Mersea Village. Microbiological monitoring results appear to support this conclusion.

It is therefore recommended that the RMP should be located on the hard by the lifeboat station on the foreshore of Mersea Village. The zone should extend east along the West Mersea foreshore to include the influence of more contaminated water ebbing from this creek. Sampling may be via dredge, hand picking, or from a deployment bag. A tolerance of 100m applies for dredging or hand picking, or 10m for bagged samples. If bagged samples are used they must be held *in situ* for at least two weeks to equilibrate. Pacific or native oysters may be sampled to classify both species. The sampling frequency should be monthly and year round. Sampled stock should be of a market size.

Mersea Flats West. This zone encompasses the western half of Mersea Flats. A series of minor surface water outfalls discharge to this zone. It may be influenced to some extent by the ebb plume from the Blackwater estuary and the three creeks to the west of Mersea Island, particularly at lower elevations. West Mersea STW discharges direct to this zone. There may also be occasional spills to the foreshore from West Mersea storm tanks, until improvements are completed here in September 2013. Parts of this zone are currently classified A for Pacific oysters and B for native oysters.

It is recommended that the RMP should be located at the West Mersea STW outfall to capture contamination from this source. Sampling may be via dredge, hand picking, or from a deployment bag. A tolerance of 100m applies for dredging or hand picking, or 10m for bagged samples. If bagged samples are used they must be held *in situ* for at least two weeks to equilibrate. Pacific or native oysters may be sampled to classify both species. The sampling frequency should be monthly and year round. Sampled stock should be of a market size.

There are some concerns regarding the presence of a large continuous sewage discharge within a class A area. A formal policy for such situations is still in development by the competent authority. The RMP selected should adequately capture *E. coli* from these sources. The discharge is UV treated so generates a low bacterial loading, but such treatment is typically less effective against viruses. Also, the bacteriological quality of the effluent does vary. There may be a case for increased monitoring frequency and norovirus testing to provide a better understanding of the potential health risks.

<u>Mersea Flats East.</u> This zone encompasses the eastern half of Mersea Flats, and only a small fraction of it is currently classified for native oysters only. A series of minor surface water outfalls discharge to this zone. One of these receives effluent from the Coopers Beach caravan park discharge. The very eastern end may be influenced to some extent by the ebb plume from the Colne estuary, particularly at lower elevations. This zone is not currently classified for Pacific oysters and only a small fraction is classified for native oysters.

It is recommended that the RMP should be located at the Coopers Beach outfall, or as close to the associated drainage channel across the intertidal as is possible. Sampling may be via dredge, hand picking, or from a deployment bag. A tolerance of 100m applies for dredging or hand picking, or 10m for bagged samples. If bagged samples are used they must be held *in situ* for at least two weeks to equilibrate. Pacific or native oysters may be sampled to classify both species. The sampling frequency should be monthly and year round. Sampled stock should be of a market size. If classification of this zone is required more rapidly, a provisional classification can be awarded on the results of 10 samples taken not less than a week apart.

3. SAMPLING PLAN

General Information

Location Reference

Production Area	West Mersea
Cefas Main Site Reference	M013
Ordnance survey 1:25,000 map	Explorer 184
Admiralty Chart	1975

Shellfishery

Species/culture	Native oysters (*Ostrea edulis*) Pacific oysters (*Crassostrea gigas*)	Wild & Cultured
Seasonality of harvest	Year round (Pacific oysters) September to April (native oysters)	

Local Enforcement Authority

Name	Planning and Protection Department Colchester Borough Council PO Box 889 Town Hall Colchester CO1 1FL
Environmental Health Officer	Tim Nice
Telephone number ☎	01206 282588
Fax number	01206 282598
E-mail	Tim.Nice@colchester.gov.uk
Name	Maldon District Council Princes Road Maldon Essex CM9 5DL
Environmental Health Officer	Malcolm Sach
Telephone number ☎	01621 875830
Fax number	01621 875899
E-mail	malcolm.sach@maldon.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 Areas, 2010) indicates that sanitary assessments should be fully reviewed every 6 years, so this assessment is due a formal review in 2019. The assessment may require review in the interim should any significant changes come to light, such as the upgrading or relocation of any major discharges, or developments in policy guidance relating to exclusion zones around sewage discharges.

Table 3.1 Number and location of representative monitoring points (RMPs) and frequency of sampling for classification zones at West Mersea

Classification zone	RMP	RMP name	NGR	Latitude & Longitude (WGS84)	Species Sampled	Growing method	Harvesting technique	Sampling method	Tolerance	Frequency	Comments
Tollesbury North	B013V	Tollesbury North	TL 9775 1145	51°46.42'N 00°52.35'E	Pacific or native oysters	Wild/ culture	Hand/ dredge	Bagged / hand picked / dredge	10m / 100m / 100m	Monthly	Represents Pacific and native oysters in this zone. Either can be sampled.
Salcott Channel	B013W	Salcott Upper	TL 9793 1317	51°46.93'N 00°52.08'E	Pacific or native oysters	Wild/ culture	Hand/ dredge	Bagged / hand picked / dredge	10m / 100m / 100m	Monthly	Represents Pacific and native oysters in this zone. Either can be sampled.
Little Ditch	B013X	Little Ditch	TL 9911 1294	51°46.68'N 00°53.10'E	Pacific or native oysters	Wild/ culture	Hand/ dredge	Bagged / hand picked / dredge	10m / 100m / 100m	Monthly	Represents Pacific and native oysters in this zone. Either can be sampled.
Ray Creek	B013Y	Ray Creek	TL 9971 1329	51°46.96'N 00°53.63'E	Pacific or native oysters	Wild/ culture	Hand/ dredge	Bagged / hand picked / dredge	10m / 100m / 100m	Monthly	Represents Pacific and native oysters in this zone. Either can be sampled.
Strood Channel	B013Z	The Hard	TM 0000 1301	51°46.80'N 00°53.88'E	Pacific or native oysters	Wild/ culture	Hand/ dredge	Bagged / hand picked / dredge	10m / 100m / 100m	Monthly	Represents Pacific and native oysters in this zone. Either can be sampled.
Mersea Flats West	B13AA	West Mersea Outfall	TM 0310 1211	51°46'.65N 00°57'.03E	Pacific or native oysters	Wild	Hand/ dredge	Bagged / hand picked / dredge	10m / 100m / 100m	Monthly	Represents Pacific and native oysters in this zone. Either can be sampled.
Mersea Flats East	B13AC	Coopers Beach	TM 0518 1345	51°46'.92N 00°58'.39E	Pacific or native oysters	Wild	Hand/ dredge	Bagged / hand picked / dredge	10m / 100m / 100m	Monthly (or 10 samples taken at least 1 week apart for a provisional classification)	This zone is not currently classified. Represents Pacific and native oysters in this zone. Either can be sampled.

Figure 3.1 Recommended classification zone boundaries and RMP locations for Pacific and native oysters

4. SHELLFISHERIES

4.1 Species, location and extent

The West Mersea production area includes the intertidal and subtidal areas south of Mersea Island and three creeks just to the west of the island (Strood Channel, Salcott Channel, and Tollesbury Fleet). It lies adjacent to the Blackwater production area to the south and east, and the Colne production area to the west. The eastern part of the area south of Mersea Island and the three creeks are subject to the Tollesbury and Mersea (Blackwater) Fishery Order 1999, whereas the area south of the eastern part of Mersea Island is a public fishery. Figure 4.1 shows the shows the extent of the area considered in this survey. The adjacent areas are considered in separate sanitary surveys (CEFAS 2013 a&b).

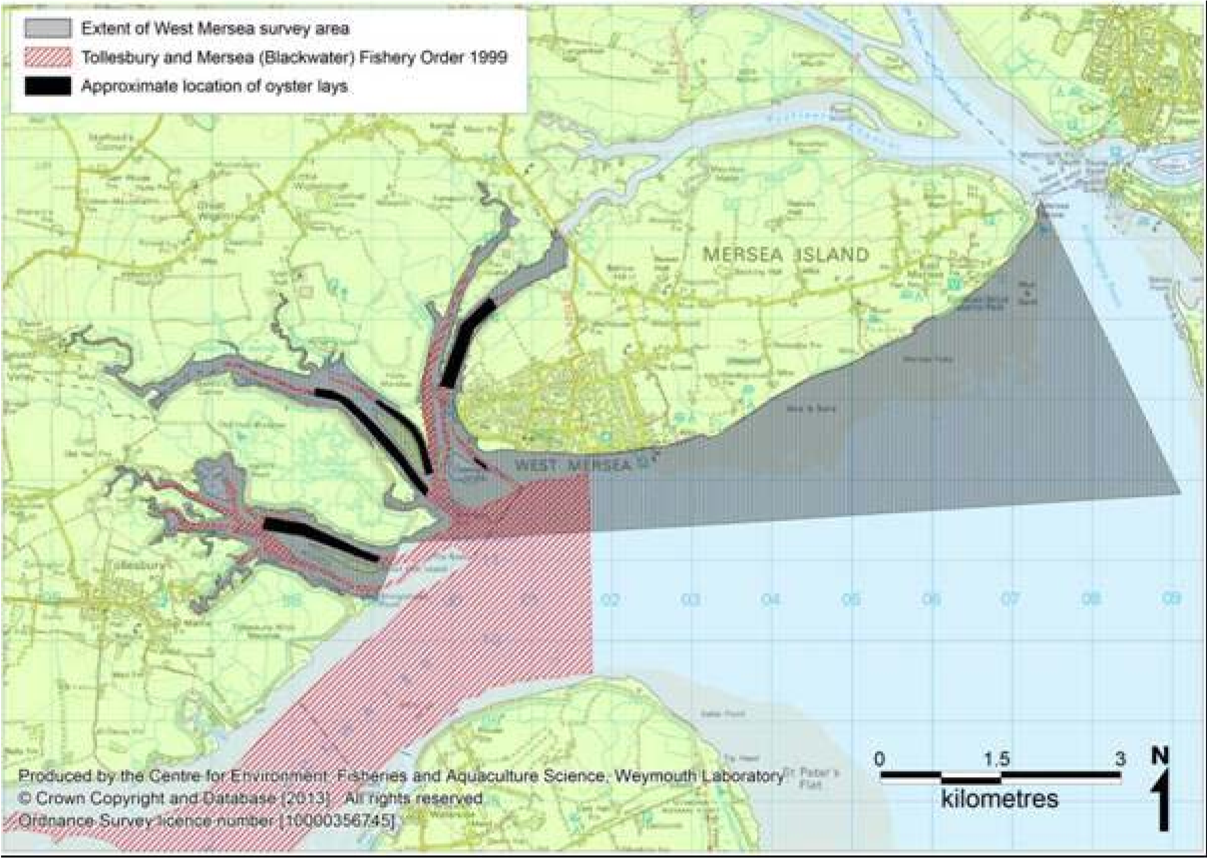


Figure 4.1 Extent of survey area, private grounds and approximate position of oyster lays

Most of the area considered in this survey is currently classified for the harvest of Pacific and/or native oysters. Pacific oysters generally occur naturally in the less muddy intertidal areas, particularly along the south shore of Mersea Island while native oysters inhabit the subtidal areas.

Wild stocks of native oysters are considerably reduced from historic levels to the extent that the public dredge fishery has been temporarily closed to aid their recovery. This does not apply on private grounds. The IFCA have indicated that they will reopen the native oyster fishery on the free grounds for 2-4 weeks staring on the 1st April 2013. Naturally occurring Pacific oysters on the other hand have proliferated in the outer Thames estuary and within Essex estuaries in recent years, to the extent that reef formation has occurred (e.g. Natural England, 2009). The temperature regime within the area is thought to be sufficiently warm for successful spatfalls to occur on an annual basis (Syvret *et al*, 2008). Considerable amounts of naturally occurring Pacific oysters were observed on the intertidal areas south of Mersea Island during the shoreline survey.

As well as the naturally occurring stocks there are a series of oyster lays within the Fishery Order area. The species cultured is primarily Pacific oysters, although smaller numbers of natives are ongrown at some of these. Both floating rafts and bed culture are used within these lays. The south channel of Tollesbury Fleet has now silted up to the extent it is no longer suitable for oyster culture.

There are other shellfish species which occur naturally within the survey area, including American hard clams (*Mercenaria mercenaria*), mussels (*Mytilus* spp.) and cockles (*Cerastoderma edule*). None of these occur in commercial quantities (Richard Haward, pers. comm.) and as such are not considered further in this report.

4.2 GROWING METHODS AND HARVESTING TECHNIQUES

Pacific oysters are subject to a dredge fishery primarily within the free grounds on the intertidal area to the south of Mersea Island. Around 6 boats were working the area at the time of shoreline survey. Fishing effort in this area has increased recently as disease controls resulting from the detection of oyster herpes virus have displaced local fishermen from other grounds within the Blackwater estuary. Pacific oysters are also cultured on the oyster lays within the private grounds, both on the riverbed and on floating rafts.

Wild native oysters were subject to a dredge fishery within subtidal areas to the south of Mersea Island which is now temporarily closed. Small numbers are ongrown of some of the private oyster layings either on the river bed or on floating rafts.

4.3 SEASONALITY OF HARVEST, CONSERVATION CONTROLS AND DEVELOPMENT POTENTIAL

There is a closed season for native oysters which runs from May to August inclusive. A minimum landing size of 70mm applies to this species. A maximum width of dredge (or dredges) of 4m applies. Native oyster fishing was closed by the Kent and Essex IFCA in May 2012 for at least to aid stock recovery, although this only applies to public grounds. The public fishery will be temporarily re-opened for up to 4 weeks on 1st April 2013. If it is fully re-opened in the future it may be subject to additional management measures to help sustain any recovery. Major changes in the spatial distribution of these stocks are not anticipated in the immediate future.

There are no specific conservation controls applying to Pacific oysters such as a closed season or minimum landing size. Harvesting may occur at any time of the year. Pacific oyster stocks have become more numerous and widespread in recent years in the south east of England, and it is likely that their expansion will continue on the whole, as recruitment occurs on an annual basis. The recent occurrence of oyster herpes virus in the area does not appear to have had a major effect on naturally occurring stocks of this species in the area. Recent increases in the numbers of boats dredging for this species to the south of West Mersea may cause noticeable reductions in stock levels, but it is anticipated that significant landings will continue to be made in the future.

4.5 HYGIENE CLASSIFICATION

Table 4.1 lists all classifications within the West Mersea production area from 2004 onwards.

Table 4.1 Classification history for West Mersea, 2004 onwards

Area	Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Strood Channel	*O. edulis*	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Freeground	*O. edulis*	B	B	B-LT	B-LT	B-LT	B-LT	-	-	-	-
Tollesbury South	*O. edulis*	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	-	-	-
Tollesbury North	*O. edulis*	A	A	A	A	B	B	B-LT	B-LT	B-LT	B-LT
Salcott	*O. edulis*	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Salcott	*C. gigas*	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Cobmarsh Island	*O. edulis*	-	-	-	-	-	B	B	-	-	-
Little Ditch	*O. edulis*	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Little Ditch	*C. gigas*	B	-	-	-	-	-	-	B-LT	B-LT	B-LT
Strood Channel	*C. gigas*	A	A	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
The Nothe	*O. edulis*	B	B	B-LT	B-LT	-	-	-	-	-	-
Mersea Shore	*O. edulis*	-	A	A	B	B	B	B	B-LT	B-LT	B-LT
Mersea Flats	*C. gigas*	-	-	-	-	-	-	-	-	B(P)	A
Creekmouth	*C. gigas*	-	-	-	-	-	-	-	-	-	A

LT denotes long term classification
P denotes preliminary classification

The classified zones within the creeks are all currently classified as long term class B areas for both species. Until recently there was an area classified for the relay of Pacific oysters in the Strood Channel, but this classification is no longer needed and it has now reverted to a classified harvesting area.

For native oysters the area to the south of Mersea Island is also classed as B, whereas this area is now classified as an A for Pacific oysters, albeit on the basis of a different monitoring dataset.

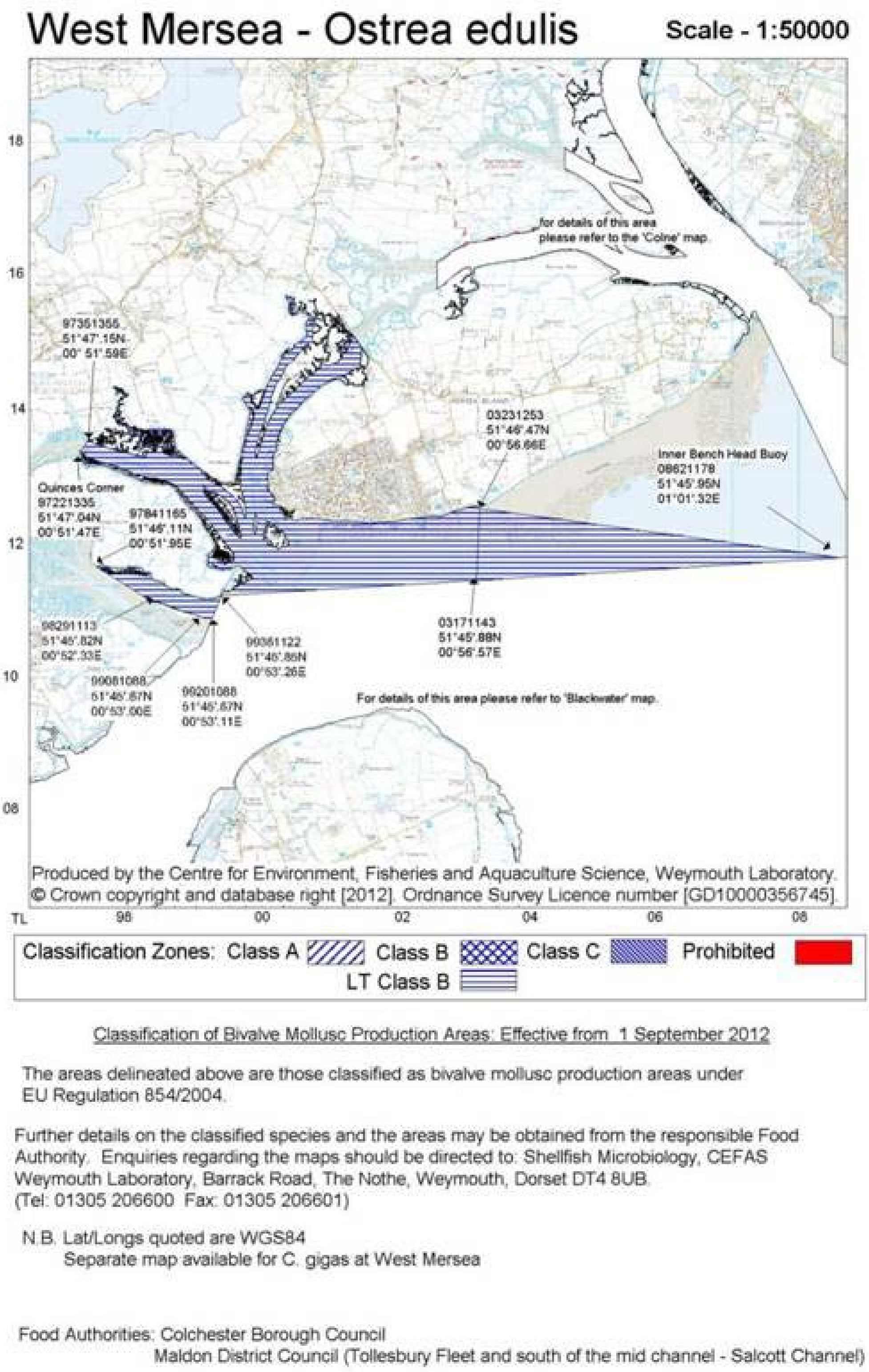
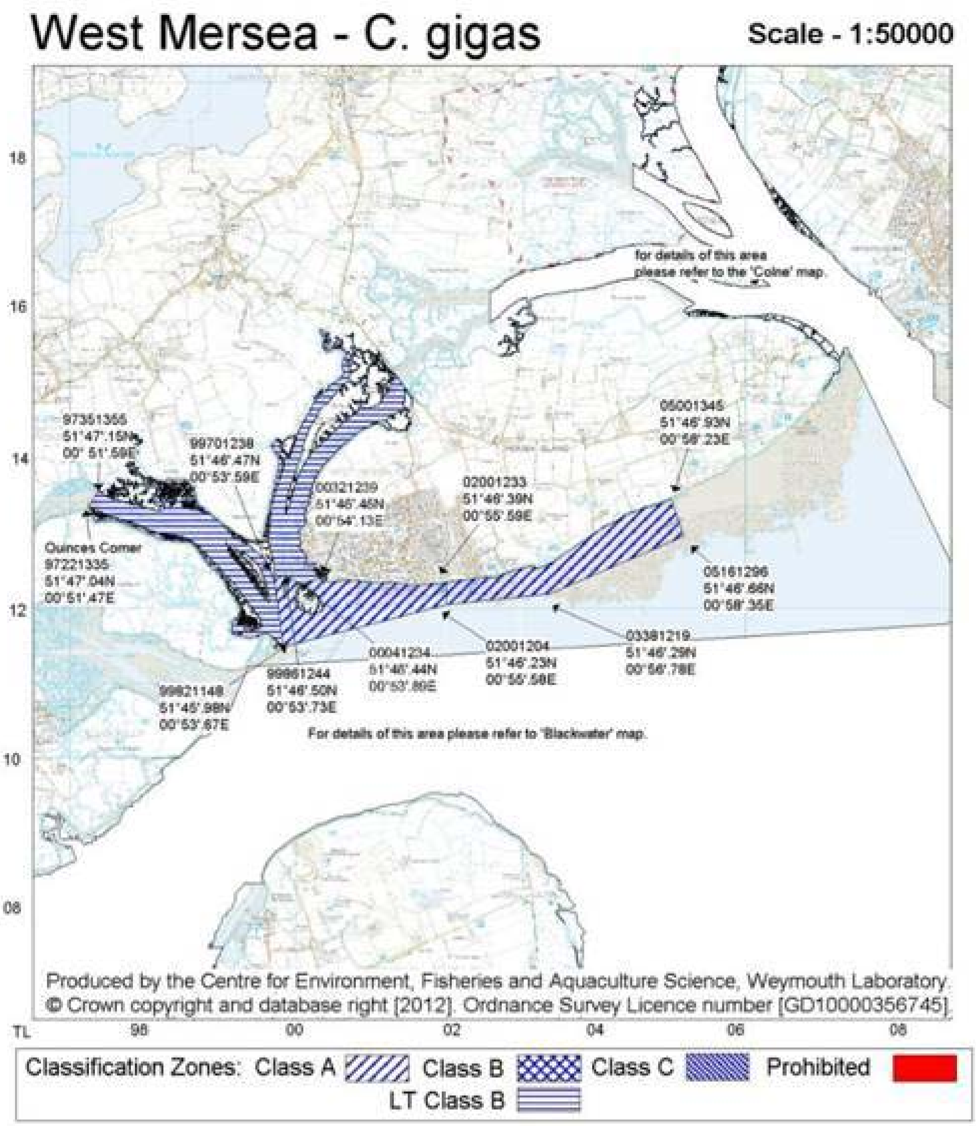


Figure 4.2 Current native oyster classifications



Classification of Bivalve Mollusc Production Areas: Effective from 1 September 2012

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 WGS84
Separate map available for O. edulis at West Mersea

Food Authorities: Colchester Borough Council

Figure 4.3 Current Pacific oyster classifications

Table 4.2 Criteria for classification of bivalve mollusc production areas.

Class	Microbiological standard[1]	Post-harvest treatment required
A[2]	Live bivalve molluscs from these areas must not exceed 230 Most Probable Number (MPN) of *E. coli*/100 g Flesh and Intravalvular Liquid (FIL)	None
B[3]	Live bivalve molluscs from these areas must not exceed the limits of a five-tube, three dilution MPN test of 4,600 *E. coli*/100 g FIL in more than 10% of samples. No sample may exceed an upper limit of 46,000 *E. coli*/100 g FIL	Purification, relaying or cooking by an approved method
C[4]	Live bivalve molluscs from these areas must not exceed the limits of a five-tube, three dilution Most Probable Number (MPN) test of 46,000 *E. coli*/100 g FIL	Relaying for at least two months in an approved relaying area or cooking by an approved method
Prohibited[6]	>46,000 *E. coli*/100 g FIL[5]	Harvesting not permitted

[1] The reference method is given as ISO 16649-3.
[2] By cross-reference from EC Regulation 854/2004, via EC Regulation 853/2004, to EC Regulation 2073/2005.
[3] From EC Regulation 1021/2008.
[4] From EC Regulation 854/2004.
[5] This level is not specifically given in the Regulation but does not comply with classes A, B or C. The competent authority has the power to prohibit any production and harvesting of bivalve molluscs in areas considered unsuitable for health reasons.
[6] Areas which are not classified and therefore commercial harvesting of LBMs cannot take place. This also includes areas which are unfit for commercial harvesting for health reasons e.g. areas consistently returning prohibited level results in routine monitoring and these are included in the FSA list of designated prohibited beds

5. OVERALL ASSESSMENT

AIM

This section presents an overall assessment of sources of contamination, their likely impacts, and patterns in levels of contamination observed in water and shellfish samples taken in the area under various programmes, summarised from supporting information in the previous sections and the Appendices. Its main purpose is to inform the sampling plan for the microbiological monitoring and classification of the bivalve mollusc beds in this geographical area.

SHELLFISHERIES

West Mersea supports commercial fisheries for both native and Pacific oysters. These occur naturally in the area, and Pacific oysters are mainly found in intertidal areas whereas native oysters prefer subtidal habitats. Whilst naturally occurring stocks of Pacific oysters have proliferated in the area in recent years, native oysters have suffered a marked decline. The western end of the survey area, including the Tollesbury Fleet, Salcott and Strood Channels, falls within the Tollesbury and Mersea (Blackwater) Fishery Order. Within these private grounds both species are ongrown in a series of managed oyster lays in the three creeks. The south channel of Tollesbury Fleet has now silted up to the extent it can no longer support oyster culture. Otherwise, all these creeks will require a sampling plan extending at least as far upstream as the fisheries.

The free grounds to the west currently support a significant dredge fishery for Pacific oysters, which are also hand picked from here. Not all of the free grounds are currently classified and there are likely to be considerable resources in the unclassified areas. A sampling plan will therefore be provided to cover the whole of the free grounds up to the boundaries of the adjacent Colne and Blackwater production areas. The native oyster fishery on the free grounds is temporarily closed in order to promote stock regeneration, although it is due to reopen for up to 4 weeks in April 2013. Whilst the harvest of native oysters continues within some parts of the private grounds, a closed season which runs from May to August inclusive applies.

Pacific and native oysters accumulate *E. coli* to similar levels (Younger & Reese, 2010) and so the use of Pacific oyster sample results to classify native oysters, and vice versa, is considered an acceptable option in some places. This would not only reduce laboratory costs but would allow the more abundant and widespread lower value species (Pacific oysters) to be sampled. In places where there is the possibility of class A compliance the standard approach is to sample and classify the two species separately so there can be no potential disputes with the industry if the compliance thresholds are exceeded. This would also apply where class B compliance is borderline, but the class B areas considered here have consistently shown very solid compliance with this classification over the years. Representatives of the local industry have indicated that they always depurate oysters from the class A area at Mersea Flats, and that for enforcement purposes a the LEA indicates a B classification may be preferable to an A (Colchester Council, pers. comm.). Therefore, the use of Pacific oyster sample results to classify native oysters is considered acceptable on the intertidal area to the south of Mersea Island.

