EC Regulation 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SANITARY SURVEY REPORT

North Kent

2011

Cover photo: Dawn at Whitstable

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

CONSULTATION:

Consultee	Date of consultation	Date of response
Environment Agency	06/08/2012	15/10/2012
Canterbury Council	20/07/2012	Ongoing to Jan 2013
Thanet Council	28/11/2012	-
IFCA	06/08/2012	20/08/2012
Southern Water	16/10/2012	16/11/2012

DISSEMINATION: Food Standards Agency, Canterbury Council, Thanet Council, Environment Agency, Kent and Essex IFCA, Southern Water.

RECOMMENDED BIBLIOGRAPHIC REFERENCE: Cefas, 2011. Sanitary survey of North Kent. 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 the BMPA. Improved monitoring should lead to improved detection of pollution events and identification of the likely sources of pollution. Remedial action may then be possible either through funding of 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 cockles (*Cerastoderma edule*), mussels (*Mytilus* spp.), Pacific oysters (*Crassostrea gigas*), native oysters (*Ostrea edulis*) and Manila clams (*Tapes* spp.) harvested from North Kent together with new information obtained from a shoreline survey undertaken in the area. The exact stretch covered includes the Canterbury and Thanet Council jurisdictions, but does not extend into the London Port Health jurisdiction which begins at the mouth of the Swale.

1.2 SITE DESCRIPTION

NORTH KENT COAST

The survey area is a stretch of coast approximately 30km in length located on the south shore of the outer Thames estuary, where it opens up into the North Sea (Figure 1.1). Much of this coastline is urban, with the towns of Seasalter, Whitstable and Herne Bay at its western end and Margate at its eastern end. Amongst these urban areas are two areas of low lying reclaimed land, one just to the west of Seasalter and another between Herne Bay and Margate. The whole north Kent coast is heavily engineered to prevent erosion, with sea walls along much of its length, and groynes and rock armour in places. Much of the upper intertidal zone is shingle beach, with varying proportions of sand, shingle and mud lower down the shoreline. At Margate the character changes and the intertidal zone is mainly a mixture of chalk reefs and sand. Beyond the intertidal zone, the bathymetry is shallow and relatively featureless, particularly at the western end. There is an offshore windfarm at Kentish Flats where fishing is prohibited within 50m of the turbine bases (Vattenfall, 2011). The north Kent coast has a long tradition of shellfish harvesting, centred at Whitstable and dating back to at least Roman times.

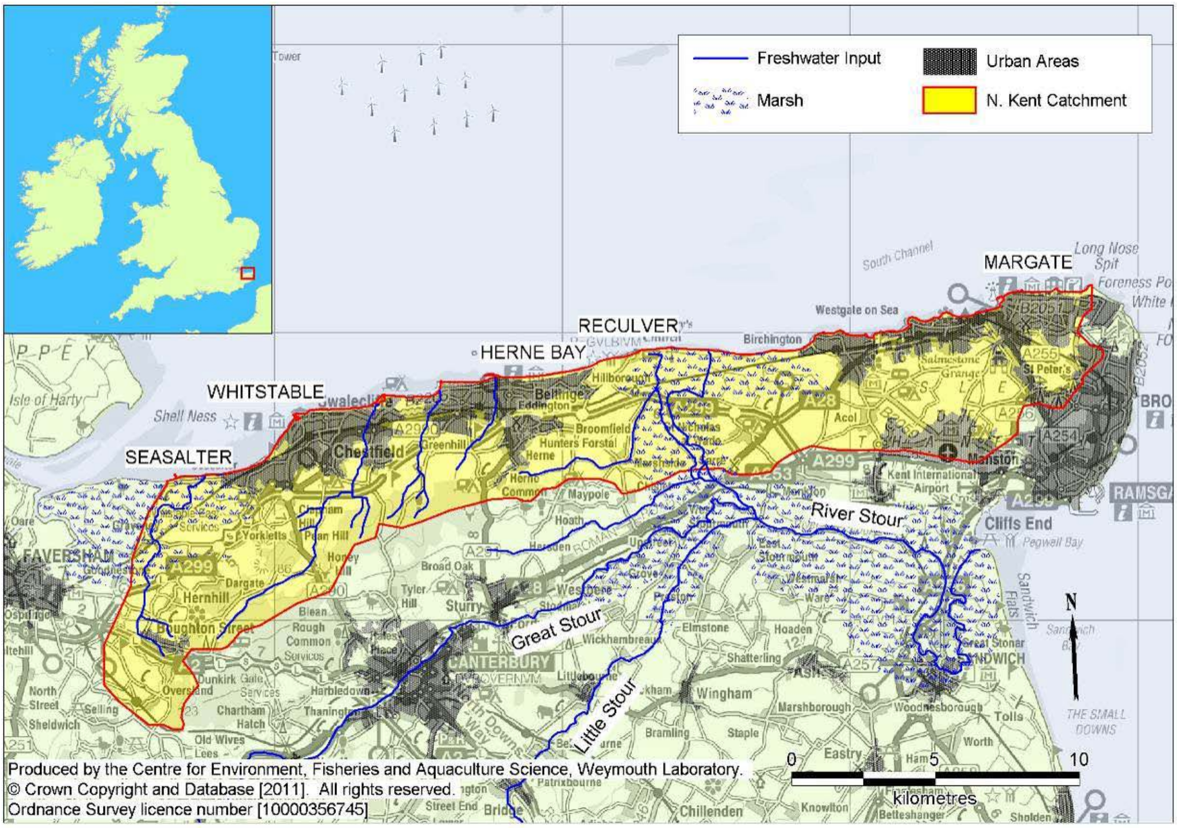


Figure 1.1 Features of the north Kent Coast.