POLLUTION SOURCES

FRESHWATER INPUTS

All freshwater inputs will carry some contamination from land runoff and so will require consideration in this assessment. The area considered in this survey lies between two major estuaries, the Blackwater and the Colne. The combined catchment area of these is about 1800km^2 most of which is used for arable farming but there are major urban centres in both. Soils are generally impermeable so relatively high rates of runoff are anticipated. Flows gauging records from the main rivers draining to these estuaries showed higher discharge volumes on average during the winter months. Increased levels of runoff are likely to result in an increased bacterial loading carried into coastal waters, particularly as river levels rise when heavy rain occurs following a dry period (the 'first flush'). The ebb plumes from these two estuaries will carry contamination from a variety of catchment sources towards the West Mersea production area. The pattern of impacts from these plumes will largely depend on the hydrography of the area.

There is relatively little in the way of freshwater inputs direct to the survey area. These consist of a series of minor watercourses, land drains and surface water outfalls along all shorelines. These are of potential significance to the sampling plan as they may cause noticeable spatial variation in levels of contamination within the survey area.

The largest of these are streams draining to the head of the Salcott Channel and two watercourses draining to the upper reaches of Ray Creek. Higher levels of runoff borne contamination are anticipated towards the upstream end of the shellfisheries within these creeks as a result. All three creeks are surrounded by sea walls, and on the landward side of these borrow dykes run adjacent for most of their length. From these borrow dykes there are a series of minor outfalls which discharge to the creeks which will carry some contamination when they are discharging and so may create minor 'hotspots'. A series of minor surface water outfalls drain to the south shore of Mersea Island. These were accessible at the time of the shoreline survey and were sampled and measured allowing estimation of the bacterial loading they were generating at the time. Although none of these were particularly large in terms of volumes discharged, some were carrying quite high concentrations of *E. coli* and so may create a localised hotspot of contamination. The estimated loadings from these ranged from 3.4×10^8 to $>2.0 \times 10^{11}$. The impacts of these minor watercourses will be greatest where they enter coastal waters, and within or immediately adjacent to any drainage channels they follow across the intertidal area.

HUMAN POPULATION

Total resident population within the Colne/Blackwater/West Mersea catchment area was 727,378 at the time of the last census for which data was available. The catchment area is predominantly rural/arable land although there are several major conurbations in the area. There are two population centres immediately adjacent to the West Mersea production area. On the western tip of Mersea Island is the village of West Mersea (population of about 7,000) and the smaller village of Tollesbury (population of about 2,000) lies at the head of Tollesbury Fleet.

The Essex coast is a popular holiday destination so the population within coastal towns is likely to increase during the summer months. Mersea Island receives significant numbers of tourists. There are a series of holiday parks along its' south shore and a variety of other holiday accommodation available on the island. Therefore at peak holiday periods the population of Mersea Island in particular is likely to be significantly larger. Increased population numbers will result in increased volumes of sewage being treated by sewage works so there may be some seasonality in the bacterial loadings generated by these, particularly any private discharges serving the holiday parks.

SEWAGE DISCHARGES

There are five water company owned sewage treatment works discharging either direct to the survey area or to watercourses which in turn discharge direct to the survey area. The largest of these in terms of volume of effluent discharged is the West Mersea STW, which discharges just above the spring low water mark to the south of the village of West Mersea. This provides UV treatment which final effluent testing data indicates is effective at reducing the faecal coliform loading to the extent that an estimate of the average loading it generates is negligible, at only 7.83×10^{8} cfu/day. Occasionally, higher concentrations of faecal coliforms were recorded in the effluent up to a maximum of between 2 and 3 orders of magnitude higher than the average, but even at this concentration its impacts would be relatively minor and localised. There was no seasonal variation in the effluent quality from the discharge, nor a summer peak in flows.

West Mersea STW does however discharge to the margins of a class A oyster area. Attenuation of viral contaminants such as norovirus by UV treatment is not as effective as for bacterial contaminants so its location gives some cause for concern. Ideally, an exclusion zone should be established around the outfall, but formal policy for such situations is still in development. An RMP at the end of the discharge pipe would best capture contamination from this source. The competent authority/LEA may also wish to consider some norovirus testing of oysters from here to gain a more accurate appreciation of the potential public health risks.

Three of the water company discharges are to the Salcott Channel or to minor watercourses draining direct to this water body. These all provide secondary treatment, and discharge upstream of the fisheries. An estimate of their combined loading is 8.7×10^{12} faecal coliforms/day. An RMP located at the upstream end of the classification zone would best capture contamination from these works. The final water company sewage works is located at Tollesbury, and discharges to the south shore in the upper reaches of Tollesbury Fleet. This generates an estimated faecal coliform loading of 2.09×10^{12} cfu/day.

In addition to the continuous water company owned sewage discharges there are a series of intermittent discharge associated with the sewer network. There is a storm overflow from West Mersea STW storm tanks which discharges to a lagoon on site, which then occasionally overtops and spills to the foreshore, perhaps 3 or 4 times per year. This is due to be improved so that it spills less than once a decade on average, and rerouted to the West Mersea STW main outfall by September 2013. Salcott SPS discharges to a watercourse just above the tidal limit at the head of the Salcott Channel. Tollesbury STW storm tanks discharge to the south shore of the upper reaches of Tollesbury Fleet. Mersea Road SPS discharges to the head of Ray Creek via watercourse. Whitaker Way SPS discharges to the lower reaches of the Strood Channel via watercourse, although it is unclear exactly where this watercourse enters the channel. No spill records from these discharges was available at the time of writing, so it is difficult to assess their significance aside from noting their location and their potential to discharge untreated sewage.

Intermittent discharges create issues in management of shellfish hygiene however infrequently they spill. Their impacts are not reliably captured during a years worth of monthly monitoring from which the classification is derived as they typically only operate occasionally. Thus when they do have a significant spill, heavily contaminated shellfish may be harvested under a better classification than the levels of *E. coli* within them may merit. A reactive system alerting relevant parties to spill events may therefore convey better public health protection. Anglian Water and Seafish are investigating the practicalities of establishing such a system but discussions are yet to be concluded.

As well as water company owned sewerage networks, there are a number of private discharges in the immediate vicinity of the West Mersea shellfisheries. Where specified, these are generally treated by either septic tank or small treatment works such as package plants. The majority of these are small, consented to discharge less than 3m^3/day. Some are however significantly larger and may have some localised impacts. The treatment works serving a Coopers Beach holiday park is consented to discharge up to 114m^3/day. This discharges to a borrow dyke, which in turn drains via a nearby pipe outfall to the south shore of Mersea Island. The pipe outfall was sampled and measured during the shoreline survey and was found to be carrying a loading of only 5.5×10^{10} *E. coli* cfu/day. However, this was during the winter period and much higher occupancy rates are anticipated during the summer. An RMP positioned in the drainage channel across the intertidal from this pipe would best capture contamination from this source. There is another relatively large private discharge (92m^3/day) which discharges secondary treated effluent to a watercourse a short distance from where it drains into the head of the Salcott Channel. This will add further to the sewage load received by the upper reaches of this creek.

On a wider scale there are discharges from major sewage works to both the Colne and Blackwater estuaries. The details of these are not presented or discussed in this report. The ebb plumes from these two estuaries will carry contamination from these and other catchment sources and this should be taken into consideration for the sampling plan.

AGRICULTURE

The majority of agricultural land within the Colne/Blackwater/West Mersea catchment is used for arable farming, although there are some pockets of pasture. There are relatively low overall numbers and densities of grazing animals (cattle and sheep) within this wider catchment. There are also significant numbers of poultry and some pigs, the manure from which is typically collected and applied tactically to nearby farmland. Sewage sludge may also be used as fertilizer, but no information on local practices was available at the time of writing. The ebb plumes from the Colne and Blackwater estuaries are therefore likely to carry some contamination of agricultural origin.

In the sub-catchment immediately adjacent to the survey area there were only 5970 sheep and 1282 cattle at the time of last census. Their impacts are therefore likely to be relatively minor overall, although they may be of local significance for example where there is an area of grazing marsh immediately adjacent to a shellfishery. Much of the land surrounding the Tollesbury Fleet, the Salcott Channel and the Strood Channel is grazing marsh, so the watercourses and field drains discharging to them are likely to carry some contamination of livestock origin. Some of the land adjacent to the south shore of the east end of Mersea Island is also pasture.

The primary mechanism for mobilisation of faecal matter deposited or spread on farmland to coastal waters is via land runoff, so fluxes of livestock related contamination into the estuary will be highly rainfall dependent. Rainfall and river flows are generally highest during the winter months, but high rainfall events may occur at any time of the year. Peak concentrations of faecal indicator bacteria in watercourses are likely to arise when heavy rain follows a significant dry period (the ‘first flush’). Numbers of sheep and cattle will increase in the spring with the birth of lambs and calves, and decrease in the autumn when animals are sent to market. The seasonal pattern of application of manures and slurries is uncertain. Cattle may be housed indoors in winter so applications of slurry to pastures in these farms may be more likely during the winter and spring.

BOATS

Overboard discharges made by boats may be a significant source of contamination to the survey area at times. There is a marina at Tollesbury and three yacht clubs/boatyards at West Mersea, none of which have sewage pump out facilities. There are extensive areas of moorings located in the south channel of Tollesbury Fleet, the lower reaches of the Salcott Channel, and within the Strood Channel and the Ray Channel which host a large number of yachts and cabin cruisers. A fishing fleet of about 30 vessels operates from West Mersea. Around 20 houseboats reside on the south west tip of Mersea Island, and a few were recorded at Tollesbury. Larger shipping vessels are only likely to be seen on a regular basis in the navigation channels leading to the Colne estuary. The area around Mersea Island is also used for watersports such as windsurfing, dinghy sailing and powerboating.

Commercial shipping is not permitted to discharge to inshore waters so should be of no impact. Smaller vessels such as sailing dinghies will not have onboard toilets and so are unlikely to make discharges. It is likely that the larger of the private vessels (yachts, cabin cruisers, fishing vessels) which have onboard toilets make overboard discharges from time to time. This may occur whilst boats are on passage, and it is quite likely that any boats in overnight occupation on the moorings will make a discharge at some point during their stay. Occupied houseboats are also likely to make regular overboard discharges. On this basis, the lower reaches of all three of the creeks considered in this report are likely to be impacted to some extent by overboard discharges, particularly the Strood Channel by West Mersea. Boat occupancy levels and hence the likelihood of overboard discharges will be significantly higher during the summer. It is difficult to be more specific about the impacts of boats without any firm information about the locations, timings and volumes of such discharges. As they may be considered as a more diffuse source of contamination, RMPs located within areas of moorings or by areas of houseboats should adequately capture any impacts on shellfish hygiene.

WILDLIFE

Overwintering waterbirds (wildfowl and waders) represent the largest aggregations of wildlife which may impact on shellfish hygiene in the area. Over the five winters up until 2010 an average total count of 96,215 overwintering and wildfowl were recorded collectively in the Blackwater and Colne estuaries. Although specific numbers are not available for the West Mersea it is expected that large numbers of wildfowl and overwintering birds will frequent the intertidal mudflats and saltmarsh present within the survey area. The shoreline survey confirmed a significant presence of overwintering waterbirds. Some species such as waders will forage (and defecate) directly on the shellfish beds across a wide area. They may tend to aggregate in certain areas holding the highest densities of bivalves of their preferred size and species, but this will change from year to year. Although they may contribute significant amounts of faecal indicator organisms, as a diffuse input they will have no influence on RMP locations. Other species, such as geese will graze on saltmarshes and pastures so their faeces will be carried into coastal waters via land runoff from these areas in the same manner as that originating from livestock.

Whilst most of the overwintering population migrate elsewhere in the summer, a much smaller but nevertheless potentially significant population of resident and breeding birds will remain. A survey of breeding seabirds (gulls, terns etc) recorded 351 pairs of gulls and terns nesting in the immediate vicinity of the survey area and 2,759 pairs across the wider Blackwater and Colne area. These are likely to forage widely throughout the area, therefore faecal inputs could be considered as diffuse. Impacts may be more concentrated in the immediate vicinity of their nest sites which are generally situated in the more undisturbed areas such as the small islands within the creeks and the Old Hall Marshes.

The Essex estuaries support a combined population of about 100 harbour seals. They are present year round but numbers tend to peak in the late summer and in mid winter. They will forage widely and have been sighted in the creeks by Mersea Island. Given the large area they are likely to forage, impact is likely to be minor, and unpredictable in spatial terms so will not be an influence on the sampling plan. No other wildlife species which have a potentially significant influence on levels of contamination within shellfish have been identified in the survey area.

DOMESTIC ANIMALS

Dog walking takes place along coastal paths and on beaches within the area and so represents a diffuse source of contamination to the nearshore zone. The intensity of dog walking activity is likely to be greatest near population centres such as West

Mersea village and Tollesbury village. As a diffuse source this will have little influence on the location of RMPs.

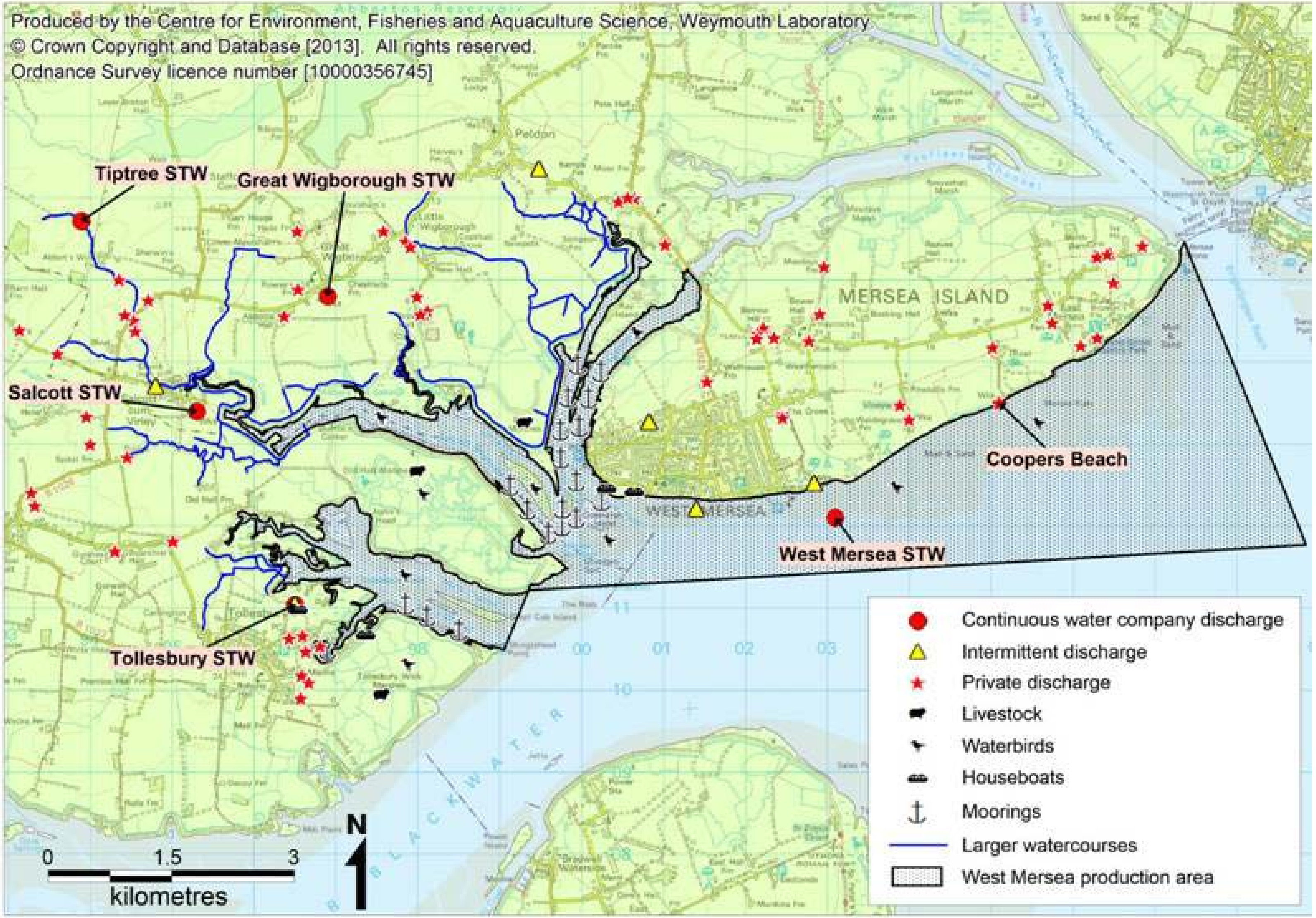
Summary of Pollution Sources

An overview of sources of pollution likely to affect the levels of microbiological contamination to the shellfish beds is shown in Table 5.1 and Figure 5.1.

Table 5.1 Qualitative assessment of seasonality of important sources of contamination.

Pollution source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Agricultural runoff	orange	orange	orange	orange	orange	orange	orange	orange	orange	orange	orange	orange
Continuous sewage discharges	orange	orange	orange	orange	orange	orange	orange	orange	orange	orange	orange	orange
Intermittent sewage discharges	orange	orange	orange	orange	orange	orange	orange	orange	orange	orange	orange	orange
Urban runoff	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow
Waterbirds	orange	orange	orange	yellow	yellow	yellow	yellow	yellow	yellow	yellow	orange	orange
Boats	yellow	yellow	yellow	yellow	orange	orange	orange	orange	orange	yellow	yellow	yellow

Red - high risk; orange - moderate risk; yellow - lower risk; white - little or no risk.


Produced by the Centre for Environment, Fisheries and Aquaculture Science, Weymouth Laboratory.
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Ordnance Survey licence number [100003567451]
Tiptree STW
Great Wigborough STW
Salcott STW
Tollesbury STW
MERSEA ISLAND
WEST MERSEA
Coopers Beach
West Mersea STW
Continuous water company discharge
Intermittent discharge
Private discharge
Livestock
Waterbirds
Houseboats
Moorings
Larger watercourses
West Mersea production area
0
1.5
3
kilometres
N

Figure 5.1 Significant sources of microbiological pollution to West Mersea.

HYDROGRAPHY

The survey area consists of three tidal creeks, as well as a gently sloping intertidal and subtidal area to the south of Mersea Island (Mersea Flats). The creeks are predominantly intertidal, with extensive mudflats fringed with salt marsh situated in the upper reaches. As a consequence a large proportion of water will be exchanged on each tide, but the dilution potential will be quite low away from the main channels. All three of these creeks have two parallel subtidal channels in their lower reaches. The upper reaches of the Strood Creek are constrained by a tidal causeway which is covered only at high water on spring tides, so water exchange between the Strood and Pyefleet Channels is minimal and limited to these times.

Mersea Flats is an extensive area of intertidal mud/sand/gravel flats that runs the length of the south coast of Mersea Island and extends southwards into the subtidal zone, to the fishing buoy outside of the Colne. This area is gently sloping and depths range from 3m above CD down to a depth of 3m relative to CD on the west. The gradient on the western side of Mersea Island is slightly steeper than on the east. Offshore from Mersea Flats there are two channels which diverge at Cone Bar and run into the Colne and Blackwater estuaries. These will carry the main tidal streams in and out off these two estuaries. A scoured channel joins the Blackwater channel at The Nass, to the South of the western tip of Mersea Island, which carries the main tidal flows in and out of the Strood and Salcott channels and Tollesbury Fleet. There is also a small subtidal channel (Besom Fleet) which runs into the mouth of the Strood Channel to the east of Cobmarsh Island.

The tidal range at West Mersea is large, at 4.6m on spring tides and 2.6m on neap tides, and this will drive extensive water movements in the area. The flood tide will convey relatively clean water originating from the open North Sea into the area and up the creeks, whereas the ebb tide will carry contamination from shoreline sources back out to sea. Offshore tidal streams flood down the Essex coast towards the Thames Estuary in a south-westerly direction, and reverse on the ebb. The indentation to the coast at the Colne and Blackwater estuaries cause the flood streams to be diverted in a north-westerley and westerly direction into these estuaries via the main channels. Current speed in the main channels at the estuary mouths peaks at about 0.8-0.9m/s on spring tides and is about 65% of this on neap tides.

The tide will flood across Mersea Flats from the two main estuary channels, and drain back away towards the main channels on the ebb. Current speeds will be slower than in the main channels. At the eastern end tidal currents will be more aligned along the north-south plane, whereas at the western end they will be more aligned to the east-west plane. The ebb plumes from the two major estuaries are likely to carry contamination from multiple sources, albeit at quite low concentrations following significant dilution within the estuaries. At the very eastern end of Mersea Flats, there will be some impacts from any plume of more contaminated water ebbing from the Colne estuary. At the western end, the ebb flows from the three creeks and the Blackwater estuary are likely to be of significance, particularly in the subtidal areas. The ebb plume from these will probably affect a larger part of Mersea Flats than that of the Colne. The intertidal areas adjacent to the more central parts of the Mersea Island foreshore will only be subject to contamination from local sources in the main.

Within the three creeks there will be a bi-directional pattern of tidal circulation, with water travelling up on the flood and back down on the ebb. Shoreline sources of contamination will therefore primarily impact up and downstream of their locations along the bank to which they discharge. The two parallel channels present in the lower reaches of all three of these creeks will further constrain the impacts of shoreline sources to the banks to which they discharge.

Freshwater inputs may significantly modify the circulation of water around estuaries via density effects. Freshwater inputs to both the Colne and the Blackwater estuaries are very low in relation to tidal exchange, and as these represent the main freshwater inputs to the general area it is anticipated that the influence of salinity on circulation within the study area is negligible. A series of salinity measurements taken within the three creeks confirm that salinity is approaching that of full strength seawater (35ppt) within these creeks, although occasionally salinities of just under 30ppt were recorded.

Tidal currents may also be modified by the effects of wind. Strong winds drive surface water currents, which in turn create return currents which may travel at depth or along sheltered margins. Exact effects are dependent on the wind speed and direction as well as state of the tide and other environmental variables so a great range of scenarios may arise. Winds from the prevailing south westerly direction will tend to push surface water from the Blackwater estuary onto Mersea Flats and possibly up the Strood Channel. Strong south easterly winds will tend to push any plume from the Colne estuary onto Mersea Flats. The Salcott Channel and Tollesbury Fleet are most exposed to the south east and winds from this direction would push surface water up these creeks. As well as driving surface currents, onshore winds will create wave action. Waves may resuspend any contamination held within the sediments of the intertidal zone, temporarily increasing levels of contamination within the water column until it is carried away by the tides. Energetic wave action will arise on the south shore of Mersea Island when there are strong wind from the south-east quadrant. Significant wave action is not generally anticipated within the creeks as they are small and more sheltered.

SUMMARY OF EXISTING MICROBIOLOGICAL DATA

The West Mersea area has been subject to considerable microbiological monitoring over recent years, deriving from the Bathing Waters and Shellfish Waters monitoring programme as well as shellfish flesh monitoring for hygiene classification purposes. Figure 5.2 shows the locations of the monitoring points referred to in this assessment.

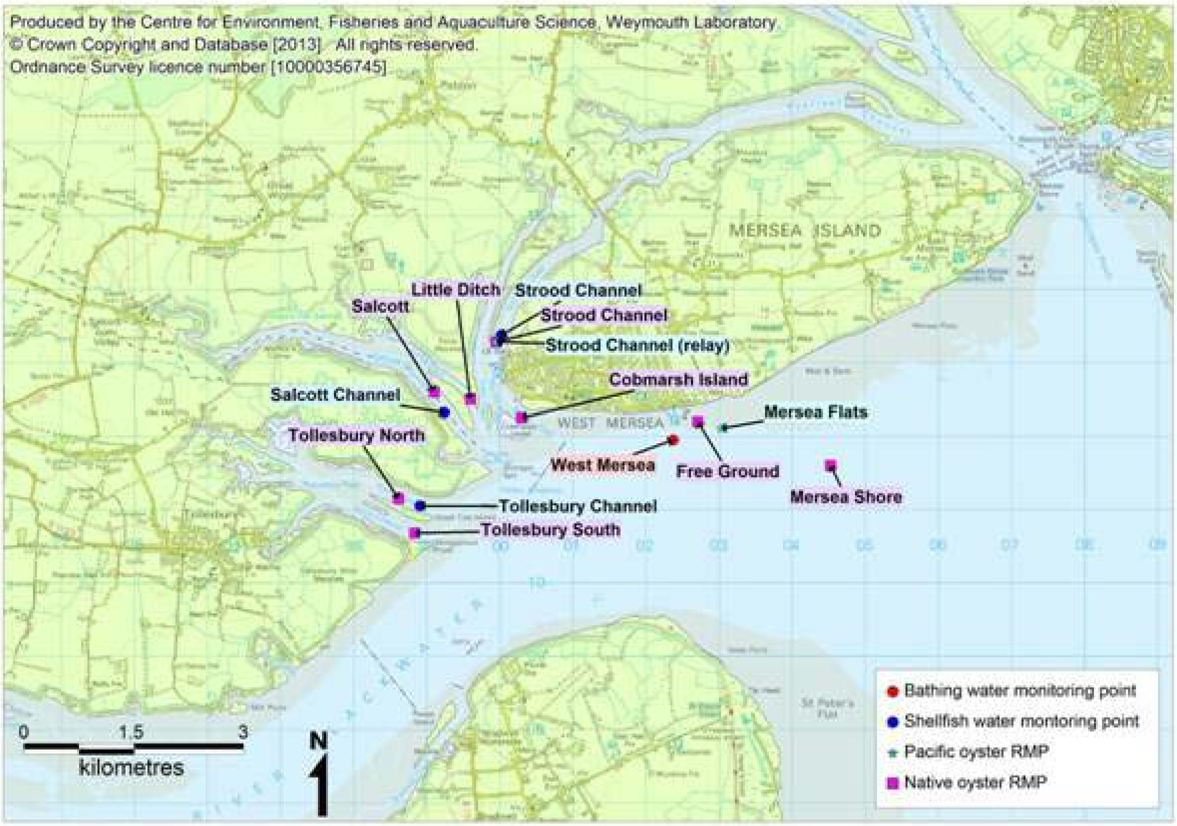

Figure 5.2 Location of microbiological sampling points referred to in this assessment.

WATER SAMPLES

Only one site on the south shore of Mersea Island was sampled under the Bathing Waters monitoring programme, where around 20 water samples were taken each bathing season (May-September) and tested for faecal coliforms. Results indicate that contamination here is light, with a geometric mean of 10.1 and a maximum result of 1360 cfu/100ml. Results have been consistent over the past decade. Significant correlations were found between levels of faecal coliforms and both of the spring/neap and high/low tidal cycles. Levels of faecal coliforms found tended to be lower around low water and on the earlier stages of the flood tide, and lower during neap tides. This suggests some influence of sources to east and in relatively close proximity. Some influence of recent rainfall on levels of faecal coliforms was detected here up to four days after a rainfall event.

Water samples were taken on a quarterly basis and tested for faecal coliforms from three locations under the Shellfish Waters monitoring programme (Strood Channel, Salcott Channel and Tollesbury Channel). Levels of faecal coliforms were low at all three sites, averaging between 3 and 5 and only exceeding 100 cfu/100ml on one occasion in the Salcott Channel. Comparisons between monitoring sites show that there are no significant differences in average faecal coliform levels between them. Results at all sites were strongly correlated on a sample by sample basis. Taken together this indicates that all three sites have similarly low average levels of faecal coliforms and are under similar environmental influences.

Some seasonality in levels of contamination was observed at these three monitoring points, with highest results generally occurring in the winter and autumn. This would suggest that there are not major decreases in water quality associated from boating and tourism activities during the summer. The effect was statistically significant at Tollesbury Channel and Salcott Channel but not in the Strood Channel. A significant correlation was found between faecal coliforms results and tidal state on both the high/low and the spring/neap tidal cycles at Tollesbury but not at either of the other sites. Plots of this data show results were higher during the ebb tide, and higher on average during neap tides. Taken together this would suggest that nearby upstream sources are of some significance within Tollesbury Fleet. The influence of rainfall on levels of faecal coliforms was weak, but was slightly more marked in the Salcott and Strood Channels than in Tollesbury Fleet where an effect was barely detected. Similarly, no significant increase in faecal coliforms was found with decreasing salinity.

SHELLFISH FLESH SAMPLES

Over the last decade, two Pacific oyster RMPs and 8 native RMPs have been sampled and tested for *E. coli* under the classification monitoring programme. All these RMPs demonstrated robust compliance with the class B requirements. No results exceeding 4600 E. coli MPN/100g were recorded at most and only a very small percentage of results (<2%) exceeding this value were recorded at three (Tollesbury North, Tollesbury South and Salcott).

Significant differences in average levels of *E. coli* were found across the native oyster RMPs. Results from Free Ground and Mersea Shore were significantly lower than at all other sites. This indicates that the enclosed creeks are subject to higher levels of contamination than Mersea Flats. Results from the Free Ground and Mersea Shore were strongly correlated on a sample by sample basis suggesting they are under similar contaminating influences.

Across the RMPs within the creeks only one significant difference was found, with higher average results at the Salcott Channel compared to the Little Ditch. These are two RMPs either side of the Island in the Salcott Creek, and this indicates that a local source of contamination is a major influence on the south (or main) Salcott Channel and that the water circulation patterns keep this separate to some degree from the Little Ditch channel. Results at these two sites were strongly correlated on a sample by sample basis suggesting that they are influenced by similar sources.

Results from Cobmarsh Island were slightly higher on average than at Strood Channel, which is located further upstream in the same channel. There was no correlation between results at these two sites on a sample by sample basis suggesting that they are subject to differing contaminating influences. The two sites in Tollesbury Fleet (Tollesbury North and Tollesbury South) were very similar on average and strongly correlated on a sample by sample basis.

A significant difference was found between the average result at the two Pacific oyster RMPs. Again, the RMP in the creek (Strood Channel) had significantly higher average levels of *E. coli* than the RMP on Mersea Flats. The latter has demonstrated 100% compliance with the class A standard over a total of 18 samples, despite its location in very close proximity to the West Mersea STW outfall.

Since 2003, results have been fairly stable at most of these RMPs, with the possible exception of Tollesbury North and Tollesbury South where there appears to have been a slight and gradual deterioration. Most RMPs showed similar seasonal patterns of higher levels of *E. coli* in the summer and autumn compared to winter and spring. This variation was statistically significant in some cases (Tollesbury North, Salcott, Little Ditch and Strood Channel native oysters), whereas in other cases no obvious seasonal variation could be seen when the data was plotted (Mersea Shore and Strood Channel Pacific oysters). The different pattern to that observed in water samples may be in part a consequence of more active metabolism within shellfish at higher temperatures.

Most sites from which more than 30 samples were taken showed a significant influence of tidal state on the high/low cycle (Tollesbury South, Tollesbury North, Salcott, Little Ditch, Free Ground, Mersea Shore and Strood Channel Pacific oysters). The only site which did not show a significant correlation with the high/low tidal cycle was Strood channel native oysters. The patterns in results were not particularly strong when this data was plotted, but did tentatively suggest higher results on average around low water at all sites except Strood Channel Pacific oysters.

Correlations between levels of *E. coli* and tidal state on the spring/neap tidal cycle were observed at Tollesbury South, Salcott, Little Ditch, Free Ground, Mersea Shore and Strood Channel Pacific oysters. These were generally weaker than for the high/low tidal cycle. When the data was plotted a vague tendency for higher results around or just after spring tides was seen, with the exception of Strood Channel Pacific oysters, where the opposite pattern was seen.

Rainfall appears to have little effect on the level of *E. coli* contamination in the West Mersea area. Some mild influence was detected at Tollesbury South, Salcott, Freeground and Strood Channel (relay).

APPENDICES

APPENDIX I
HUMAN POPULATION

Figure I.1 shows population densities in census output areas within or partially within the West Mersea catchment area, derived from data collected from the 2001 census. Equivalent data from 2011 census was unavailable at the time of writing.

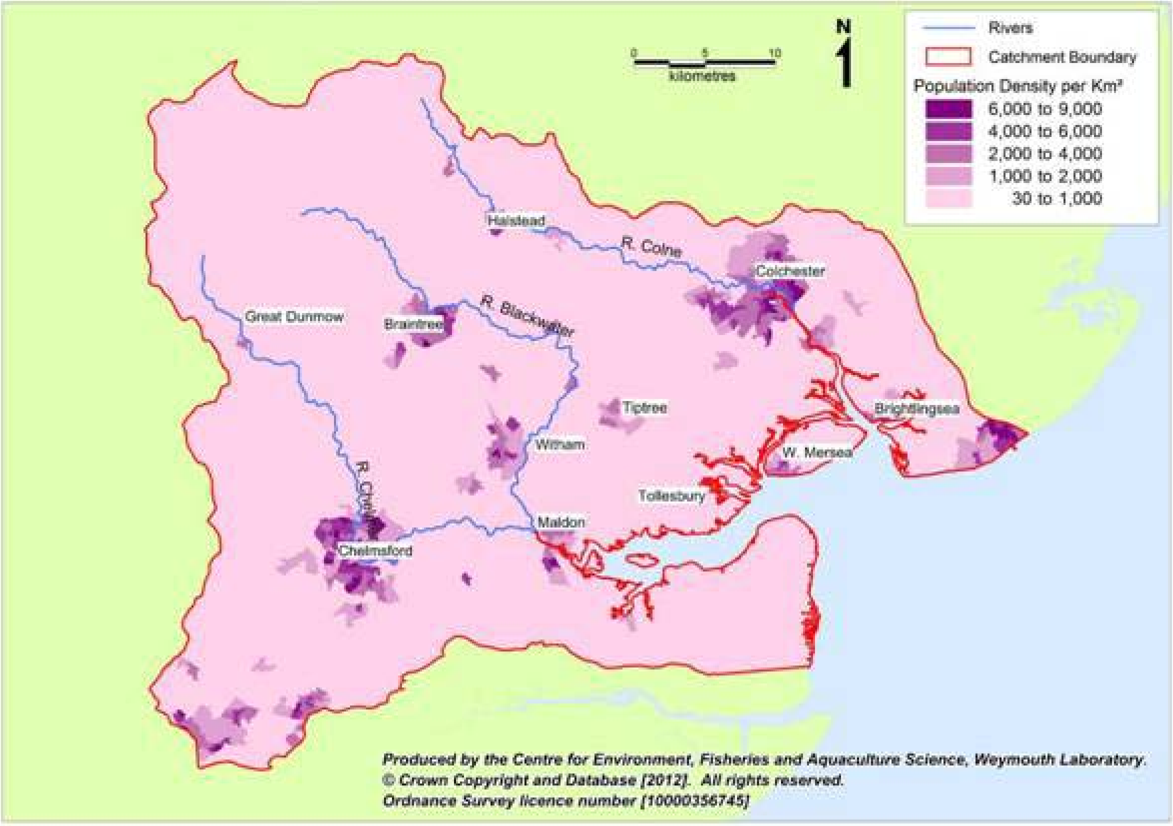

Figure I.1 Human population density in Census Areas in the West Mersea Catchment.
Source: ONS, Super Output Area Boundaries (Lower layer). Crown copyright 2004. Crown copyright material is reproduced with the permission of the Controller of HMSO.

Total resident population within the West Mersea catchment area was about 727,378 at the time of the last census. The catchment area is predominantly rural/arable land; this is reflected in the relatively low population densities throughout most of the catchment of less than 1000 persons per km^2. The towns of Colchester and Chelmsford are the major conurbations in the area. There are two population centres adjacent to the West Mersea production area. On the western tip of Mersea Island is the village of West Mersea (population of about 7,000) and the smaller village of Tollesbury (population of about 2,000) lies at the head of Tollesbury Fleet.

Significant numbers of tourists are attracted to the Essex coast because of its variety of both marine and land based activities and its close proximity to London. Activities include maritime history and culture, a multitude of watersports, bird watching, scenic coastal and countryside walks and other outdoor pursuits (Maldon District Council and Colchester Borough Council, 1996). Colchester, the oldest recorded town in Britain attracts an abundance of visitors each year, approximately 4.5 million (Visit Colchester, 2012) are drawn to the town's spectacular 2000 year old history, culture and heritage and outdoor pursuits. Tourism plays an important part in Colchester's economy contributing to expenditure of £200 million plus to the region and supporting over 6,000 jobs each year (Colchester Borough Council, 2012). In 2010 4,163,000 trips (both day and staying trips) were made to Chelmsford, therefore it can be assumed that the actual number of visitors is likely to considerably higher. Brightlingsea a quaint seaside town, also popular amongst tourists, offers a variety of activities including fishing trips and watersports. The Maldon district attracts in the region of two million tourists each year and visitors to the area tend to stay in the various guesthouses, B&B's, caravan and camping sites. Although accurate tourism figures are not known for the majority of the catchment it is likely that the numbers are increased during the summer months.

There are a series of holiday parks along the south shore of Mersea Island which together host somewhere between 1000 and 1500 static caravans, as well as providing areas for mobile caravans and camping. There is also a variety of other holiday accommodation available on the island, including hotels, B&Bs and holiday cottages. Therefore at peak holiday periods the population of Mersea Island is likely to increase by several thousand. Tollesbury is not a tourist destination.

In conclusion during the summer months when tourism is at its highest the total population will be higher and bacterial loadings from sewage treatment works serving the area are likely to increase accordingly. A particularly large increase in population is anticipated for Mersea Island. Deterioration in the microbiological quality of water and bivalve molluscs is frequently detected in coastal areas that are impacted by pollution sources associated with tourism activities, possibly due to increased loads from sewage treatment plants (Younger et al., 2003).

APPENDIX II
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: SEWAGE DISCHARGES

Details of all consented discharges in the vicinity of the West Mersea fisheries were taken from the Environment Agency's national discharge database (July 2012). The locations of the water company owned sewage treatment works, intermittent and private discharges are shown in Figure II.1. The area covered includes areas draining to Tollesbury Fleet, Salcott Channel and Stroud Channel as well as the south shore of Mersea Island. There are multiple discharges to the neighbouring Colne and Blackwater estuaries but these are not discussed in this report. For sewage works consented for a population equivalent rather than a dry weather flow a water usage of 160 L/head/day was assumed.

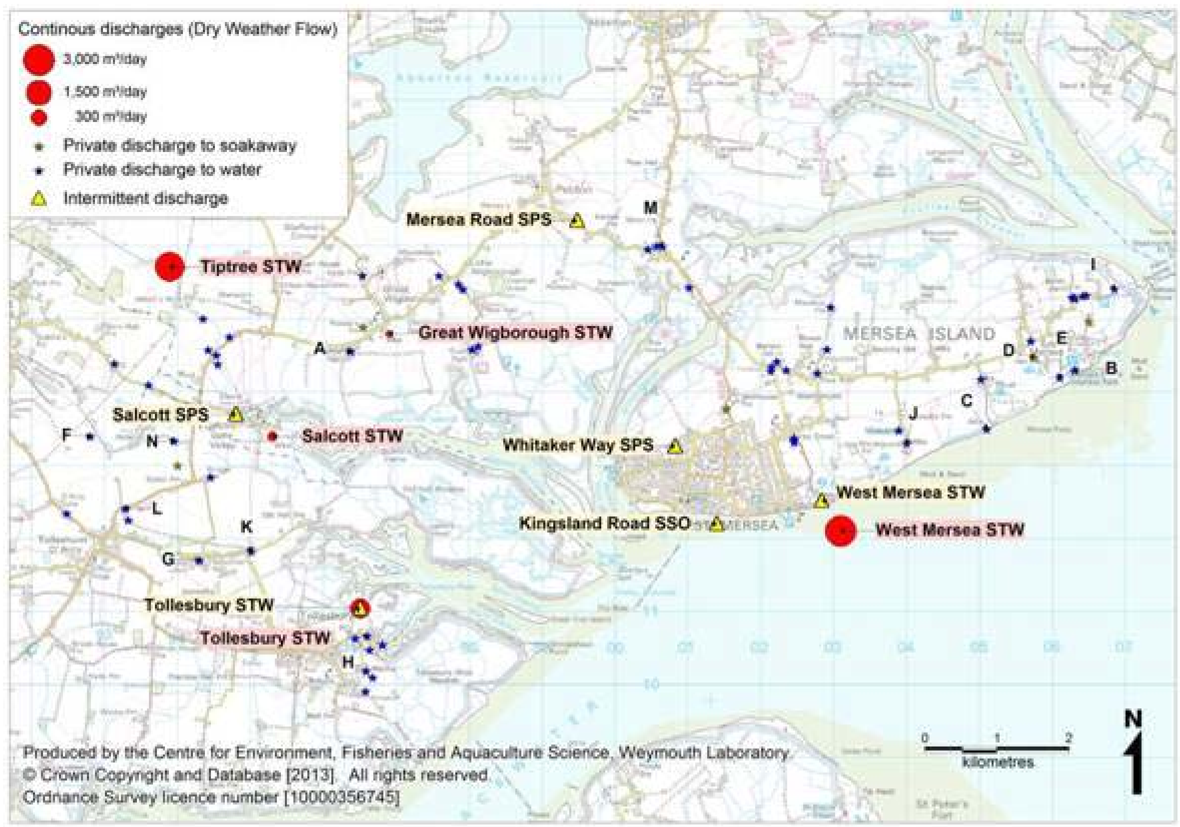

Figure II.1 Water company sewage treatment works discharging in the vicinity of West Mersea fisheries

There are only four continuous water company discharges to the area, details of which are presented in Table II.1.

Table II.1 Details of continuous water company sewage works

Name	NGR	Treatment	Dry weather flow (m^3/day)	Estimated bacterial loading (cfu/day)	Receiving water
Great Wigborough STW	TL9690014800	Secondary	17.6	5.81×10^{10}*	Unnamed stream
Salcott STW	TL9530013400	Secondary	56	1.85×10^{11}*	Salcott Creek
Tiptree STW	TL9389015720	Secondary	2567	8.47×10^{12}*	Virley Brook
Tollesbury STW	TL9650011040	Secondary	634	2.09×10^{12}*	Tollesbury Fleet
West Mersea STW	TM0310012100	Tertiary (UV)	2900	7.83×10^{8}**	Intertidal off W. Mersea

*Faecal coliforms (cfu/day) based on geometric base flow averages from a range of UK STWs providing secondary treatment (Table II.2).
** *E. coli* (cfu/day) based on geometric mean final effluent testing data (Table II.3)

Table II.2 Summary of reference faecal coliform levels (cfu/100ml) for different sewage treatment levels under different flow conditions.

Treatment Level	Flow			
	Base-flow		High-flow	
	n	Geometric mean	n	Geometric mean
Storm overflow (53)	-	-	200	7.2×10^6
Primary (12)	127	1.0×10^7	14	4.6×10^6
Secondary (67)	864	3.3×10^5	184	5.0×10^5
Tertiary (UV) (8)	108	2.8×10^2	6	3.6×10^2

Data from Kay et al. (2008b).
n - number of samples.
Figures in brackets indicate the number of STWs sampled.

Of these, the first three discharge to watercourses discharging directly to the Salcott Creek. The Tiptree STW is the largest of these. An estimate of their combined loading is 8.7×10^{12} faecal coliforms/day. It is therefore concluded that the Salcott Creek is likely to be most heavily impacted by water company owned sewage works, and these impacts will be greatest towards its head. Tollesbury STW discharges secondary treated effluent to Tollesbury Fleet upstream of the fisheries. The final discharge is to the intertidal area off West Mersea direct to an area supporting oyster stocks. It receives UV treatment, and the final effluent has been subject to regular bacteriological testing.

Table II.2 Summary statistics for final effluent testing data from West Mersea STW, January 2008 to December 2010, E. coli *cfu/100ml*

Sewage works	No.	Geometric mean result (cfu/100ml)	Minimum	Maximum
West Mersea STW	64	27	1	9,800

Data from the Environment Agency

During this period the effluent was tested on 64 occasions and returned an average result of 27 *E. coli* cfu/100ml, and never exceeded 10,000 *E. coli* cfu/100ml. This indicates that the disinfection at the STW is consistently very effective. The estimated (average) bacterial loading it generates is therefore very small. It must be noted that UV disinfection is less effective at eliminating viruses than bacteria (e.g. Tree et al, 1997). Viral contamination originating from this discharge is a major concern given its proximity to an area currently classified as A for the harvest of oysters.

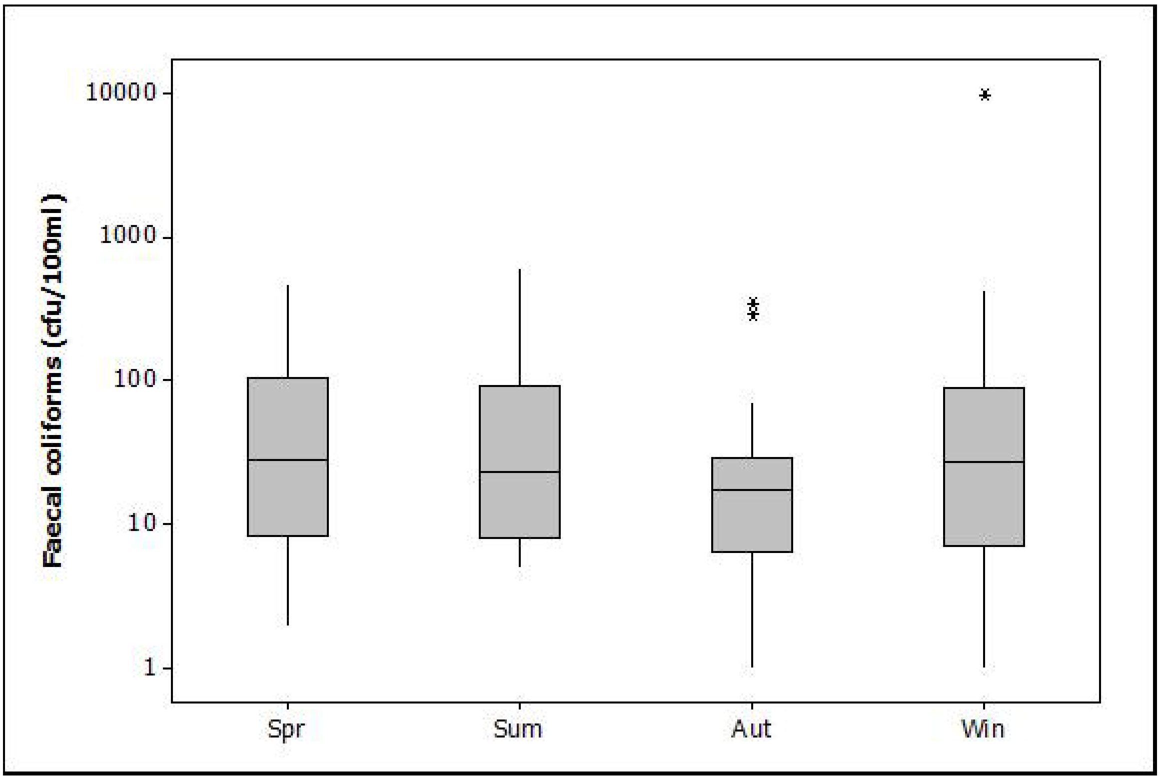

Figure II.2. Boxplot of faecal coliform concentrations in West Mersea STW final effluent by season. *Data from the Environment Agency.*

Figure II.2 indicates that there is little seasonal variation in the concentrations of bacterial indicators within the effluent from West Mersea STW.

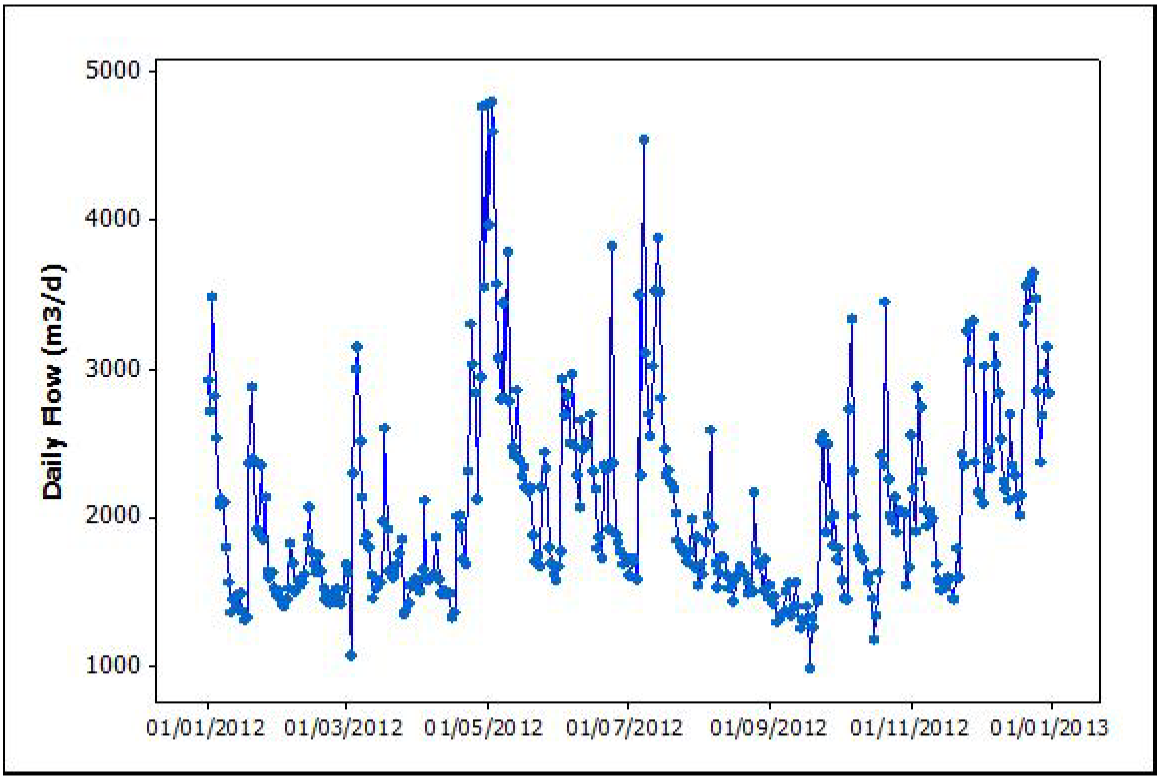

Figure II.3. Measured flows at West Mersea STW, 2011.
Data from Anglian Water

Flow data from the works for 2011 indicated some day to day fluctuation, presumably related to rainfall, but no consistent increase during the summer months. Taken together this suggests there are no major seasonal fluctuations in the bacterial loading the works delivers despite the major influx of visitors during the summer holiday. The average flow for 2011 was 2069 m^3/day, which is considerably less than the consented dry weather flow.

In addition to the continuous sewage discharges, there are several intermittent water company discharges associated with the sewerage networks also shown on Figure II.1. Details of these are shown in Table II.4.

Table II.4. Intermittent discharges of potential significance West Mersea fisheries

Name	NGR	Type	Receiving water
Salcott SPS	TL9480013700	Pumping Station	Salcott Channel via watercourse
Mersea Road SPS	TL9948116350	Pumping Station	Ray Creek via watercourse
Kingsland Road SSO	TM0140012200	Storm Overflow	Intertidal area off W. Mersea
Tollesbury STW	TL9650011040	Storm Overflow	Tollesbury Fleet
West Mersea STW	TM0284023517	Storm Overflow	Foreshore at W. Mersea via lagoon
Whitaker Way SPS	TM0082813265	Pumping Station	Strood Channel via watercourse

Data from the Environment Agency

There are two permits for storm overflows which discharge directly to the West Mersea foreshore (Kingsland Road SSO and West Mersea STW storm tanks). The former now only carries surface water, and Anglian Water intend to surrender this permit in the near future (Anglian Water, pers. comm.) although a sample taken during the shoreline survey was carrying a high concentration of *E. coli*. The West Mersea STW storm tanks actually discharge to a lagoon within the sewage works site, which occasionally overtops and spills onto the foreshore, perhaps 3 or 4 times per year. Improvements are planned for this discharge, which will redirect it to the main sewage works outfall and reduce the frequency of spills to less than one every ten years on average. It is anticipated that this will be completed by September 2013 (Anglian Water, pers. comm.).

Salcott SPS discharges to a watercourse just above the tidal limit at the head of the Salcott Channel. Tollesbury STW storm overflow discharges to Tollesbury Fleet. Mersea Road SPS discharges to the head of Ray Creek via watercourse. Whitaker Way SPS discharges to the lower reaches of the Strood Channel via watercourse, although it is unclear from maps exactly where this watercourse enters the channel. No spill records from these discharges was available at the time of writing, so it is difficult to assess their significance aside from noting their location and their potential to discharge untreated sewage. Such events may occur either under storm conditions when the sewers are inundated with runoff which may happen after intense rainfall events, or in the event of an emergency such as a pump failure or blockage which may occur at any time. Typically, spills are too infrequent for their impacts to be captured reliably under monthly classification sampling.

As well as water company owned sewerage infrastructure, there are also a number of private discharges in the area. Where specified, these are generally treated by either septic tank or small treatment works such as package plants. The majority of these are small, serving one or two properties. Details of the larger private discharges (>3m^3/day maximum permitted flow) are presented in Table II.5.

Table II.5. Details of private sewage discharges of over 3m^3/day

Ref.	Property served	Location	Treatment type	Max. daily flow (m^3/day)	Receiving environment
A	Abbots Hall	TL9637014560	Package Plant	5	Salcott Creek trib.
B	Caravan Site	TM0630014300	Unspecified	14	Intertidal off W. Mersea
C	Coopers Beach	TM0510013500	Unspecified	114	Borrow Dyke
D	Caravan/Campsite	TM0575014480	Septic Tank	11.5	Soakaway
E	Caravan Site	TM0610014200	Package Plant	3	Unnamed watercourse
F	Greenkeepers Complex	TL9280013400	Unspecified	3	Salcottstone Brook
G	Guisnes Court	TL9430011700	Unspecified	7	Salcott Creek trib.
H	Industrial Unit	TL9659610666	Package Plant	2.6	Woodrolfe Creek trib.
I	Ivy Farm	TM0685015420	Unspecified	4	Borrow Dyke
J	Youth Camp	TM0400013300	Unspecified	27.3	Unnamed watercourse
K	1-7 Old Hall Lane	TL9501011820	Unspecified	4	Salcott Brook trib.
L	Old Station House	TL9328012410	Unspecified	3	Unnamed watercourse
M	Peldon Rose	TM0065016000	Package Plant	14.5	Strood Channel trib.
N	Quietwaters Club	TL9395013340	Activated Sludge	92	Salcott Stone Brook

Data from the Environment Agency.

The holiday parks on the south shore of Mersea Island (B, C, D, E & J) are likely to be of some significance to the oyster fishery on Mersea Flats given their combined discharge volume and locations. Coopers Beach holiday park outlet is the largest in terms of consented volumes although the level of treatment provided is uncertain. Ariel photography indicates that it discharges to a borrow dyke, which in turn drains to the shoreline. Levels of occupation (and hence discharge volumes) are likely to be highly seasonal, peaking during the summer months. The Quietwaters Club (N) is also a relatively large private discharge, which may have some impacts on the upper reaches of the Salcott Channel.

APPENDIX III
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: AGRICULTURE

The vast majority of agricultural land within the wider West Mersea catchment is used for arable farming, although there are some pockets of pasture. This includes some of the land adjacent to the south shore of the east end of Mersea Island, and some of the land adjacent to Tollesbury Fleet (Figure 1.2). Table III.1 and Figure III.1 present livestock numbers and densities for the catchments draining to the area. This data was provided by Defra and is based on the 2010 census. Geographic assignment of animal counts in this dataset is based on the allocation of a single point to each farm, whereas in reality an individual farm may span the catchment boundary. Nevertheless, the data should give an indication of the numbers of livestock within the area.

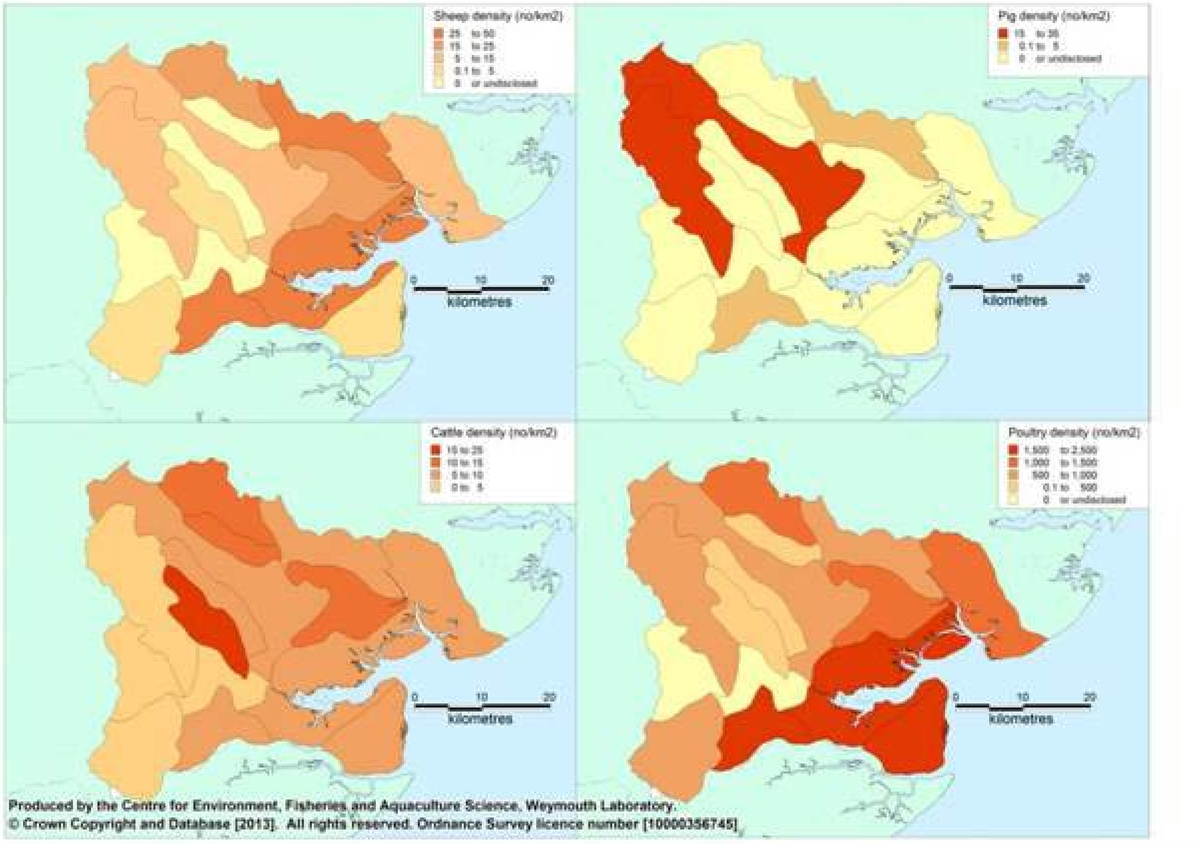

Figure III.1. Livestock densities within the West Mersea catchment.

Table III.1 Summary statistics from 2010 livestock census

	Numbers				Density (animals/km^2)			
Catchment name	Cattle	Pigs	Sheep	Poultry	Cattle	Pigs	Sheep	Poultry
Blackwater Estuary	1,282	*	5,970	470,807	5.8	*	27.0	2,132
Blackwater Pant	1,240	7,954	2,199	209,668	5.0	32.4	8.9	853
Bourne Brook (Essex)	604	0	*	193	12.8	0	*	4
Brain	345	*	*	2,507	5.2	*	*	38
Can & Roxwell Brook	259	*	*	*	2.7	*	*	*
Chelmer (Lower)	286	*	*	*	4.2	*	*	*
Chelmer (Upper)	459	3,003	1,290	127,819	2.3	15.3	6.6	650
Colne (Essex.Lower)	1,037	373	5,380	88,712	9.0	3.2	46.6	768
Colne (Essex.Upper)	1,405	*	1,989	130,699	13.4	*	18.9	1,243
Dengie	675	*	425	243,979	6.6	*	4.2	2,385
Roman River	1,185	*	2,368	124,785	10.6	*	21.1	1,113
Sandon Brook	618	383	2,448	142,758	7.4	4.6	29.4	1,713
Tendring Streams	1,080	*	2,087	180,400	7.1	*	13.7	1,182
Ter	1,867	*	87	23,518	22.9	*	1.1	289
Wid	251	*	216	97,638	1.8	*	1.5	701
TOTAL	12,593	>11,713	>24,459	>1,843,483	6.9	>6.4	>13.4	>1,007

**Data suppressed to prevent disclosure of information about individual holdings

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

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

Farm Animal	Faecal coliforms (No. g^{-1} wet weight)	Excretion rate (g day^{-1} wet weight)	Faecal coliform load (No. day^{-1})
Chicken	1,300,000	182	2.3×10^8
Pig	3,300,000	2,700	8.9×10^8
Human	13,000,000	150	1.9×10^9
Cow	230,000	23,600	5.4×10^9
Sheep	16,000,000	1,130	1.8×10^{10}

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

There are relatively low numbers and densities of grazing animals (cattle and sheep) within the area. In the catchment immediately adjacent to the fisheries (Blackwater Estuary) there were 5970 sheep and 1282 cattle. Their impacts are therefore likely to be relatively minor overall, although they may be of local significance for example where there is an area of grazing marsh immediately adjacent to a shellfishery. Most of the major watercourses will be impacted in some extent by agriculture, but the smaller watercourses draining areas of grazing marsh adjacent to the shore may be of most impact on the shellfisheries. Livestock were only recorded during the shoreline survey on the Feldy Marshes (~20 sheep) and on the Tollesbury Wick Marshes (~15 sheep and ~15 cattle). The Old Hall marshes are an RSPB reserve which is grazed by cattle in the summer and sheep in the winter to preserve the habitat (Wild Essex, 2013). Much of the land surrounding the three creeks is therefore used for grazing, so the watercourses and field drains discharging to them are likely to carry some contamination of livestock origin.

As well as direct deposition on pastures by livestock, slurry is also collected from livestock sheds when cattle are housed indoors and subsequently applied to fields as fertilizer. Large numbers of poultry and a few pigs are also raised within the catchment. Manure from pig and poultry operations is typically collected, stored and spread on nearby farm land (Defra, 2009). Sewage sludge may also be used as fertilizer, but no information on local practices was available at the time of writing. The primary mechanism for mobilisation of faecal matter deposited or spread on farmland to coastal waters is via land runoff, so fluxes of agricultural contamination into the estuary will be highly rainfall dependent. Peak concentrations of faecal indicator bacteria in watercourses are likely to arise when heavy rain follows a significant dry period (the ‘first flush’).

There is likely to be seasonality in levels of contamination originating from livestock. Numbers of sheep and cattle will increase significantly in the spring, with the birth of lambs and calves, and decrease in the autumn when animals are sent to market. During winter cattle may be transferred from pastures to indoor sheds, and at these times slurry will be collected and stored for later application to fields. Timing of these applications is uncertain, although farms without large storage capacities are likely to spread during the winter and spring. Poultry/pig manure and sewage sludge may be spread at any time of the year. Therefore peak levels of contamination from sheep and cattle may arise following high rainfall events in the summer, particularly if these have been preceded by a dry period which would allow a build up of faecal material on pastures. More localised contamination events may arise if wet weather follows a slurry application which is perhaps more likely in winter or spring.

APPENDIX IV
SOURCES AND VARIATION AND MICROBIOLOGICAL POLLUTION: BOATS

The discharge of sewage from boats is potentially a significant source of bacterial contamination of shellfisheries within the West Mersea estuary. There is significant boat traffic within the West Mersea estuary; it is a popular place for commercial fishing and small pleasure craft. Figure IX.1 presents an overview of boating activity derived from the shoreline survey, satellite images and various internet sources.

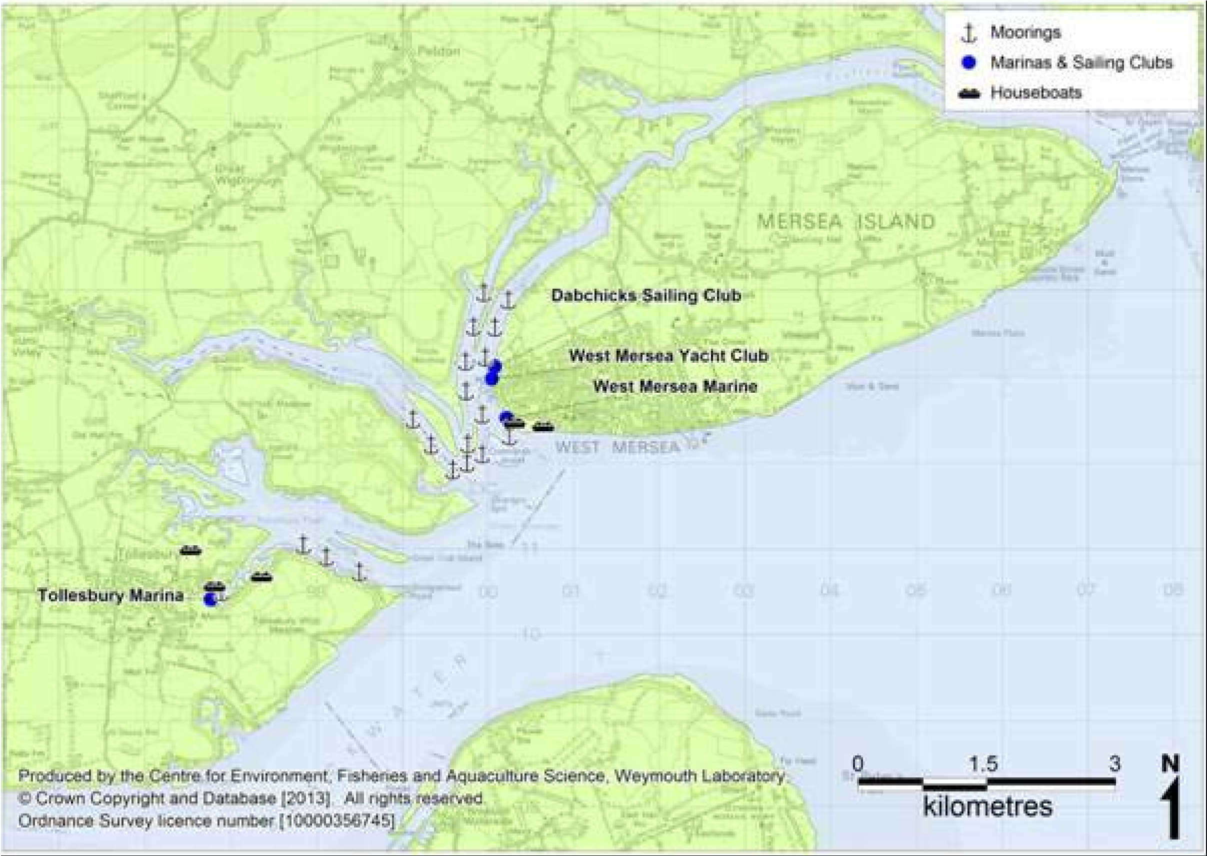

Figure IX.1 Location of mooring areas and sailing clubs at West Mersea

There is a 240 berth marina at Tollesbury and three yacht clubs/boatyards at West Mersea, none of which have sewage pump out facilities (Reeds, 2011). There are extensive areas of moorings located in the south channel of Tollesbury Fleet, the lower reaches of the Salcott Channel, and within the Strood Channel and the Ray Channel which host a large number of yachts and cabin cruisers. Around 30 commercial fishermen operate from West Mersea, 53% work fulltime through all seasons, 37% on a part time seasonal basis and 10% as a hobby (Marine Management Organisation, 2010). Around 20 houseboats reside on the south west tip of Mersea Island, and a few were recorded at Tollesbury. No commercial ports are situated in the West Mersea, the closest, Brightlingsea Port, is situated approximately 10 km north east in the Colne estuary. It is therefore assumed that merchant shipping is only likely to pass regularly through the navigation channel leading into the Colne, and such vessels are not allowed to make overboard discharges in inshore waters. Watersports are popular within the sheltered waters of West Mersea, including windsurfing, dinghy sailing and powerboating but such vessels are generally too small to have onboard toilets.

Small private vessels such as yachts, cabin cruisers and fishing vessels are likely to make overboard discharges from time to time. Those in overnight occupation on moorings or at anchor may be more likely to make overboard discharges. It is likely that overboard discharges are also made from time to time by boats navigating in and out of the area. Peak pleasure craft activity is anticipated during the summer and it is probable that more moorings will be occupied at this time. Houseboats in occupation are also likely to make regular discharges and it is quite probable that these will have a higher occupancy rate during the summer months.

On this basis, the areas most at risk from overboard discharges are the lower reaches of the Strood Channel, particularly the area adjacent to West Mersea village, the lower reaches of the Salcott channel, and the south channel of Tollesbury Fleet and the creeks adjacent to Tollesbury village. Given the large numbers of craft present their combined impacts are potentially highly significant. Peak pleasure craft activity is anticipated during the summer, so associated impacts are likely to follow this seasonal pattern. It is difficult to be more specific about the potential impacts from boats and how they may affect the sampling plan without any firm information about the locations, timings and volumes of such discharges.

APPENDIX V
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: WILDLIFE

West Mersea is situated between the Blackwater Estuary and the Colne Estuary and contains significant areas of mudflats and salt marsh which support internationally and nationally important flocks of overwintering birds and wildfowl. Like its neighbouring estuaries the survey area coincides with several national and international designations for nature conservation. It forms part of the Essex Estuaries European Marine Site SAC, and Ray Island Nature Reserve situated in the Strood channel has been designated as an SSSI (West Mersea Town Council, 2011).

Studies in the UK have found significant concentrations of microbiological contaminants (thermophilic campylobacters, salmonellae, faecal coliforms and faecal streptococci) from intertidal sediment samples supporting large communities of birds (Obiri-Danso and Jones, 2000). Over the five winters up until 2010 an average total count of 96,215 overwintering and wildfowl were recorded collectively in the Blackwater and Colne estuaries (Holt *et al*, 2012). Species recorded were Dark Bellied Brent Goose, Golden Plover, Knot, Dunlin and Black Tailed Godwit. Although specific numbers are not available for the West Mersea it is expected that, due to its close proximity to the Blackwater and Colne, large numbers of wildfowl and overwintering birds will frequent the mudflats and saltmarsh of the West Mersea. On the shoreline survey a significant presence of overwintering waterbirds was confirmed.

Some species, such as Grey Plover forage upon shellfish and so will forage (and defecate) directly on the shellfish beds across a wide area. They may tend to aggregate in certain areas holding the highest densities of bivalves of their preferred size and species, but this will change from year to year. Contamination via direct deposition may be quite patchy, with some shellfish containing quite high levels of *E. coli* with others a short distance away unaffected. Due to the diffuse and spatially unpredictable nature of contamination from wading birds it is difficult to select specific RMP locations to best capture this, although they may well be a significant influence during the winter months. Other species, such as geese will graze on saltmarsh areas so their faeces will be carried into coastal waters either via land runoff from these areas or via tidal inundation.

Whilst most of the overwintering population migrate elsewhere in the summer, a much smaller but nevertheless potentially significant population of resident and breeding birds will remain. A survey of breeding seabirds (gulls, terns etc) recorded 351 pairs of gulls and terns nesting in the immediate vicinity of the survey area and 2,759 pairs across the wider Blackwater and Colne area (Mitchell *et al*, 2004). These are likely to forage widely throughout the area, therefore faecal inputs could be considered as diffuse. However, it is expected to be more concentrated in the immediate vicinity of their nest sites which are generally situated in the more undisturbed areas such as the small islands within the creeks and the Old Hall Marshes.

Harbour Seals have been sighted within the West Mersea creeks, and the Essex estuaries support a population of about 100 animals. In the Blackwater they can be sighted all year round but are most predominant in the late summer and mid-winter when they utilise the extensive mudflats as feeding and haulout sites (Marine Management Organisation, 2011). In spatial terms, contamination is likely to be heaviest in the immediate vicinity of their haulout site. However, because they mostly occur at the mouth of the estuary they are not considered significant sources of contamination for the purposes of this assessment and given the large area they are likely to forage over impacts are likely to be minor, and unpredictable in spatial terms, but will peak during the summer, and be at its lowest during the autumn.

An otter survey conducted in 2008 revealed that otters are not present within the West Mersea estuary (Tansley, 2009). No other wildlife species which have a potentially significant influence on levels of contamination within shellfish within the survey area have been identified.

APPENDIX VI
METEOROLOGICAL DATA: RAINFALL

West Mersea is located in the east of England, which is one of the driest and warmest regions in the country. The Mersea weather station received an average of 483mm per year between 2003 and 2012. Figure II.1 presents a boxplot of daily rainfall records by month at Mersea.

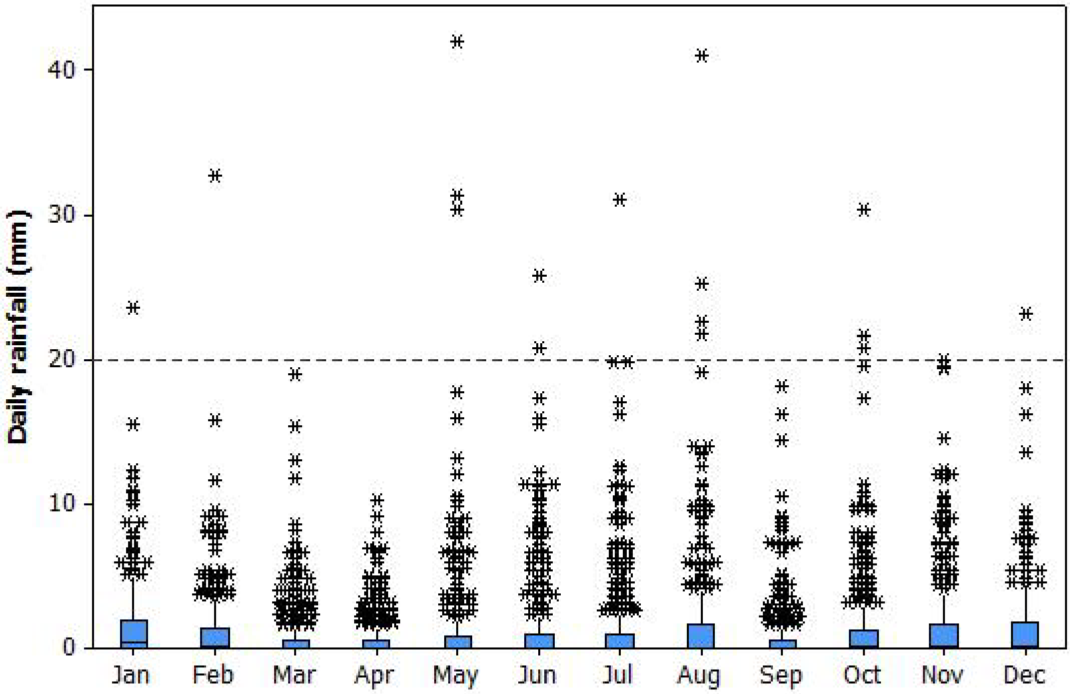

Figure II.1 Boxplot of daily rainfall totals at Mersea, January 2003 to August 2012.
Data from the Environment Agency

Rainfall records from Mersea, which is representative of conditions in the vicinity of the shellfish beds indicate relatively low seasonal variation in average rainfall. Rainfall was lowest on average in March, April and September and highest on average in November and August. Daily totals of over 20mm were recorded on 0.45% of days and 52.5% of days were dry. High rainfall events, whilst relatively rare, tended to occur most during the summer and autumn but events of over 20mm were recorded in all months apart from March, April September and November.

Rainfall may lead to the discharge of raw or partially treated sewage from combined sewer overflows (CSO) and other intermittent discharges as well as runoff from faecally contaminated land (Younger *et al.*, 2003). Representative monitoring points located in parts of shellfish beds closest to rainfall dependent discharges and freshwater inputs will reflect the combined effect of rainfall on the contribution of individual pollution sources. Relationships between levels of *E. coli* and faecal coliforms in shellfish and water samples and recent rainfall are investigated in detail in Appendices XI and XII.

APPENDIX VII
METEOROLOGICAL DATA: WIND

Eastern England is one of the more sheltered parts of the UK, since the windiest areas are to the north and west, closer to the track of Atlantic storms (Met Office, 2012). The strongest winds are associated with the passage of deep depressions across or close to the UK. The frequency of depressions is greatest during the winter months so this is when the strongest winds normally occur.

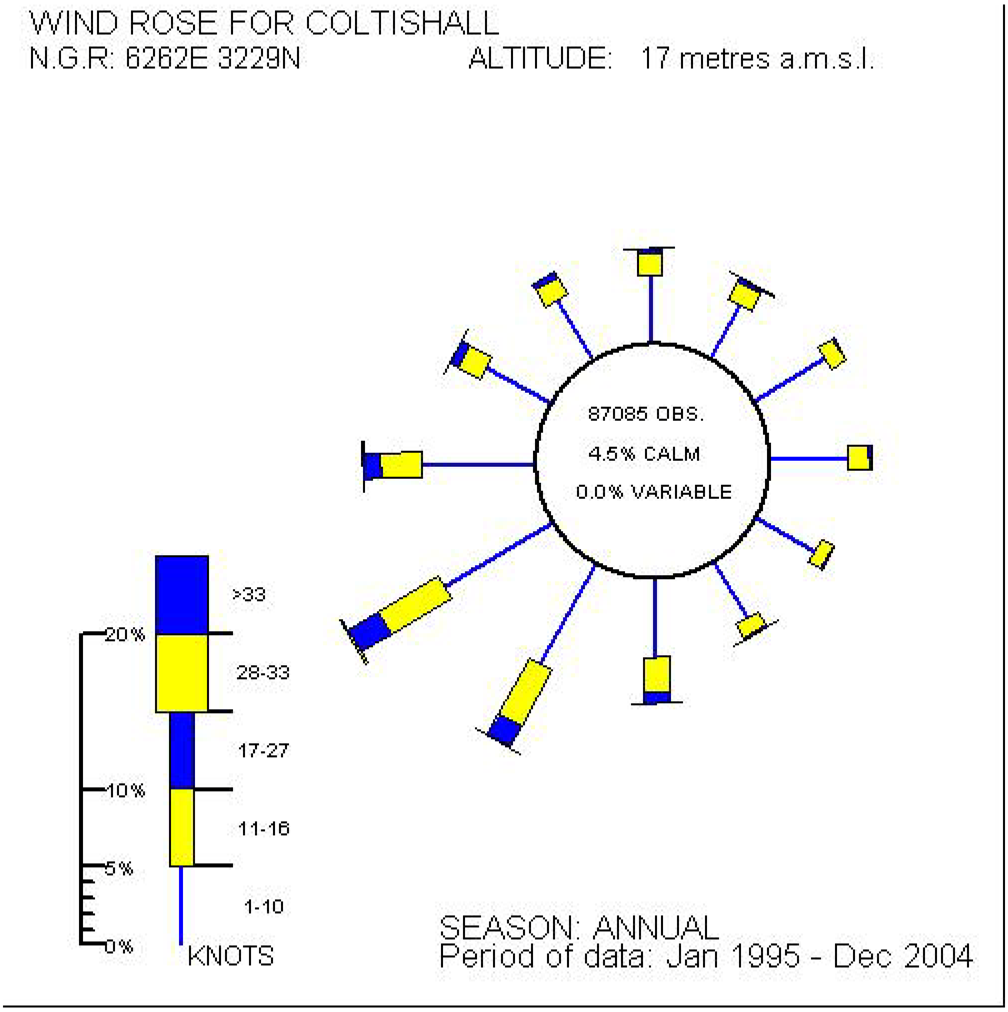

Figure VI.1 Wind rose for Coltishall
Produced by the Meteorological Office. Contains public sector information licensed under the Open Government Licence v1.0

The wind rose for Coltishall, typical of open, level locations across the region. There is a prevailing south-westerly wind direction throughout the year. During spring there is also a high frequency of north-easterly wind's due to a build up of high pressure over Scandinavia (Met Office, 2012). Periods of very light or calm winds are more prevalent inland, with coastal areas having similar wind directions to inland locations but higher wind speeds. The area south of Mersea Island is most exposed to the south east, although it is also exposed to the south west as winds blow down the Blackwater estuary. The land surrounding the creeks is low lying but will offer some shelter from winds blowing from most directions.

APPENDIX VIII
HYDROMETRIC DATA: FRESHWATER INPUTS

There are two major estuaries (Colne and Blackwater) which discharge either side of Mersea Island, but relatively little in the way of freshwater inputs direct to the survey area. Figure VIII.1 shows the main rivers in the wider catchment area.

Figure VIII.1 Watercourses within the wider catchment area

The three main inputs to this catchment are the River Chelmer, the River Blackwater and the River Colne, which have a combined catchment area of about 1800km^2. Land use throughout their catchments is mainly arable farming but there are major urban centres in both (Figure 1.2). For the most part, the underlying bed rock is largely low-permeability clay. In the most northern reaches of the catchment however, the bed rock is high permeability chalk. The low permeability of the catchment means that there are relatively high runoff rates that flow directly into the watercourses (Environment Agency, 2009). There are several flow gauging sites within this wide catchment, summary statistics for which are presented in Table VIII.1.

Table VIII.1: Summary flow statistics for flow gauge stations on watercourses draining into the Colne estuary

Watercourse	**Station name**	**Catchment area (km^2)**	**Mean annual rainfall 1961-90 (mm)**	**Mean flow (m^3s^{-1})**	**Q95[1] (m^3s^{-1})**	**Q10[2] (m^3s^{-1})**
Bentley Brook	Saltwater Bridge	12.1	550	0.034	0.003	0.076
Colne	Lexden	238.2	566	1.065	0.202	2.197
Roman	Bounstead Bridge	52.6	560	0.340	0.066	0.641
Sixpenny Brook	Ship House Bridge	5.1	554	0.025	0.003	0.059
St Osyth Brook	Main Road Bridge	8.0	544	0.032	0.000	0.085
Tenpenny Brook	Tenpenny Bridge	29.0	556	0.085	0.011	0.212
Blackwater	Langford	337	570	1.376	0.224	2.884
Chelmer	Rushes Lock	534	583	1.909	0.132	4.830
Chelmer	Churchend	73	591	0.357	0.052	0.774

[1]Q95 is the flow that is exceeded 95% of the time (i.e. low flow). [2]Q10 is the flow that is exceeded 10% of the time (i.e. high flow). Data from NERC (2012).

Boxplots of mean daily flow records by month at the Lexden, Churchend and Langford gauging stations are presented in Figures VIII.2 to VIII.4. It should be noted that abstraction occurs on all three of these rivers below the gauging station, so flows at the tidal limit will be lower at times.

Flows were highest in the colder months at all gauging stations. At Langford, record flows of up to 53 m^3/s were recorded in February 2009 following heavy rainfall events. The seasonal pattern of flows is not entirely dependent on rainfall as during the colder months there is less evaporation and transpiration, leading to a higher water table. This in turn leads to a greater level of runoff immediately after rainfall. Increased levels of runoff are likely to result in an increase in the amount of microorganisms carried into coastal waters. Additionally, higher runoff will decrease residence time in rivers, allowing contamination from more distant sources to have an increased impact during high flow events.

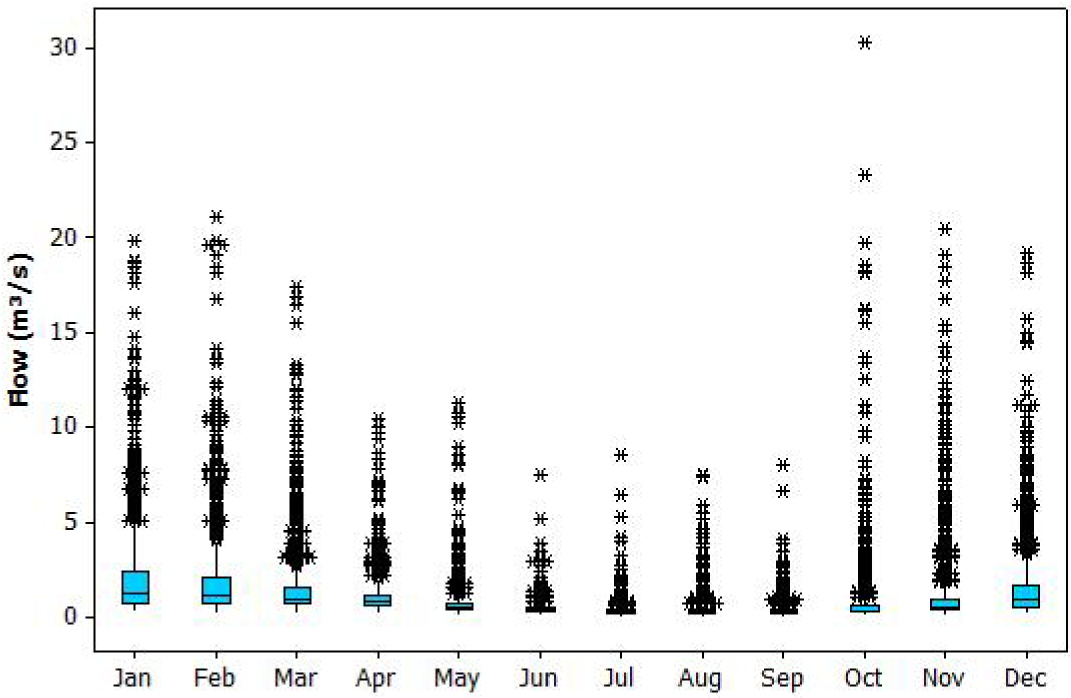

Figure VIII.2: Boxplots of mean daily flow records from the Lexden gauging station on the River Colne from 1959-2010. *Data from the Environment Agency.*

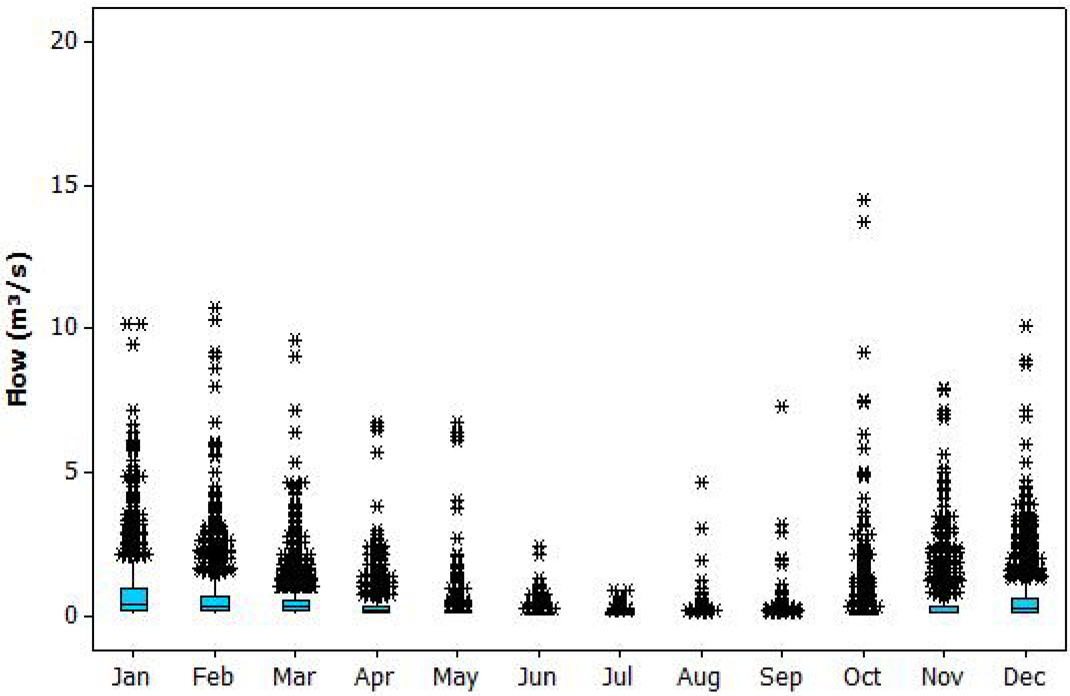

Figure VIII.3: Boxplots of mean daily flow records from the Churchend gauging station on the River Chelmer from 1963-2010. *Data from the Environment Agency.*

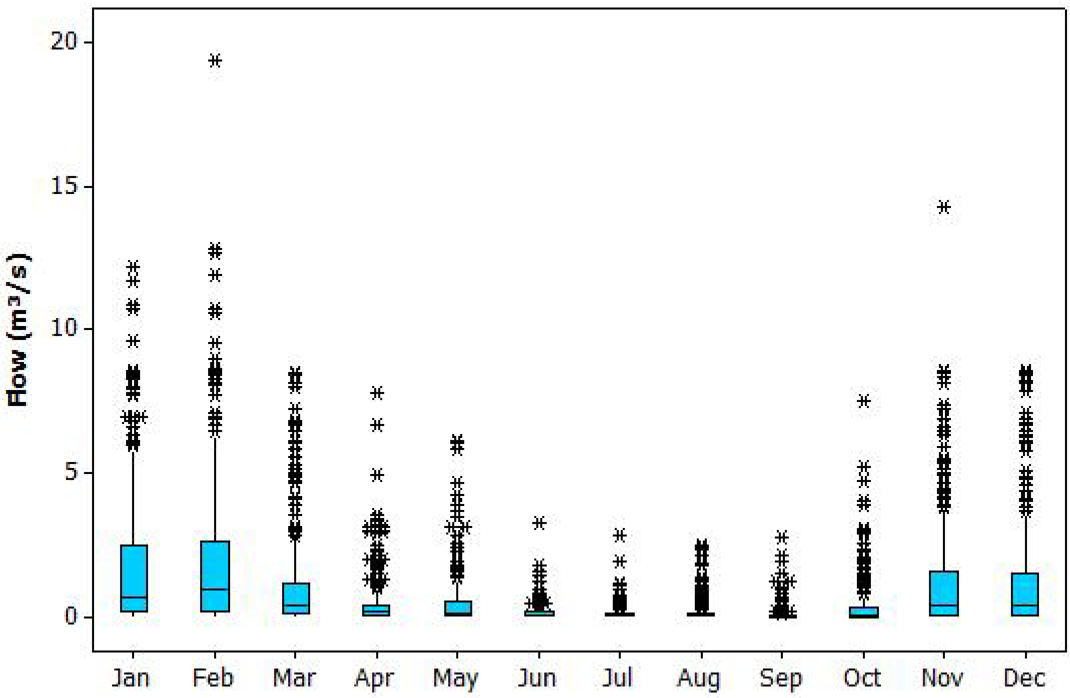

Figure VIII.4: Boxplots of mean daily flow records from the Langford gauging station on the River Blackwater from 2000-2009. Two data points from February 2009 were removed from the dataset. These data showed flows of 53 and 48 m³/s following heavy rainfall events.
Data from the Environment Agency.

The combined effects of freshwater inputs and other sources of contamination to the Colne and Blackwater estuaries are likely to be of significance to shellfisheries within the survey area at West Mersea. Their influence will be felt via the plumes emanating from their mouths as the tide ebbs. As such, this is likely to be widespread, and of little immediate influence within the three tidal creeks considered in this survey, as the tide will also be ebbing from these at the same time. As such, any small watercourses discharging to these creeks and to the south shore of Mersea Island will be of more influence to the sampling plan as they may create small 'hotspots' of contamination within the survey area.

Figure VIII.5 shows the 'main rivers' draining to the area. These are watercourses which are under the control of the Environment Agency. In addition to these there are a series of minor watercourses, land drains and surface water outfalls along all shorelines. During the shoreline survey, all freshwater inputs to the south shore of Mersea Island were sampled and measured, from which an estimate of the bacterial loading they were generating at the time was made (Table XII.2 for details). Those discharging to the three creeks could not however be sampled or measured due to access constraints.

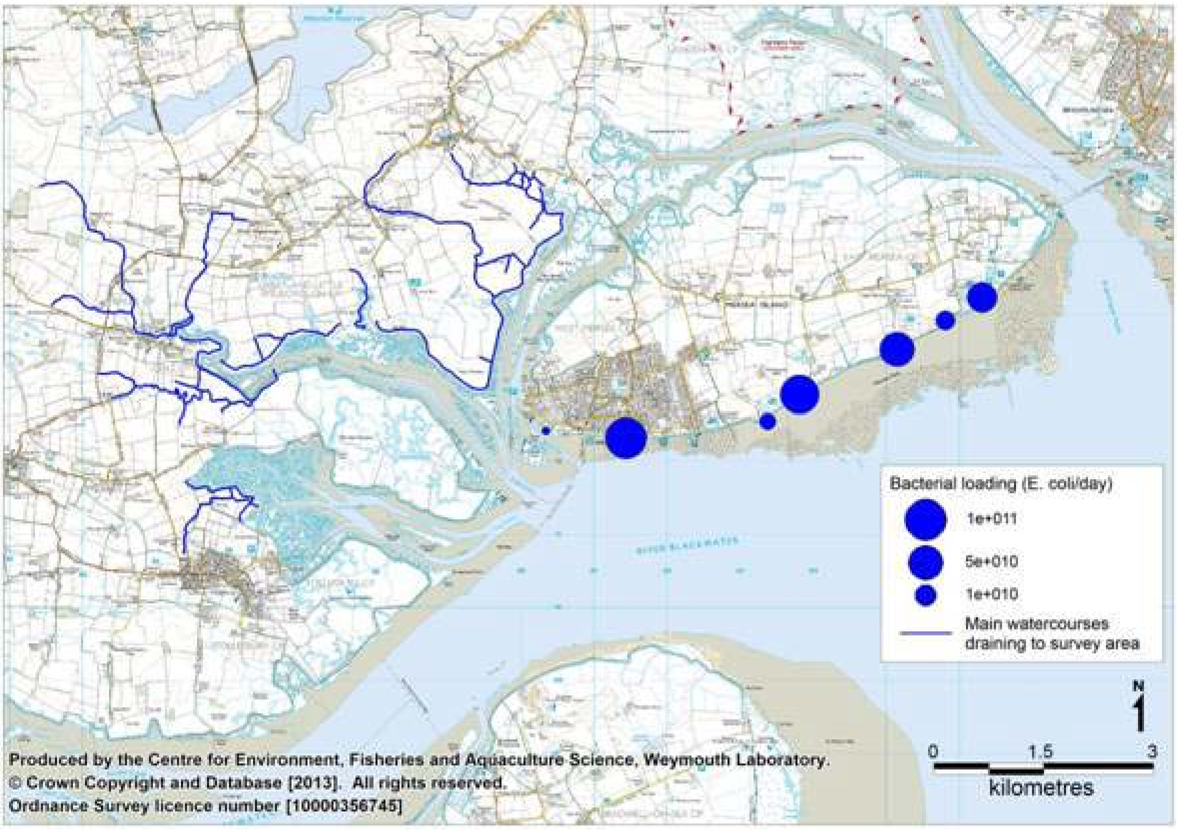

Figure VIII.5. Freshwater inputs direct to the survey area

Although none of the freshwater inputs to the south shore of Mersea Island were particularly large in terms of volumes discharged, some were carrying quite high concentrations of *E. coli* and so may create a localised hotspot of contamination. There are no 'main rivers' draining to the survey area from Mersea Island. The three creeks do all receive freshwater inputs from 'main rivers' as well as other freshwater inputs although these are only small streams and field drains with small catchment areas. The largest of these include streams draining to the head of the Salcott Channel and two watercourses draining to the upper reaches of Ray Creek. All three creeks are surrounded by sea walls, and on the landward side of this drains (or borrow dykes) run adjacent for most of the length. From these drains there are a large number of minor outfalls which discharge to the creeks which will carry some contamination when they are discharging.

In summary, there are two major estuaries either side of the survey area which will have some influence on levels of indicator bacteria in the area, particularly Mersea Flats which will be exposed to some extent to the ebb plumes from them. The largest watercourses discharging direct to the survey area are streams discharging to the head of the Salcott Channel and to the upper reaches of Ray Creek, which may result in decreased water quality in the upper reaches of these water bodies at times. Otherwise, freshwater inputs are via a large number of small land drains and surface water outfalls, all of which are minor in terms of volumes discharged. Some of those which were sampled and measured during the shoreline survey of the south shore of Mersea Island were carrying quite high concentrations of *E. coli* so could be of influence to the fishery on Mersea Flats.

APPENDIX IX
HYDROGRAPHY

BATHYMETRY

Figure IX.1 presents part of the Imray chart for the Colne, Blackwater, Crouch and Roach. This was printed in 2007 but did not indicate when the depth measurements were taken. The bathymetry may be slightly different now but important features are unlikely to have changed significantly.

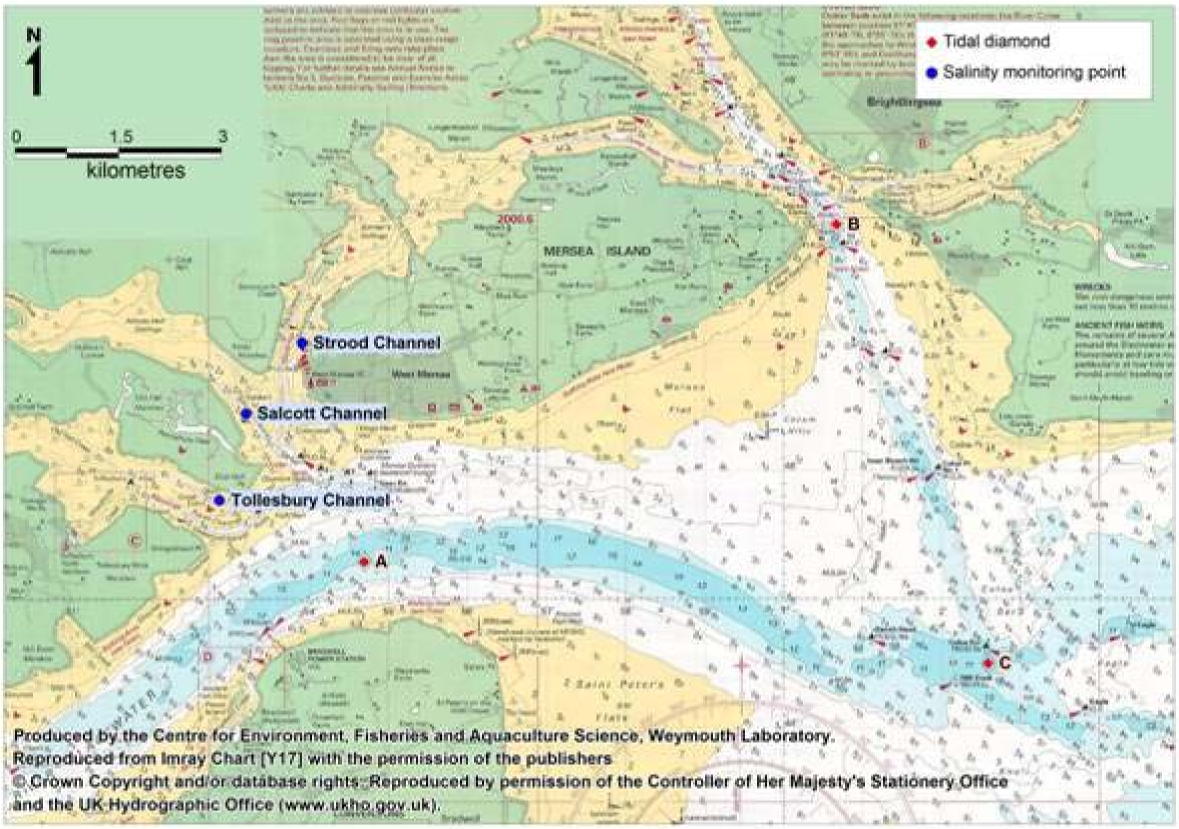

Figure IX.1 Bathymetry chart of the West Mersea

The survey area consists of three main tidal creeks which converge south east of Old Hall Point where they meet with the mouth of the Blackwater estuary (Figure IX.1), as well as a gently sloping intertidal and subtidal area to the south of Mersea Island. The creeks are predominantly intertidal, with extensive mudflats fringed with salt marsh situated in the upper reaches. As a consequence a large proportion of water will be exchanged on each tide, but the dilution potential will be quite low away from the main channels. An extensive area of salt marsh, the Old Hall Marshes, which is not submerged at high tide is situated between the Tollesbury and Salcott Creek. The upper reaches of the Strood Creek are constrained by a tidal causeway which is covered only at high water on spring tides. Consequently, water exchange between the Strood and Pyefleet Channel is minimal and limited to these times. Land surrounding West Mersea is low lying and prone to flooding, and the entire perimeter on the mainland the northern perimeter of Mersea Island is protected by sea walls. Groynes intermittently protect the west and south of Mersea Island.

Mersea Flats is an extensive area of intertidal mud/sand/gravel flats that runs the length of the south coast of Mersea Island and extends southwards into the subtidal zone, to the fishing buoy outside of the Colne. This area is gently sloping and depths range from 3m above chart datum (CD) down to a depth of 3m relative to CD on the west. The gradient on the western side of Mersea Island is slightly steeper than on the east. Offshore from Mersea Flats there are two channels which diverge at Cone Bar and run into the Colne and Blackwater estuaries. These will carry the main tidal streams in and out off these two estuaries. A scoured channel joins the Blackwater channel at The Nass, to the South of the western tip of Mersea Island, which carries the main tidal flows in and out of the Strood and Salcott channels and Tollesbury Fleet.

WATER CIRCULATION PATTERNS

Currents in coastal waters are predominantly driven by a combination of tide, wind and density effects. Tidal amplitude is large (Table IX.1) and will drive extensive water movements throughout the area.

Table IX.1 Tide levels and ranges at West Mersea

	Height (m) above Chart Datum				**Range (m)**	
Port	MHWS	MHWN	MLWN	MLWS	Springs	Neaps
West Mersea	5.1	3.8	1.2	0.5	4.6	2.6

Data from the Proudman Oceanographic Laboratory

The flood tide will convey relatively clean water originating from the open North Sea into the area and up the creeks, whereas the ebb tide will carry contamination from shoreline sources back out to sea. Offshore tidal streams flood down the Essex coast towards the Thames Estuary in a south westerly direction, and reverse on the ebb. The indentation to the coast at the Colne and Blackwater estuaries cause the flood streams to be diverted in a northwesterley and westerly direction into these estuaries. There are three tidal diamonds in the area, all of which are located in the main channels leading into the two estuaries (Figure IX.1). Tidal stream information from this diamond is shown in Table IX.2.

Table IX.2. Tidal stream information from tidal diamonds

	A (51° 45.3'N 0° 54.7'E) Blackwater estuary mouth			B (51° 47.9'N 1° 00.7'E) Colne estuary mouth			C (51° 44.5'N 1° 02.6'E) Colne Bar		
	Direction (°)	Spring rate (m/s)	Neap rate (m/s)	Direction (°)	Spring rate (m/s)	Neap rate (m/s)	Direction (°)	Spring rate (m/s)	Neap rate (m/s)
HW-6	85	0.05	0.05		0.00	0.00	90	0.05	0.05
HW-5	264	0.31	0.21	0	0.21	0.15	284	0.21	0.15
HW-4	262	0.46	0.31	12	0.41	0.26	283	0.46	0.31
HW-3	264	0.57	0.36	10	0.46	0.31	275	0.67	0.46
HW-2	263	0.62	0.41	2	0.57	0.36	275	0.72	0.46
HW-1	258	0.72	0.46	358	0.46	0.31	290	0.72	0.46
HW	249	0.46	0.31	353	0.31	0.21	291	0.36	0.26
HW+1	90	0.21	0.15	180	0.26	0.15	81	0.41	0.26
HW+2	86	0.51	0.36	183	0.62	0.41	100	0.77	0.51
HW+3	79	0.77	0.51	190	0.67	0.41	98	0.87	0.57
HW+4	74	0.77	0.51	187	0.51	0.36	99	0.67	0.46
HW+5	81	0.31	0.21	180	0.21	0.15	102	0.41	0.26
HW+6	86	0.21	0.15	180	0.10	0.05	94	0.26	0.15

These tidal diamonds confirm that the tidal streams into the two estuaries diverge at Colne Bar and follow their respective channels into the estuaries, with the reverse occurring on the ebb. Current speed is slightly faster in the Blackwater estuary mouth than the Colne estuary mouth, and in both cases neap current speeds are about 65% of that experienced on springs.

The Bathymetry shows a scoured channel diverges from the main Blackwater channel at the Nass Beacon, through which tidal streams into the three creeks (Tollesbury Fleet and the Salcott and Strood Channels). All three of these creeks have two parallel subtidal channels in their lower reaches that are separated at the lower states of tide. There is a smaller subtidal channel (Besom Fleet) which runs north of Cobmarsh Island through which some of the flows in and out of the Strood Channel are likely to pass. Within these creeks a bi-directional pattern of tidal circulation is anticipated, travelling up on the flood and back down on the ebb. Shoreline sources of contamination will therefore primarily impact up and downstream of their locations along the bank to which they discharge.

Mersea Flats forms an elevated triangle between the two main estuary channels, and backed by Mersea Island. The tide here is likely to flood across this area from the two main estuary channels. Current speeds are likely to be significantly slower than in the main channels. During the ebb tide, water will drain back away towards the main channels. At the very eastern end of Mersea Flats, there will be some impacts from any plume of more contaminated water ebbing from the Colne estuary. At the western end, the ebb flows from the three creeks and to the Blackwater estuary are likely to be of significance, particularly in the subtidal areas, and such influences will extend further along the Mersea Island shore than that of the Colne. Contamination carried within these plumes will have been subject to a high level of dilution by the time it reaches the estuary mouth. Intertidal areas adjacent to the central parts of the Mersea Island foreshore will only be subject to contamination from local sources in the main.

Freshwater inputs may significantly modify the circulation of water around estuaries via density effects. Both the Colne and the Blackwater estuaries have low flow ratios, indicating that freshwater inputs are very low in relation to tidal exchange (Futurecoast, 2012). As the majority of freshwater inputs to the area are via these estuaries it is anticipated that the influence of salinity on circulation within the study area is negligible. Salinity measurements taken within the three creeks (n=41 in all cases) are presented in Figure IX.2, and sampling locations are shown in Figure IX.1.

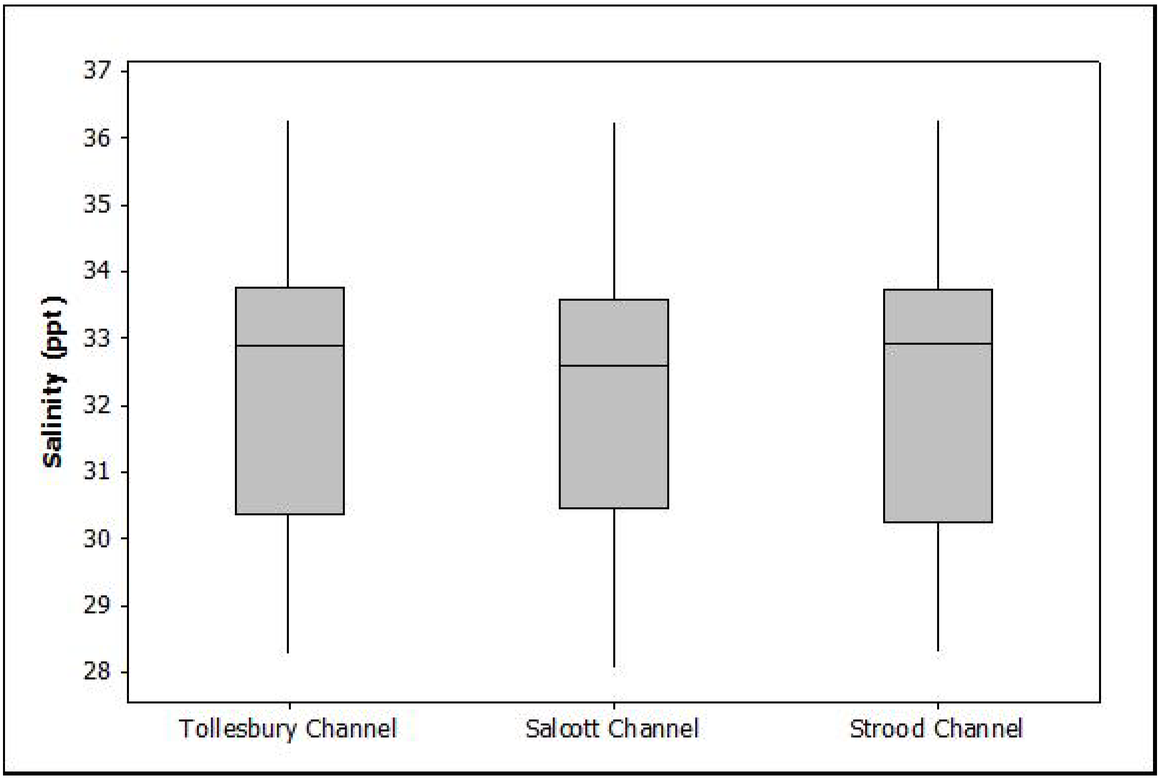

Figure IX.2. Boxplot of salinity measurements taken under the Shellfish Waters monitoring programme. *Data from the Environment Agency*

These salinity measurements confirm that salinity is approaching that of full strength seawater (35ppt) within these creeks, although occasionally salinities of just under 30ppt were recorded. These slight decreases in salinity were not correlated with higher levels of faecal indicator organisms in the water column (Appendix X).

Tidally driven currents may also be modified by the effects of wind. Strong winds will typically drive surface water at about 3% of the wind speed (Brown, 1991) so a gale force wind (34 knots or 17.2 m s^{-1}) would drive a surface water current of about 1 knot or 0.5 m s^{-1}. These currents in turn create return currents, which may travel at depth or along sheltered margins. Exact effects are dependent on the wind speed and direction as well as state of the tide and other environmental variables so a great range of scenarios may arise. Winds from the prevailing south westerly direction will tend to push surface water from the Blackwater estuary onto Mersea Flats and possibly up the Strood Channel. Mersea Flats, the Salcott Channel and Tollesbury Fleet are most exposed to the south east and winds from this direction would push surface water up towards the shore and up the creeks. As well as driving surface currents, onshore winds will create wave action. Waves may resuspend any contamination held within the sediments of the intertidal zone, temporarily increasing levels of contamination within the water column until it is carried away by the tides. Energetic wave action will arise on the south shore of Mersea Island when there are strong winds from the south-east quadrant. Significant wave action is not generally anticipated within the creeks as they are small and more sheltered.

APPENDIX X
MICROBIOLOGICAL DATA: SEAWATER

BATHING WATERS

There is one bathing water site within the survey area designated under the Directive 76/160/EEC (Council of the European Communities, 1975). Due to changes in the analyses of bathing water quality by the Environment Agency from 2012, only data produced up to the end of 2011 was used in these analyses.

Figure X.1 Location of designated bathing and shellfish water monitoring points at West Mersea.

Twenty water samples were taken from the bathing waters site during each bathing season, which runs from the 15th May to the 30th September. Faecal coliforms (confirmed) were enumerated in all these samples. Summary statistics of all results from 2003 to 2011 are presented in Table X.1. Figure X.2 presents box plots of all results from the West Mersea bathing water site by year from 2003 to 2011.

Table X.1 Summary statistics for bathing waters faecal coliforms results, 2003-2011 (cfu/100ml).

N	Geo-mean	Min.	Max.	% exceeding 100 cfu/100ml	% exceeding 1000 cfu/100ml
180	10.1	<2	1360	12.8	2.2

Data from the Environment Agency

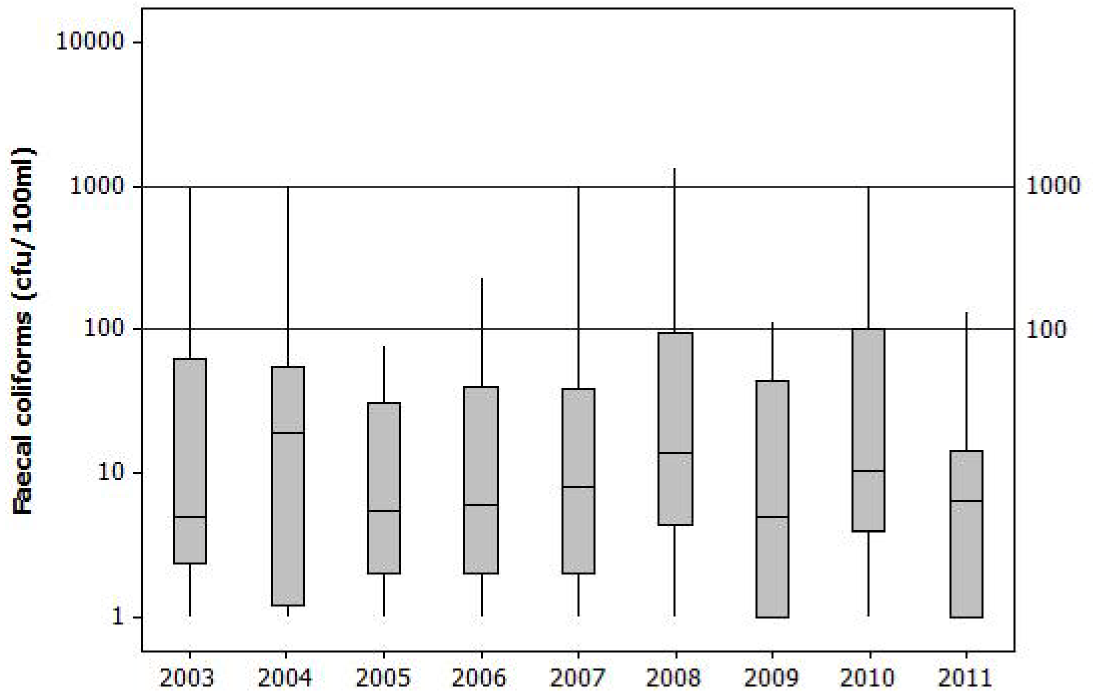

Figure X.2 Box-and-whisker plots of all faecal coliforms results by year
Data from the Environment Agency

Comparisons of the results found no significant difference by year (1-way ANOVA, p=0.557). This indicates that the level of faecal coliforms found in these bathing waters has not changed significantly in recent years.

To investigate the effects of tidal state on faecal coliform results, circular-linear correlations were carried out against both the high/low and spring/neap tidal cycles. Correlation coefficients are presented in Table X.2.

Table X.2 Circular linear correlation coefficients (r) and associated p values for faecal coliform results against the high low and spring/neap tidal cycles

	high/low		spring/neap	
n	**r**	**p**	**r**	**p**
180	0.389	<0.001	0.317	<0.001

Data from the Environment Agency

Significant correlations were found between levels of faecal coliforms and both of the tidal cycles. Figure X.3 present polar plots of $\log_{10}$ faecal coliform results against tidal states on the high/low cycle. High water at West Mersea is at 0° and low water is at 180°. Results of 100 faecal coliforms/100ml or less are plotted in green, those from 101 to 1000 are plotted in yellow, and those exceeding 1000 are plotted in red.

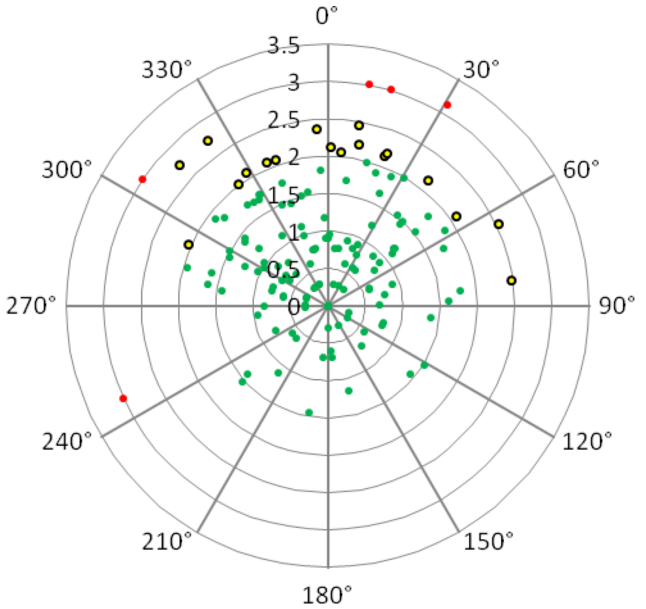

Figure X.3. Polar plots of $\log_{10}$ faecal coliforms against tidal state on the high/low tidal cycle for West Mersea bathing waters monitoring point
Data from the Environment Agency

Sampling was targeted mostly towards high water. Levels of faecal coliforms found tended to be lower during around low water and on the earlier stages of the flood tide. Figure X.4 presents a polar plot of faecal coliform results against the spring/neap tidal cycle. Full/new moons occur at 0º, and half moons occur at 180º. 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.

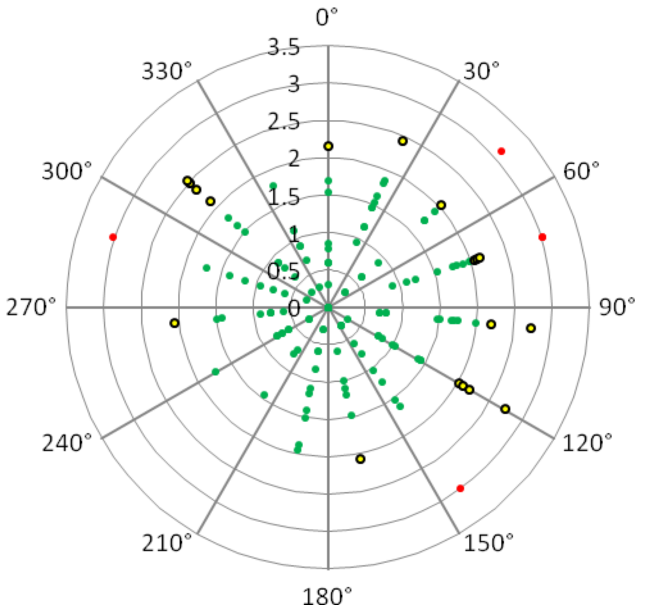

Figure XI.4. Polar plots of $\log_{10}$ faecal coliforms against tidal state on the spring/neap tidal cycle for West Mersea bathing water monitoring point
Data from the Environment Agency

Levels of faecal coliforms at the West Mersea bathing waters monitoring point were highest on average during spring tides and lowest on average during neap tides.

To investigate the effects of rainfall on levels of contamination at the bathing waters sites Spearman's rank correlations were carried out between rainfall recorded at the Mersea weather station (Appendix VI for details) over various periods running up to sample collection and faecal coliforms results at the West Mersea bathing water site. These are presented in Table X.4 and statistically significant correlations ($p<0.05$) are highlighted in yellow.

Table X.4 Spearmans Rank correlation coefficients for faecal coliforms results against recent rainfall

		r
24 hour periods prior to sampling	1 day	0.229
	2 days	0.160
	3 days	0.226
	4 days	0.181
	5 days	0.018
	6 days	0.054
	7 days	0.016
Total prior to sampling over	2 days	0.262
	3 days	0.330
	4 days	0.334
	5 days	0.277
	6 days	0.265
	7 days	0.243

Correlations show that levels of faecal coliforms at the West Mersea bathing water site is influenced by rainfall up to four days after a rainfall event.

SHELLFISH WATERS

Figure X.1 shows the location of the three shellfish water monitoring points which fall within the survey area, designated under Directive 2006/113/EC (European Communities, 2006). Table X.5 presents summary statistics for bacteriological monitoring results from these points. Only water sampling results are presented as flesh results from the shellfish hygiene monitoring programme (Appendix XI) are used to assess compliance with bacteriological standards in shellfish flesh. These were taken on a quarterly basis throughout the period considered.

Table X.5 Summary statistics for shellfish waters faecal coliforms results (cfu/100ml), 2003-2012.

Site	No.	Geometric mean	Minimum	Maximum	% exceeding 100 cfu/100ml	% exceeding 1000 cfu/100ml
Tollesbury Channel	48	4.3	<2	54	0.0	0.0
Salcott Channel	48	3.8	<2	207	2.1	0.0
Strood Channel	48	3.9	<2	81	0.0	0.0

Data from the Environment Agency

Levels of faecal coliforms were low at all three sites, only exceeding 100 cfu/100ml on one occasion in the Salcott Channel. Comparisons between monitoring sites show that there are no significant differences in average faecal coliform levels between them (2-way ANOVA, p=0.645). This analysis did reveal significant variation by sample date (p=0.000), and results at all sites were strongly correlated on a sample by sample basis (Pearsons correlation, r=0.461 or greater, p=0.001 or less). Taken together this indicates that all three sites have similarly low average levels of faecal coliforms and are under similar environmental influences.

Figure X.5 indicates that there is some seasonality in levels of contamination in and around West Mersea, with highest results in the winter and autumn. Statistically significant differences were found between seasons in Tollesbury and Salcott Channels (One-way ANOVA, p<0.001 & p=0.003 respectively) but not in Strood Channel (p=0.166). Post ANOVA tests (Tukeys comparison) showed that in Tollesbury Channel winter and autumn levels of faecal coliforms were significantly greater than in the spring and summer. While in Salcott channel there was significantly higher levels of faecal coliforms in the winter than in spring and summer, but there were no significant differences in contamination between autumn and any other season.

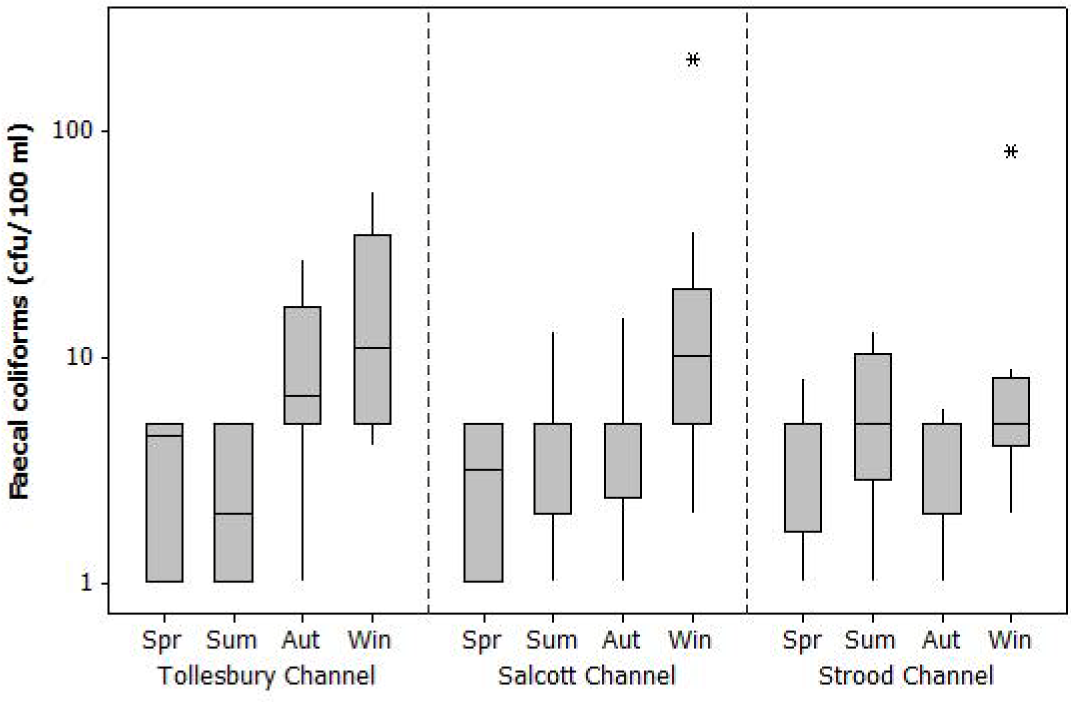

Figure X.5 Boxplot of shellfish growing waters faecal coliforms results by season
Data from the Environment Agency

A significant correlation was found between faecal coliforms results and both the high/low (r=0.370, p=0.002) and the spring/neap tidal cycles at Tollesbury (r=0.399, p=0.001). No significant correlations were found between tidal states and faecal coliforms at either of the other sites. Figure X.6 presents polar plots of $\log_{10}$ faecal coliforms results against tidal state West Mersea. For the high/low cycles, high water at West Mersea is at 0° and low water is at 180°. For the spring/neap cycles, full/new moons occur at 0º, and half moons occur at 180º. 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.

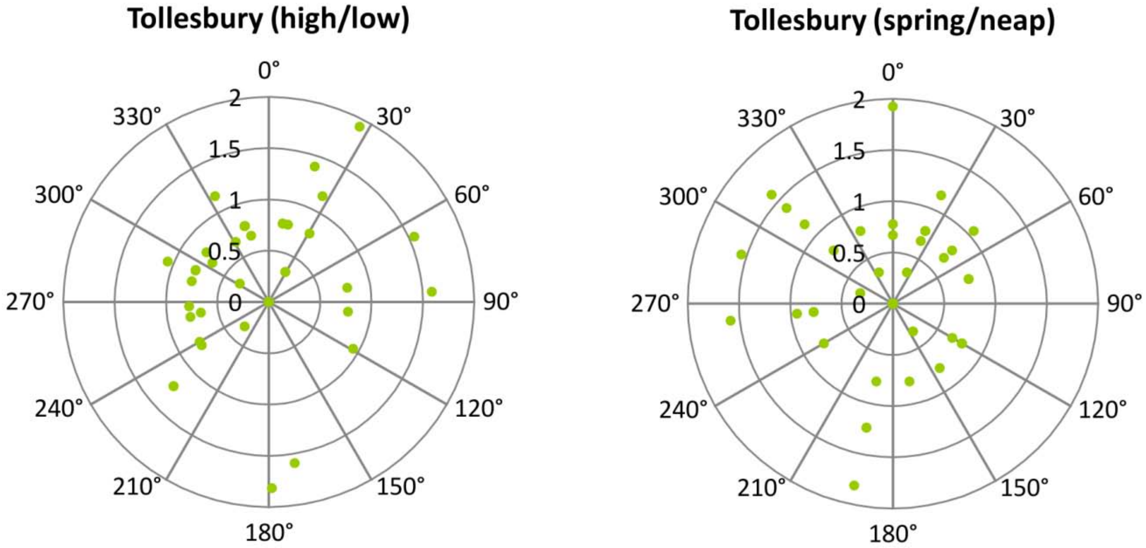

Figure X.6: Polar plots of log_{10} faecal coliforms against tidal state on the high/low and spring/neap tidal cycles
Data from the Environment Agency

Figure X.6 suggests that results were higher during the ebb tide, and higher on average during neap tides. Taken together this would suggest that nearby upstream sources are of some significance.

To investigate the effects of rainfall on levels of contamination at the bathing waters sites Spearman's rank correlations were carried out between rainfall recorded at the Mersea weather station over various periods running up to sample collection and faecal coliforms results. These are presented in Table X.6 and statistically significant correlations ($p<0.05$) are highlighted in yellow.

Table X.6 Spearmans Rank correlation coefficients for faecal coliform results against recent rainfall

		Salcott	Tollesbury	Strood
	n	**47**	**47**	**47**
24 hour periods prior to sampling	1 day	0.154	0.129	0.214
	2 days	-0.030	-0.086	0.070
	3 days	0.195	-0.031	0.217
	4 days	0.303	0.224	0.154
	5 days	0.197	0.008	0.081
	6 days	-0.039	0.033	-0.026
	7 days	0.114	0.342	-0.063
Total prior to sampling over	2 days	0.172	0.132	0.340
	3 days	0.256	0.145	0.336
	4 days	0.377	0.137	0.427
	5 days	0.369	0.090	0.405
	6 days	0.281	0.058	0.281
	7 days	0.196	0.090	0.165

Data from the Environment Agency

Table X.6 shows the influence of rainfall is weak, and is more marked in the Salcott and Strood Channels than in Tollesbury Fleet where an effect was barely detected.

Salinity was recorded on most sampling occasions, and Figure X.7 presents scatter plots of faecal coliforms against salinity.

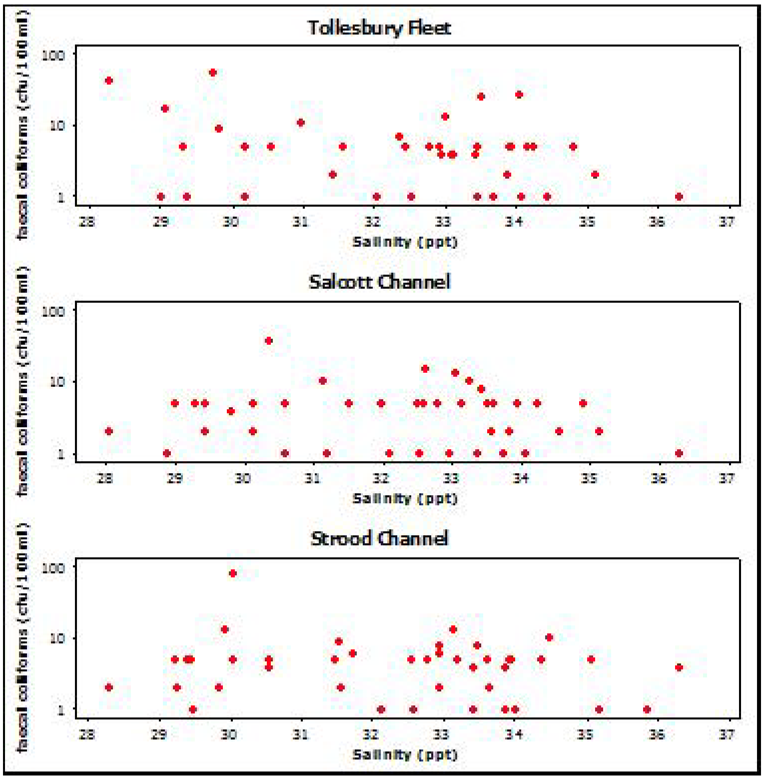

Figure X.6: Scatter plots of faecal coliforms against salinity
Data from the Environment Agency

Figure X.6 indicates that there is no increase in faecal coliforms as salinity decreases, and no correlations were found between the two parameters (Pearson's correlation, p=0.169 or greater).

APPENDIX XI
MICROBIOLOGICAL DATA: SHELLFISH FLESH

SUMMARY STATISTICS AND GEOGRAPHICAL VARIATION

The geometric mean results of shellfish flesh monitoring from all RMPs sampled from 2003 onwards are presented in Figures XI.1 and XI.2. Summary statistics are presented in Table XI.1 and boxplots are presented in Figures XI.3 and XI.4.

Figure XI.1 Native oyster RMPs active since 2003

Figure XI.2 Pacific oyster RMPs active since 2003

Table XI.1 Summary statistics of E. coli *results (MPN/100g) from native oyster and pacific oyster RMPs sampled from 2003 onwards*

RMP	Species	n	Date of first sample	Date of last sample	Geometric mean	Min.	Max.	% over 230	% over 4600
Tollesbury South	Native oyster	80	28/02/2003	13/07/2010	105.0	<20	9100	31.3	1.3
Tollesbury North	Native oyster	113	28/02/2003	02/08/2012	117.4	<20	9200	31.0	1.8
Salcott	Native oyster	111	22/01/2003	15/08/2012	150.1	<20	5400	31.5	0.9
Little Ditch	Native oyster	108	22/01/2003	15/08/2012	71.1	<20	1300	23.1	0.0
Strood Channel	Native oyster	101	22/01/2003	09/01/2012	101.0	<20	3500	25.7	0.0
Cobmarsh Island	Native oyster	25	12/06/2007	19/08/2009	136.8	<20	2200	36.0	0.0
Free Ground	Native oyster	58	22/01/2003	12/05/2008	31.9	<20	1300	8.6	0.0
Mersea Shore	Native oyster	102	22/01/2003	11/07/2012	25.1	<20	1300	6.9	0.0
Strood Channel (relay)	Pacific oyster	106	22/01/2003	15/08/2012	111.9	<20	1700	24.5	0.0
Mersea Flats	Pacific oyster	18	24/03/2011	05/09/2012	36.0	<20	230	0.0	0.0

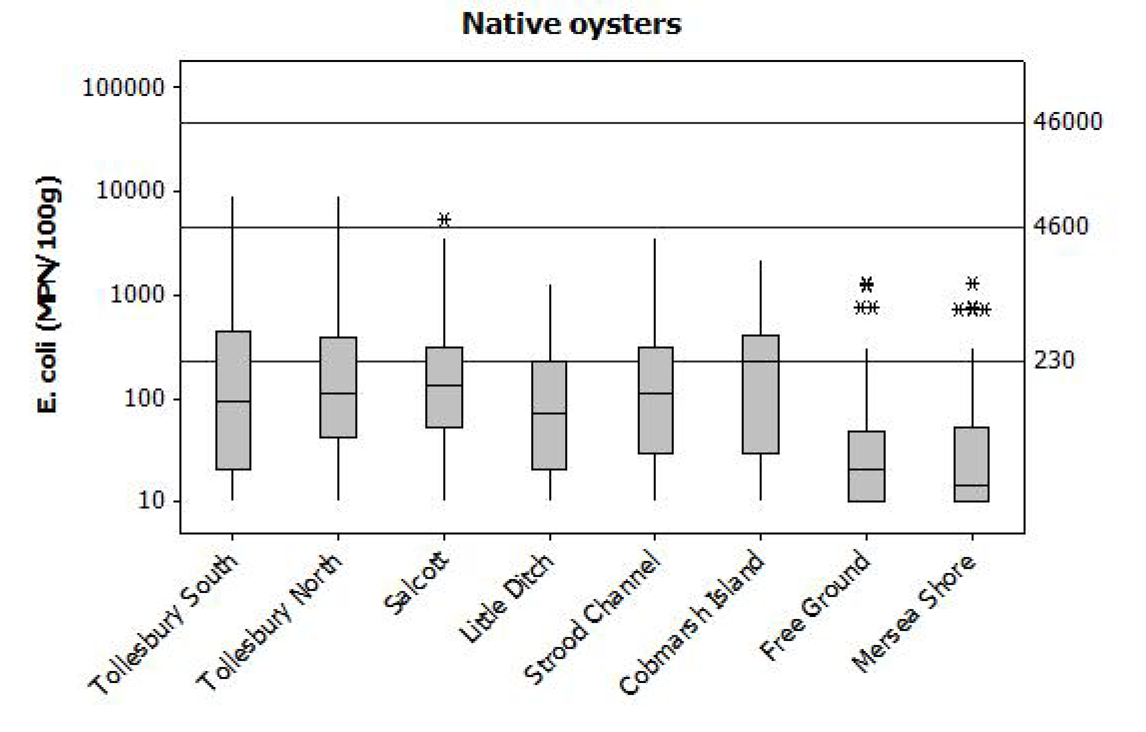

Figure XI.3 Boxplots of* E. coli *results from native oyster RMPs sampled on 10 or more occasions from 2003 onwards.

E. coli levels in native oysters were fairly consistent in all RMPs except Free Ground and Mersea Shore. Comparisons of the sites showed that there was a significant difference in the levels of *E. coli* detected native oysters (One-way ANOVA, $p<0.001$). Post ANOVA tests (Tukey) showed that Salcott and Little Ditch were significantly different from each other, and both Free Ground and Mersea Shore had significantly lower levels of *E. coli* than all other sites. Free Ground and Mersea Shore are both situated on the Mersea Flats, whereas the other sites are within enclosed tidal creeks.

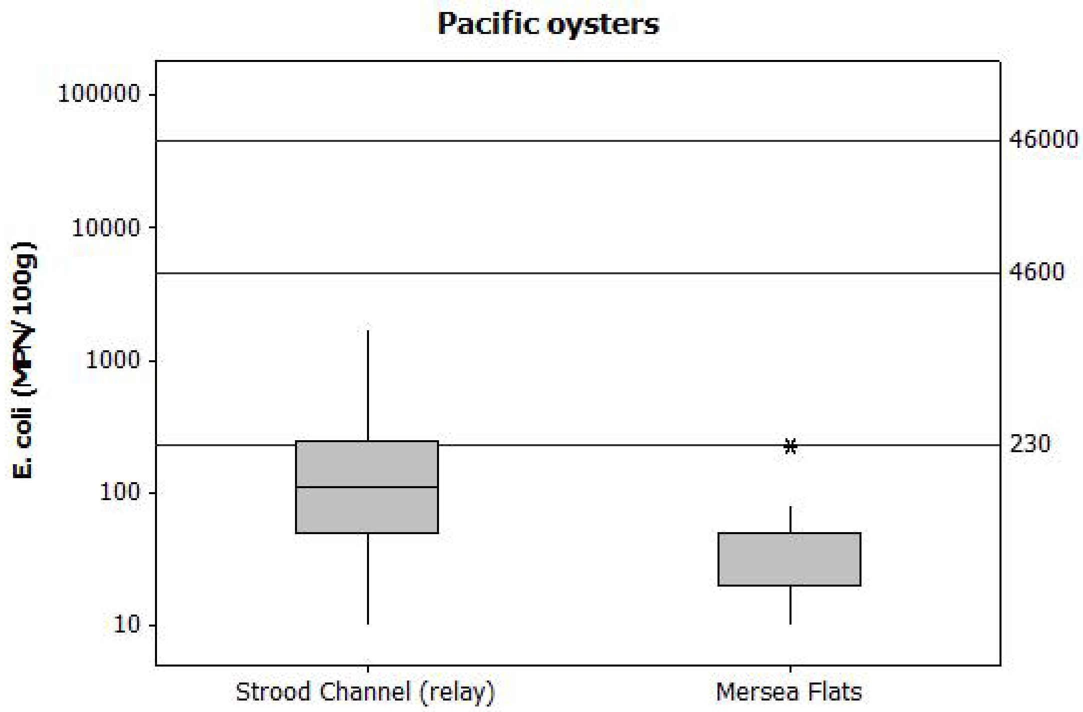

Figure XI.4 Boxplots of* E. coli *results from native oyster RMPs sampled on 10 or more occasions from 2003 onwards.

At the two pacific oyster RMPs *E. coli* levels were similar to those found in the native oyster RMPs. Strood Channel (relay) had significantly higher levels of *E. coli* than Mersea Flats (One-way ANOVA, p<0.001). Similar to native oyster RMPs, the site with lower levels of *E. coli* is located outside of the enclosed tidal creeks.

More robust 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 20 or more occasions. The results of these correlations are summarised in Table XI.2, and significant (p<0.05) results are highlighted in yellow. The Pacific oyster RMPs were not sampled on the same date more than 20 times and so were no compared this way.

Non-significant results suggest that some sites are influenced by a different range of sources which react in a different manner to environmental conditions. This was most frequently the case with comparisons which included Mersea Shore as discussed above. Unlike Mersea Shore, Free Ground had only one comparison (Strood Channel) which gave a non-significant result.

Table XI.2 Pearson's correlations between E. coli results for native oyster RMPs from 2003 onwards

Comparison	r	p
Tollesbury South vs. Tollesbury North	0.534	<0.001
Salcott vs. Little Ditch	0.551	<0.001
Salcott vs. Strood Channel	0.355	<0.001
Salcott vs. Cobmarsh Island	0.546	0.005
Salcott vs. Free Ground	0.381	0.004
Salcott vs. Mersea Shore	-0.007	0.947
Little Ditch vs. Strood Channel	0.370	<0.001
Little Ditch vs. Cobmarsh Island	0.571	0.004
Little Ditch vs. Free Ground	0.411	0.002
Little Ditch vs. Mersea Shore	0.111	0.290
Strood Channel vs. Cobmarsh Island	0.101	0.663
Strood Channel vs. Free Ground	0.062	0.649
Strood Channel vs. Mersea Shore	-0.087	0.417
Cobmarsh Island vs. Mersea Shore	0.020	0.930
Free Ground vs. Mersea Shore	0.464	<0.001

OVERALL TEMPORAL PATTERN IN RESULTS

The overall variation in levels of *E. coli* found in bivalves is shown in Figures XI.5 and XI.6. Only RMPs with data for more than two years were included.

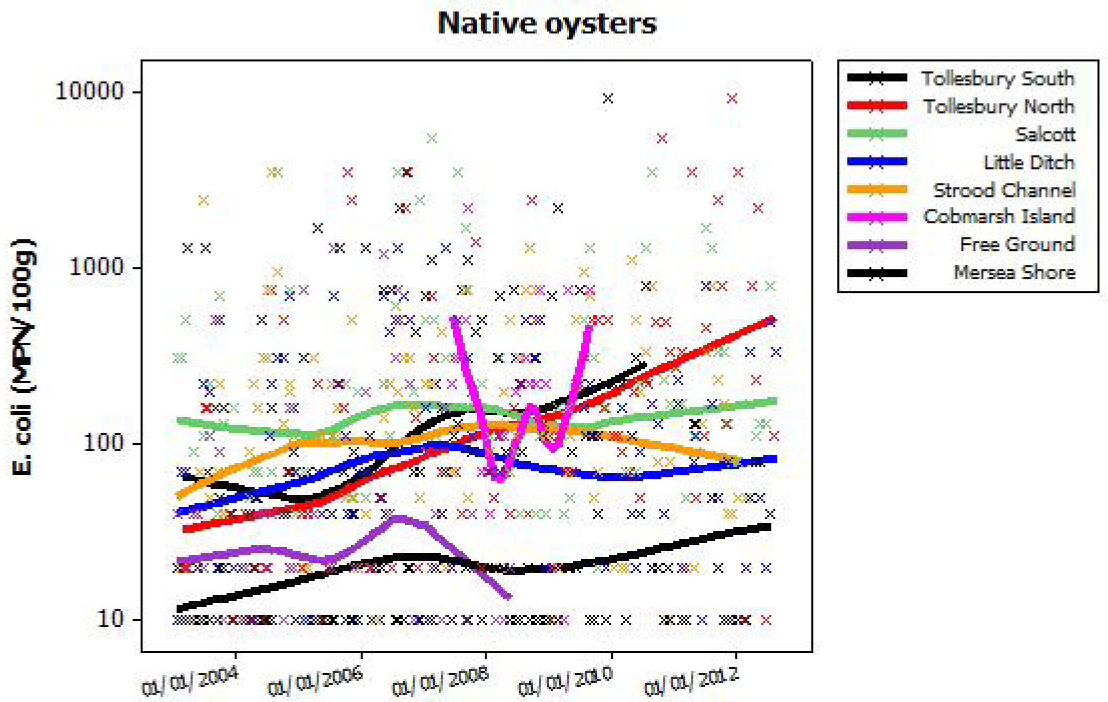

Figure XI.5 Scatter plot of* E. coli *results for native oysters by RMP and date, overlaid with loess lines for each RMP

Figure XI.5 shows that over the years that native oysters have been sampled, the level of *E. coli* found has remained quite consistent at most sites. However, there may have been a slight increase on average at both Tollesbury South and Tollesbury North.

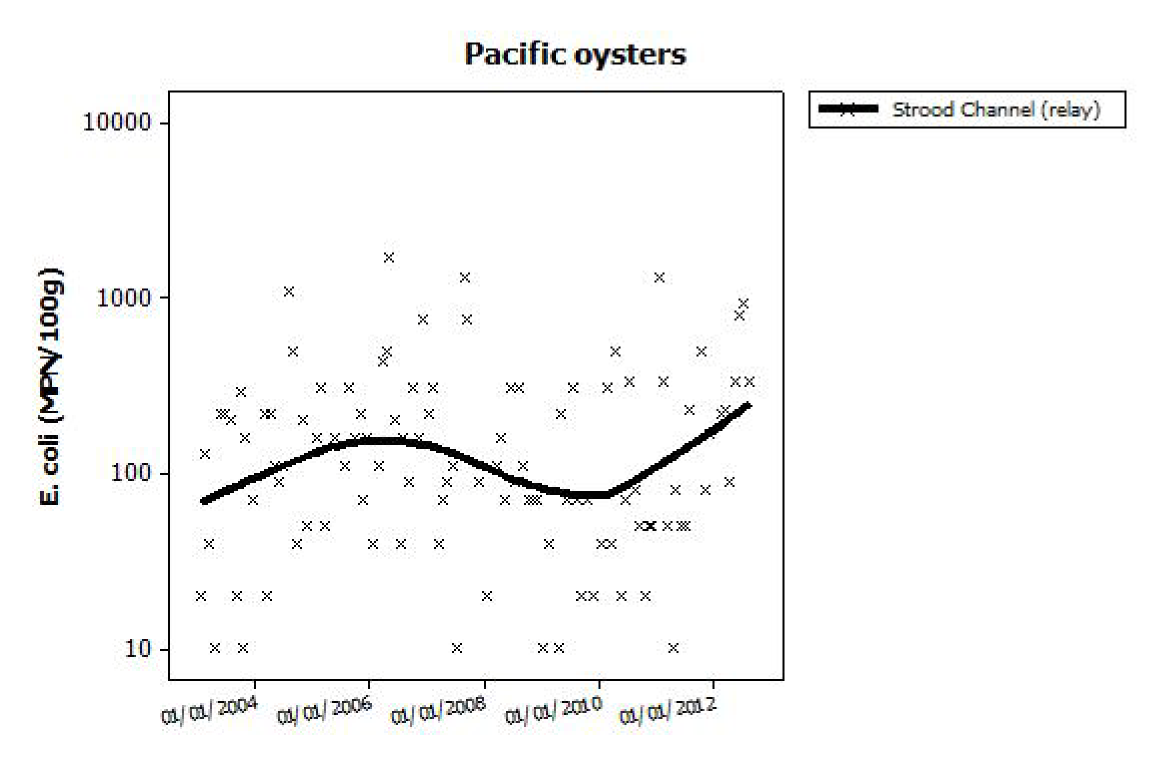

Figure XI.6 Scatter plot of* E. coli *results for Pacific oysters by date, overlaid with loess line

Figure XI.6 shows that the level of *E. coli* found in Pacific oysters has varied only slightly over the years that the data have been recorded.

SEASONAL PATTERNS OF RESULTS

The seasonal patterns of results from 2003 onwards were investigated by RMP for all RMPs where at least 30 samples had been taken.

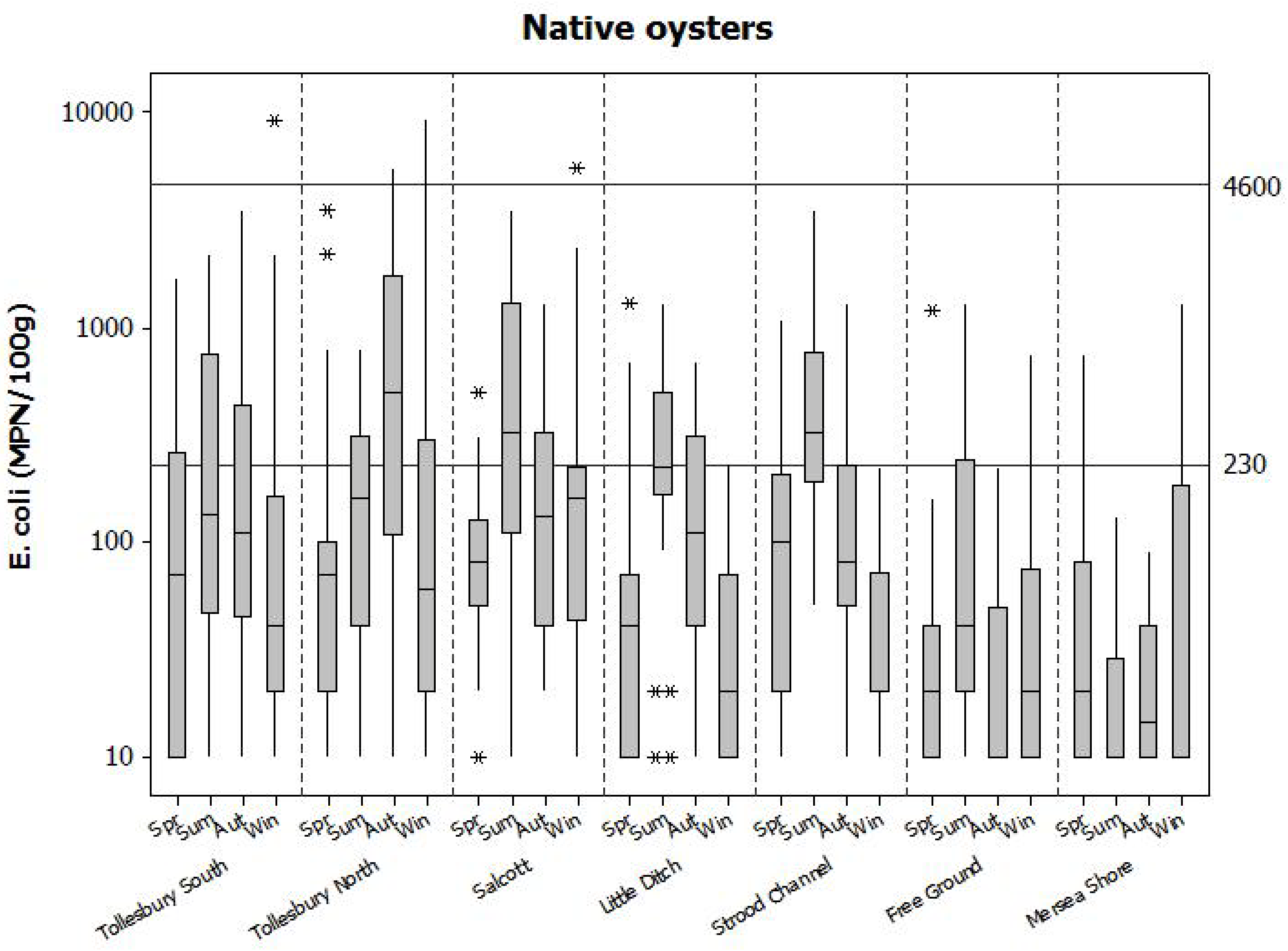

Figure XII.7 Boxplot of native oyster* E. coli *results by RMP and season

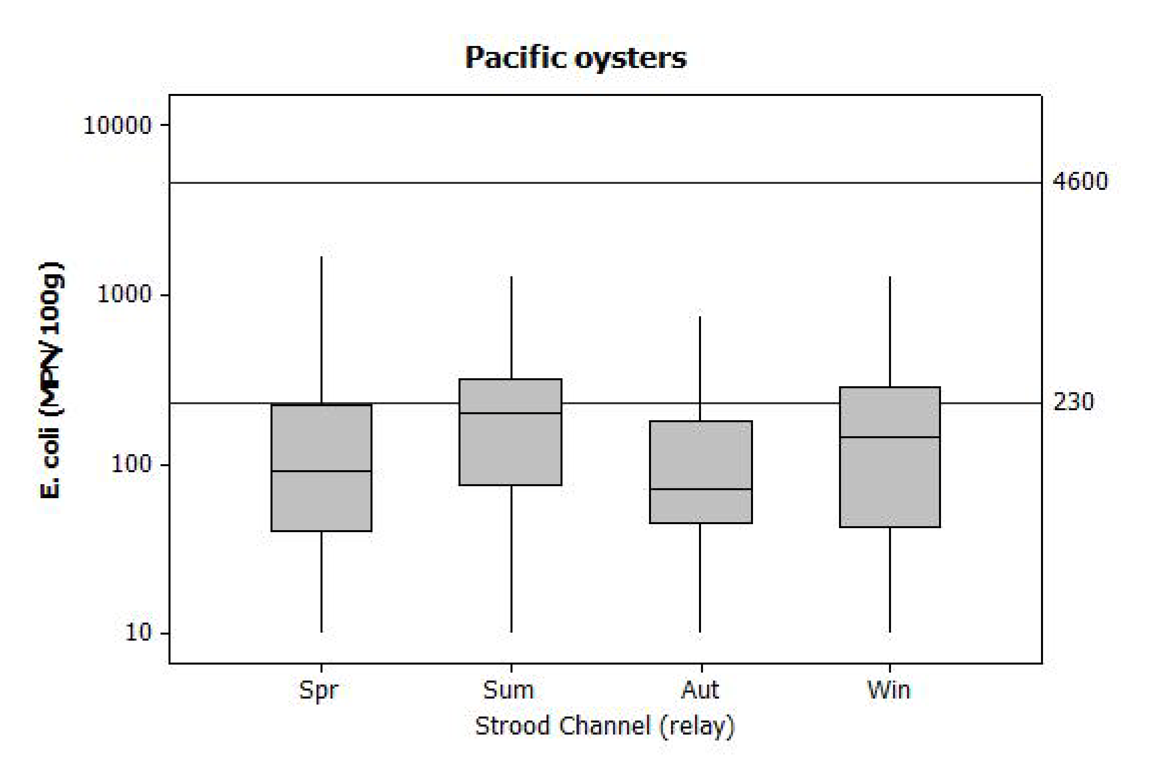

Figure XI.8 Boxplot of Pacific oyster* E. coli *results by RMP and season

Significant differences in levels of *E. coli* found in native oysters were found between seasons at Tollesbury North, Salcott, Little Ditch and Strood Channel (One-way ANOVA, p ≤0.001 in all cases). At Tollesbury North, levels of *E. coli* were found to be significantly higher in autumn compared to the other three seasons. At Salcott *E. coli* levels were greater in the summer than the other seasons. At Little Ditch, the autumn and summer had significantly higher levels of *E. coli* than in the spring and winter. At Strood Channel *E. coli* levels were significantly higher in the summer than for the other seasons, and during the winter months, *E. coli* levels were significantly lower than in autumn (but not spring). No significant variation between seasons was found at the Strood Channel (relay) Pacific oyster RMP.

INFLUENCE OF TIDE

To investigate the effects of tidal state on *E. coli* results, circular-linear correlations were carried out against the spring/neap tidal cycle for each RMP where at least 30 samples had been taken since 2003. Results of these correlations are summarised in Table XI.3, and significant results are highlighted in yellow.

Table XI.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		Spring neap	
Site	**Species**	**n**	**r**	**p**	**r**	**p**
Tollesbury South	Native oyster	80	0.341	<0.001	0.209	0.035
Tollesbury North	Native oyster	113	0.202	0.011	0.088	0.426
Salcott	Native oyster	111	0.243	0.002	0.197	0.015
Little Ditch	Native oyster	108	0.218	0.007	0.202	0.014
Strood Channel	Native oyster	101	0.104	0.348	0.080	0.530
Free Ground	Native oyster	58	0.362	<0.001	0.318	0.004
Mersea Shore	Native oyster	102	0.204	0.016	0.192	0.026
Strood Channel (relay)	Pacific oyster	106	0.225	0.005	0.246	0.002

Figures XI.9 and XI.10 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 West Mersea 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 4600 are plotted in yellow, and those exceeding 4600 are plotted in red.

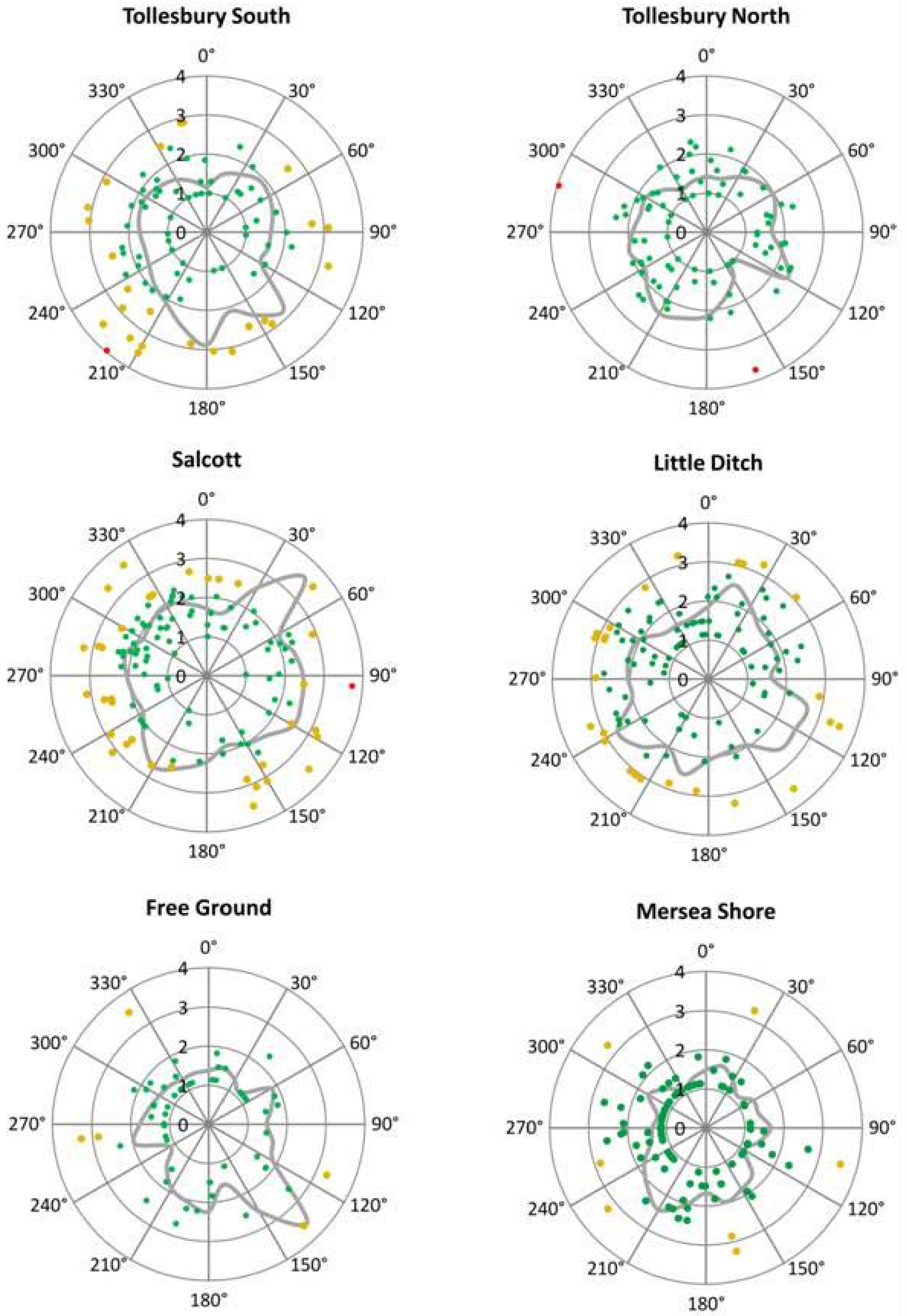

Figure XI.9 Polar plots of log_{10}* E. coli *results (MPN/100g) against high/low tidal state for native oyster RMPs

While significant correlations were found between *E. coli* numbers and tidal state for native oysters at many sites around West Mersea, the degree of influence of the high/low tide cycle on *E. coli* levels is fairly low. At most sites there does appear to be a tendency for higher results around low tide.

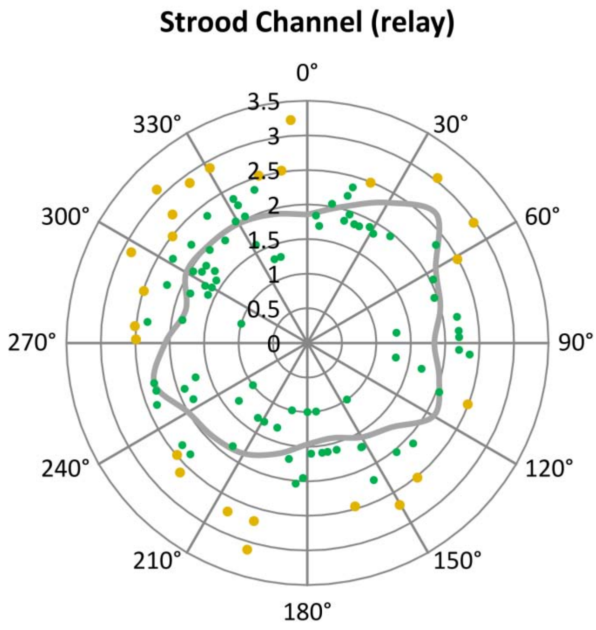

Figure XI.10 Polar plots of log_{10}* E. coli *results (MPN/100g) against high/low tidal state for Pacific oyster RMPs

No particular pattern is apparent in Figure XI.10.

Figures XI.11 to XI.12 present polar plots of log_{10} *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 4600 are plotted in yellow, and those exceeding 4600 are plotted in red.

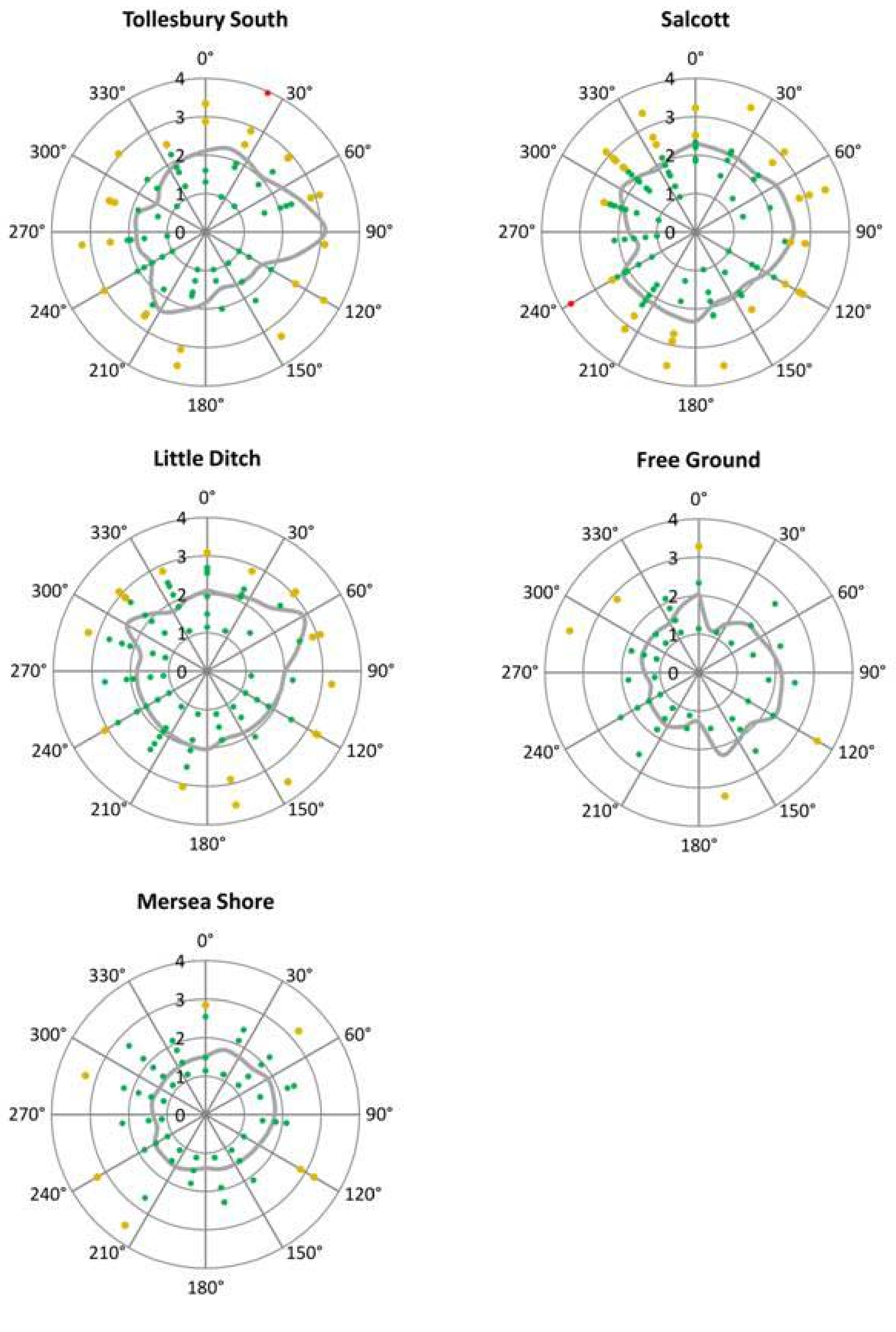

Figure XI.11 Polar plots of log$_{10}$* E. coli *results (MPN/100g) against spring/neap tidal state for native oyster RMPs

Figure XI.11 suggests there is a weak tendency for higher *E. coli* results around spring tides or just after at all these RMPs.

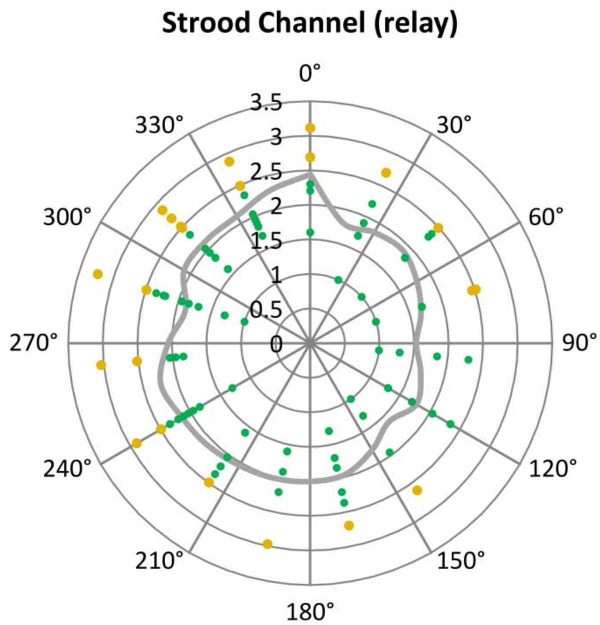

Figure XI.12 Polar plots of log$_{10}$* E. coli *results (MPN/100g) against spring/neap tidal state for Pacific oyster RMPs

Figure XI.12 tentatively suggests higher levels of contamination on neap and increasing tides at Strood Channel (relay).

INFLUENCE OF RAINFALL

To investigate the effects of rainfall on levels of contamination within shellfish samples Spearman's rank correlations were carried out between *E. coli* results and rainfall recorded at the Mersea weather station (Appendix VI for details) over various periods running up to sample collection. These are presented in Table XI.4, and statistically significant positive correlations ($p<0.05$) are highlighted in yellow.

Table XI.4 Spearman's Rank correlations between rainfall recorded at Mersea and shellfish hygiene results

	Species	Native oyster								Pacific oyster	
	Site	Tollesbury South	Tollesbury North	Salcott	Little Ditch	Strood Channel	Cobmarsh Island	Free Ground	Mersea Shore	Strood Channel (relay)	Mersea Flats
	n	80	112	111	108	100	25	58	100	106	18
24 hour periods prior to sampling	1 day	-0.020	0.009	0.150	-0.019	-0.080	-0.183	0.132	-0.021	0.122	-0.074
	2 days	0.195	0.127	0.134	0.001	-0.104	-0.085	0.198	0.016	0.060	0.232
	3 days	-0.014	0.103	0.249	0.101	-0.144	0.171	0.211	0.027	0.011	0.394
	4 days	-0.107	0.063	0.105	-0.023	0.142	-0.083	0.308	0.140	0.105	0.134
	5 days	0.173	0.097	0.012	-0.018	-0.113	0.020	-0.044	-0.159	0.125	0.326
	6 days	-0.055	0.040	0.028	0.029	0.008	0.144	0.008	0.002	0.134	0.339
	7 days	-0.112	-0.236	0.116	-0.033	-0.054	0.078	-0.053	-0.035	0.096	0.165
Total prior to sampling over	2 days	0.058	0.066	0.147	-0.021	-0.114	-0.121	0.214	-0.002	0.104	0.191
	3 days	0.085	0.128	0.205	0.024	-0.131	-0.048	0.274	-0.035	0.101	0.383
	4 days	0.080	0.135	0.232	0.070	-0.032	-0.083	0.427	0.028	0.131	0.351
	5 days	0.151	0.177	0.241	0.120	-0.024	-0.036	0.396	-0.010	0.204	0.294
	6 days	0.124	0.159	0.247	0.141	0.050	0.085	0.351	-0.022	0.205	0.333
	7 days	0.120	0.118	0.276	0.166	0.075	0.154	0.313	-0.075	0.271	0.314

Rainfall appears to have little effect on the level of *E. coli* contamination in the West Mersea area. Some mild influence was detected at Tollesbury South, Salcott, Freeground and Strood Channel (relay).

APPENDIX XII
SHORELINE SURVEY
SHORELINE SURVEY REPORT

Date (time): 9 February 2011 (06:30-15:30)
5 December 2012 (08:45-12:00)
17 January 2013 (08:30-15:00)

Cefas Officers: Simon Kershaw & Carlos Campos (9/2/2011), Rachel Parks (17/1/2013), Ben Stubbs (5/12/2012 & 17/1/2013), David Walker (5/12/2012).

Local Enforcement Authority Officers:
Tim Nice (Colchester Council, 9/2/2011)
Malcolm Sach (Maldon District Council, 17/1/2013)

Area surveyed: South shore of Mersea Island & Tollesbury Fleet (foot), Strood Channel & Salcott Channel (boat).

Weather: 9 February 2011 - Wind E force 4, temp. not recorded, overcast
5 December 2012 - Wind NW force 3, 1°C, snow
15 January 2013 - Wind NE force 3, 3°C, overcast

Tidal predictions:

Admiralty TotalTide - 0124 West Mersea 51°47'N 0°54'E. Times GMT+0000.

9/2/2011			5/12/2012			17/1/2013		
High	03:15	4.7m	High	03:30	4.5m	High	02:30	5.3m
Low	09:25	0.7m	Low	09:38	0.8m	Low	08:50	0.3m
High	15:40	4.6m	High	15:58	4.4m	High	14:56	5.4m
Low	21:32	0.9m	Low	21:38	1.2m	Low	20:57	0.9m

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; find out more information about the fishery. A full list of recorded observations is presented in Table XII.1 and the locations of these observations are mapped in Figure XII.1. Photographs referenced in Table XII.1 are presented in Figures XII.3-18.

The shoreline survey in this instance was carried out over three visits. One visit was undertaken in February 2011, when the Strood and Salcott Channels were surveyed from a boat. A second visit was undertaken in December 2012, when the south shore of Mersea Island was surveyed by foot. A third visit was undertaken in January 2013 when Tollesbury Fleet was surveyed by foot.

Description of Fishery

The eastern part of the area south of Mersea Island and the three creeks are private grounds, where naturally occurring stocks of Pacific and native oysters are ongrown and harvested. The southern channel of Tollesbury Fleet has now become too silted for oyster culture. The area south of the eastern part of Mersea Island is a public fishery where Pacific oysters are harvested via dredge and by hand, but the native oyster fishery here is currently closed for stock preservation purposes.

Sources of contamination

Sewage discharges

The locations of the West Mersea STW outfall and the Tollesbury STW outfall were confirmed (observations 26 and 50). The outfall from the Borrow Dyke to which the Coopers Beach caravan site discharges was sampled and measured (observation 19). The Kingsland Road SSO outfall was tentatively identified and sampled and measured as it was flowing at the time (observation 28).

House boats were seen at West Mersea and at Tollesbury which may make regular discharges to the shore when in occupation.

Freshwater inputs

The three tidal creeks are surrounded by flood defence walls, through which a regular series of surface water outfalls discharge. None of these could be sampled and measured due to access constrains, but all represent relatively minor inputs. Surface water outfalls and streams discharging to the south shore of Mersea Island were sampled and measured, the results of which are shown in Table XII.2 and Figure XII.2. Again, these were minor in terms of volumes discharged but some were carrying high concentrations of *E. coli* (above the limit of quantification).

Animals

Dog owners use the beach on the south of West Mersea Island and the coastal footpath to exercise dogs. Small flocks of wading birds were regularly sighted and some geese were observed on the south shore of Mersea Island. Sheep (20) were observed grazing on the margins of Feldy Marsh, and cattle and sheep (~15 of each) were observed on the Tollesbury Wick marshes.

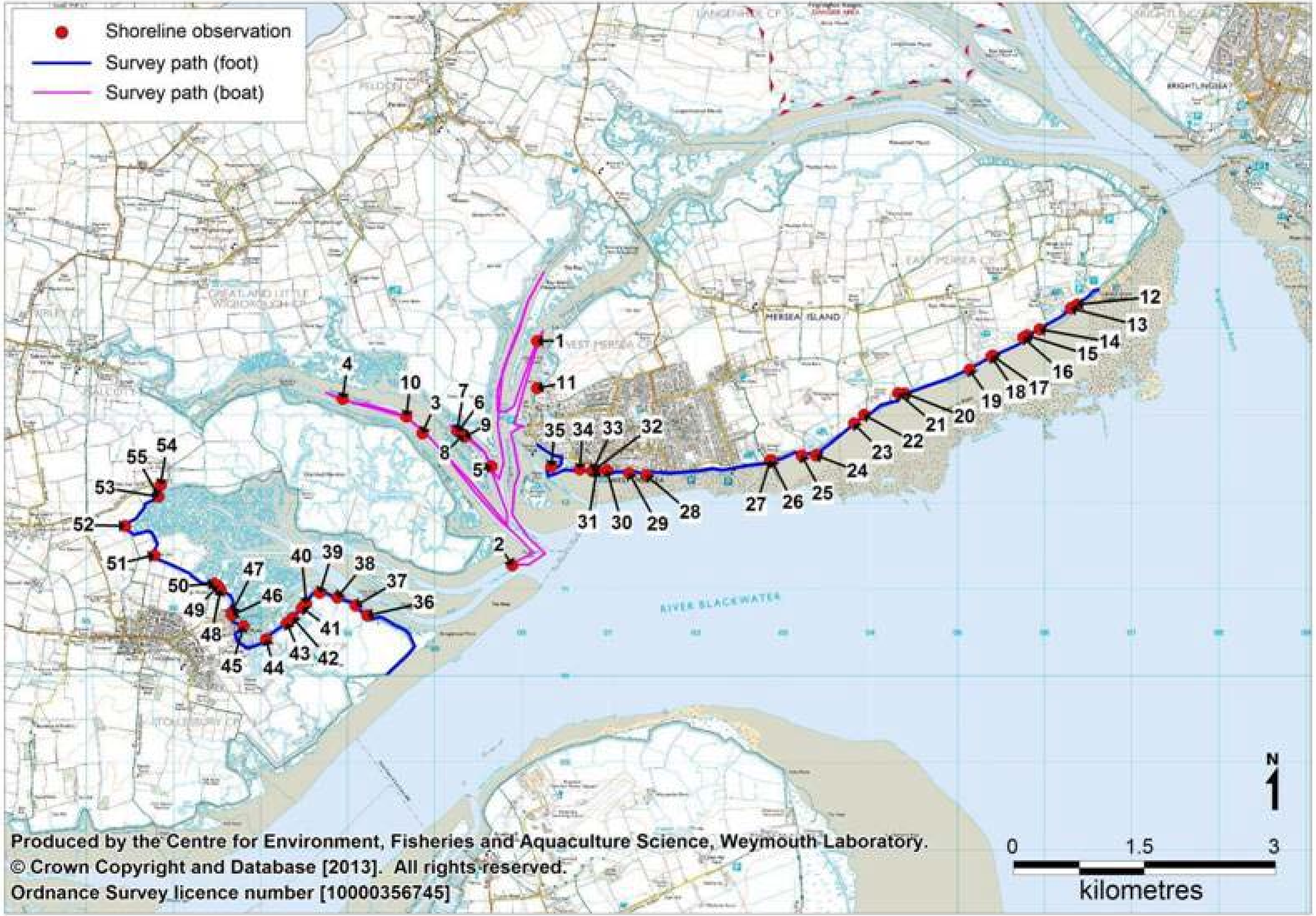

Figure XII.1: Locations of shoreline observations (see Table 1 for details)

Table XII.1: Details of shoreline observations

No.	Date and time	NGR	Photograph	Observation
1	09/02/2011 10:14	TM 00172 13848		29.9ppt, 5.6°C, mussels beds (LA not previously aware of)
2	09/02/2011 10:39	TL 99886 11271		30.79ppt, 5.7°C, Tollesbury Creek entrance
3	09/02/2011 10:45	TL 98853 12786		30.1ppt, 5.6°C,
4	09/02/2011 11:20	TL 97939 13186		Oyster rafts
5	09/02/2011 11:25	TL 99648 12414		Boundary of oyster raft(s)
6	09/02/2011 11:26	TL 99265 12812		Boundary of oyster raft(s)
7	09/02/2011 11:27	TL 99255 12815		Boundary of oyster raft(s)
8	09/02/2011 11:28	TL 99324 12767		Boundary of oyster raft(s)
9	09/02/2011 12:00	TL 99340 12750	Figure XII.3	Little Ditch oyster rafts
10	09/02/2011 12:29	TL 98670 12980	Figure XII.4	Salcott Channel oyster rafts
11	09/02/2011 14:02	TM 00173 13307		Ditch/culvert
12	05/12/2012 08:52	TM 06367 14267		Dead shells of cockles, mussels, Pacific oysters and hard clams.
13	05/12/2012 08:59	TM 06296 14230	Figure XII.5	Freshwater outfall, 60cmx6cmx0.110m/s. Water sample M1. May receive caravan park discharge.
14	05/12/2012 09:07	TM 05941 13986		Pipe, ~20cm diameter. May be discharge from caravan park.
15	05/12/2012 09:14	TM 05793 13914		Flow from buried pipe, 68cmx6cmx0.372m/s. Water sample M2.
16	05/12/2012 09:20	TM 05750 13888	Figure XII.6	Pipe from caravan park, not flowing.
17	05/12/2012 09:27	TM 05398 13682		Groundwater outlet, seeping.
18	05/12/2012 09:28	TM 05384 13674		Groundwater outlet, seeping.
19	05/12/2012 09:33	TM 05136 13519	Figure XII.7	Pipe outfall, 38cmx10cmx1.288m/s. Water sample M3. Receives effluent from the Coopers Beach caravan park via a borrow dyke.
20	05/12/2012 09:52	TM 04393 13247		20 birds.
21	05/12/2012 10:00	TM 04316 13251		Sluice outfall, not flowing.
22	05/12/2012 10:08	TM 03921 13000	Figure XII.8	Plastic pipe, not flow
23	05/12/2012 10:14	TM 03806 12901	Figure XII.9	Freshwater outfall, 60cmx6cmx0.254m/s. Water sample M4
24	05/12/2012 10:27	TM 03370 12535	Figure XII.10	Freshwater outfall, 35cmx7cmx0.762m/s. Water sample M5
25	05/12/2012 10:32	TM 03207 12534		~20 geese
26	05/12/2012 10:39	TM 02858 12474	Figure XII.11	Pipe, end covered by tide, not possible to access (W. Mersea STW outfall)
27	05/12/2012 10:41	TM 02843 12478		Surface water outfall, very little flow
28	05/12/2012 11:06	TM 01429 12309	Figure XII.12	Outfall pipe, 35cmx7cmx0.938m/s. Water sample M6. Probably the Kingsland Road SSO outfall.
29	05/12/2012 11:13	TM 01230 12332		Blocked pipe
30	05/12/2012 11:17	TM 00975 12364		Small plastic pipe
31	05/12/2012 11:19	TM 00859 12363		Old rusty broken pipe
32	05/12/2012 11:20	TM 00807 12354		Pipe

33	05/12/2012 11:21	TM 00808 12359		Pipe
34	05/12/2012 11:23	TM 00663 12379		~20 geese
35	05/12/2012 11:31	TM 00333 12410		Stream, 90cmx4cmx0.182m/s. Water sample M07.
36	17/01/2013 10:14	TL 98218 10693		~15 cattle
37	17/01/2013 10:37	TL 98087 10807		~15 sheep
38	17/01/2013 10:44	TL 97876 10900		Birds on mudflats x100
39	17/01/2013 10:47	TL 97674 10953		Boats moored x5
40	17/01/2013 10:51	TL 97517 10830		Birds on mudflats x100
41	17/01/2013 10:54	TL 97469 10784		Boats moored x2
42	17/01/2013 10:56	TL 97366 10669		Houseboat
43	17/01/2013 10:58	TL 97299 10607	Figure XII.13	Tollesbury Sluice No.1 - Not Flowing
44	17/01/2013 11:01	TL 97059 10421	Figure XII.14	Tollesbury Wick Sluice - Flowing
45	17/01/2013 11:08	TL 96802 10571		Houseboats
46	17/01/2013 11:19	TL 96667 10697	Figure XII.15	Pipe, flowing
47	17/01/2013 11:29	TL 96670 10735		Woodrolfe Road Sluice - Flowing
48	17/01/2013 11:31	TL 96538 10991		Houseboat
49	17/01/2013 11:36	TL 96504 11035		Salcott Sewage Treatment Works
50	17/01/2013 11:39	TL 96467 11060	Figure XII.16	Tollesbury STW outfall - flowing
51	17/01/2013 11:41	TL 95774 11385		Outfall - Not Flowing
52	17/01/2013 11:54	TL 95437 11726		Tollesbury Brook Sluice - Flowing
53	17/01/2013 12:08	TL 95823 12067		Guisnes Court Sluice - Flowing
54	17/01/2013 12:17	TL 95849 12198	Figure XII.17	Old Hall No.3 Sluice
55	17/01/2013 12:21	TL 95823 12067	Figure XII.18	Dripping pipe

Sample results

Freshwater inputs were sampled and spot discharge measurements taken, to give spot estimates of their *E. coli* loadings (Table XII.2 and Figure XII.2). Due to the extensive microbiological monitoring history of the area no seawater or shellfish sampling was considered necessary.

Table XII.2: Water sample* E. coli *results and estimated stream loadings

Sample No.	Date and Time	Position	*E. coli* (cfu/100ml)	Flow (m³/day)	*E. coli* (cfu/day)*
M1	05/12/2012 08:59	TM 06296 14230	>10000	342	$>3.42 \times 10^{10}$
M2	05/12/2012 09:14	TM 05793 13914	600	1311	7.87×10^{9}
M3	05/12/2012 09:33	TM 05136 13519	1300	4229	5.50×10^{10}
M4	05/12/2012 10:14	TM 03806 12901	>10000	790	$>7.90 \times 10^{10}$
M5	05/12/2012 10:27	TM 03370 12535	280	1613	4.52×10^{9}
M6	05/12/2012 11:06	TM 01429 12309	>10000	1986	$>1.99 \times 10^{11}$
M7	05/12/2012 11:31	TM 00333 12410	60	566	3.40×10^{8}

*Numbers of *E. coli* per day introduced to coastal waters from each input, calculated from spot gauging of discharges and corresponding water sample *E. coli* results.

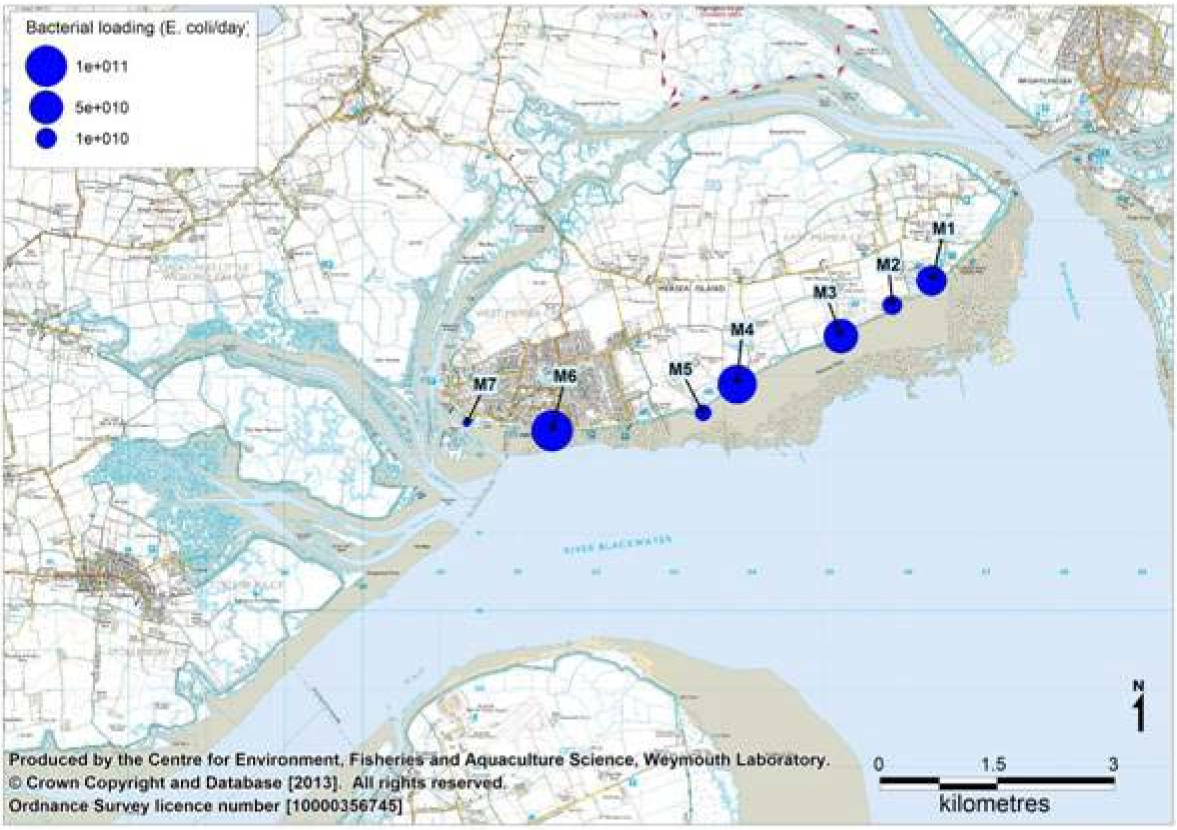

Figure XII.2: Water sampling locations and estimated bacterial loadings at time of survey

Figure XII.3

Figure XII.4

Figure XII.5

Figure XII.6

Figure XII.7

Figure XII.8

Figure XII.9

Figure XII.10

Figure XII.11

Figure XII.12

Figure XII.13

Figure XII.14

Figure XII.15

Figure XII.16

Figure XII.17

Figure XII.18

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List of Abbreviations

AONB	Area of Outstanding Natural Beauty
BMPA	Bivalve Mollusc Production Area
CD	Chart Datum
Cefas	Centre for Environment Fisheries & Aquaculture Science
CFU	Colony Forming Units
CSO	Combined Sewer Overflow
CZ	Classification Zone
Defra	Department for Environment, Food and Rural Affairs
DWF	Dry Weather Flow
EA	Environment Agency
E. coli	*Escherichia coli*
EC	European Community
EEC	European Economic Community
EO	Emergency Overflow
FIL	Fluid and Intravalvular Liquid
FSA	Food Standards Agency
GM	Geometric Mean
IFCA	Inshore Fisheries and Conservation Authority
ISO	International Organization for Standardization
km	Kilometre
LEA (LFA)	Local Enforcement Authority formerly Local Food Authority
M	Million
m	Metres
ml	Millilitres
mm	Millimetres
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MPN	Most Probable Number
NM	Nautical Miles
NRA	National Rivers Authority
NWSFC	North Western Sea Fisheries Committee
OSGB36	Ordnance Survey Great Britain 1936
mtDNA	Mitochondrial DNA
PS	Pumping Station
RMP	Representative Monitoring Point
SAC	Special Area of Conservation
SHS	Cefas Shellfish Hygiene System, integrated database and mapping application
SSSI	Site of Special Scientific Interest
STW	Sewage Treatment Works
UV	Ultraviolet
WGS84	World Geodetic System 1984

Glossary

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

Flow ratio	Ratio of the volume of freshwater entering into an estuary during the tidal cycle to the volume of water flowing up the estuary through a given cross section during the flood tide.
Geometric mean	The geometric mean of a series of N numbers is the N^{th} root of the product of those numbers. It is more usually calculated by obtaining the mean of the logarithms of the numbers and then taking the anti-log of that mean. It is often used to describe the typical values of skewed data such as those following a log-normal distribution.
Hydrodynamics	Scientific discipline concerned with the mechanical properties of liquids.
Hydrography	The study, surveying, and mapping of the oceans, seas, and rivers.
Lowess	LOcally WEighted Scatter plot Smoothing, more descriptively known as locally weighted polynomial regression. At each point of a given dataset, a low-degree polynomial is fitted to a subset of the data, with explanatory variable values near the point whose response is being estimated. The polynomial is fitted using weighted least squares, giving more weight to points near the point whose response is being estimated and less weight to points further away. The value of the regression function for the point is then obtained by evaluating the local polynomial using the explanatory variable values for that data point. The LOWESS fit is complete after regression function values have been computed for each of the *n* data points. LOWESS fit enhances the visual information on a scatter plot.
Telemetry	A means of collecting information by unmanned monitoring stations (often rainfall or river flows) using a computer that is connected to the public telephone system.
Secondary Treatment	Treatment to applied to breakdown and reduce the amount of solids by helping bacteria and other microorganisms consume the organic material in the sewage or further treatment of settled sewage, generally by biological oxidation.
Sewage	Sewage can be defined as liquid, of whatever quality that is or has been in a sewer. It consists of waterborne waste from domestic, trade and industrial sources together with rainfall from subsoil and surface water.
Sewage Treatment Works (STW)	Facility for treating the waste water from predominantly domestic and trade premises.
Sewer	A pipe for the transport of sewage.
Sewerage	A system of connected sewers, often incorporating inter-stage pumping stations and overflows.
Storm Water	Rainfall which runs off roofs, roads, gulleys, etc. In some areas, storm water is collected and discharged to separate sewers, whilst in combined sewers it forms a diluted sewage.
Waste water	Any waste water but see also “sewage”.

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