CATCHMENT

The hydrological catchment area of the north Kent coast, as estimated from topographical maps, is shown in Figure 1.2. Most of north Kent is drained by the River Stour, which discharges to the east coast of Kent away from the survey area. Only a narrow coastal strip drains directly to the north Kent coast.

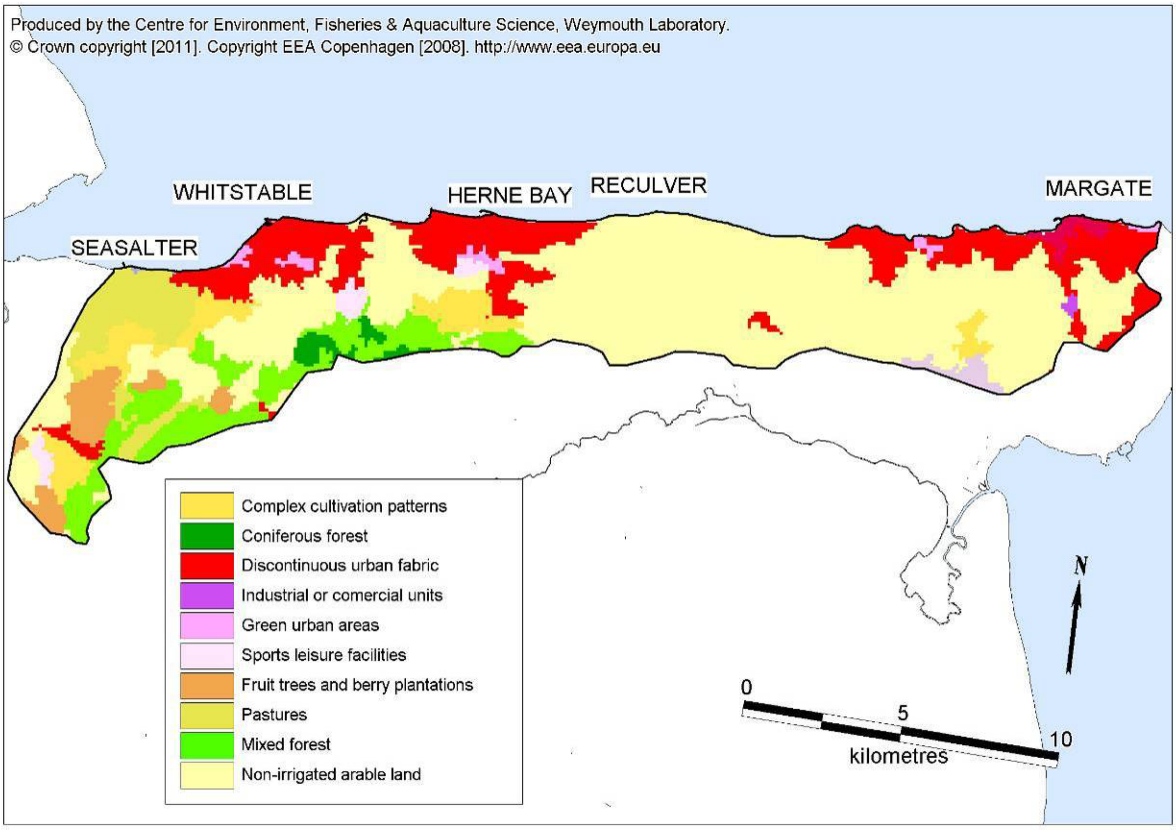


Figure 1.2 Land cover in the catchments draining to the north Kent coast.

Different land cover types will generate differing levels of contamination in surface runoff. 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.

The North Kent coastal strip is heavily urbanised for much of its length, with pockets of reclaimed land used for agriculture at its centre and western end. It is low lying, with elevation rarely exceeding 50m and is drained by a series of small watercourses, most of which are highly modified for flood defence purposes. The majority of agricultural land is used for arable farming, but there is an area of pasture at the western end of the survey area.

2. SHELLFISHERIES

2.1 SPECIES, LOCATION AND EXTENT

This sanitary survey was prompted by an application for classification of wild Pacific oyster beds lying between Reculver and Margate. The applicant (Canterbury Council) also identified a need for rationalisation of hygiene sampling plans for this area, which have evolved over the years without a formal sanitary assessment. The current sampling arrangements cover a considerable diversity of fisheries. Maps showing the classification zones, current RMPs, and locations of shellfish beds/culture sites are shown in Figures 2.1 to 2.5. It should be noted that the exact extent of wild shellfish beds are liable to change in response to significant weather events, fishing pressures and ecological cycles.

For all species the classification zones continue east from the North Kent Coast production area into the Swale and/or Thames estuary production areas. Geographic boundaries are not defined for these production areas. Therefore, the jurisdictional boundaries between Canterbury Council and Swale Council were taken from the ordnance survey map and extended due northwards, and this was used as the western boundary of the area considered in this report. Existing monitoring arrangements outside of the survey area are briefly described and discussed for each species to ensure classification zones overlapping into other production areas receive adequate monitoring outside of the north Kent production area.

PACIFIC OYSTERS

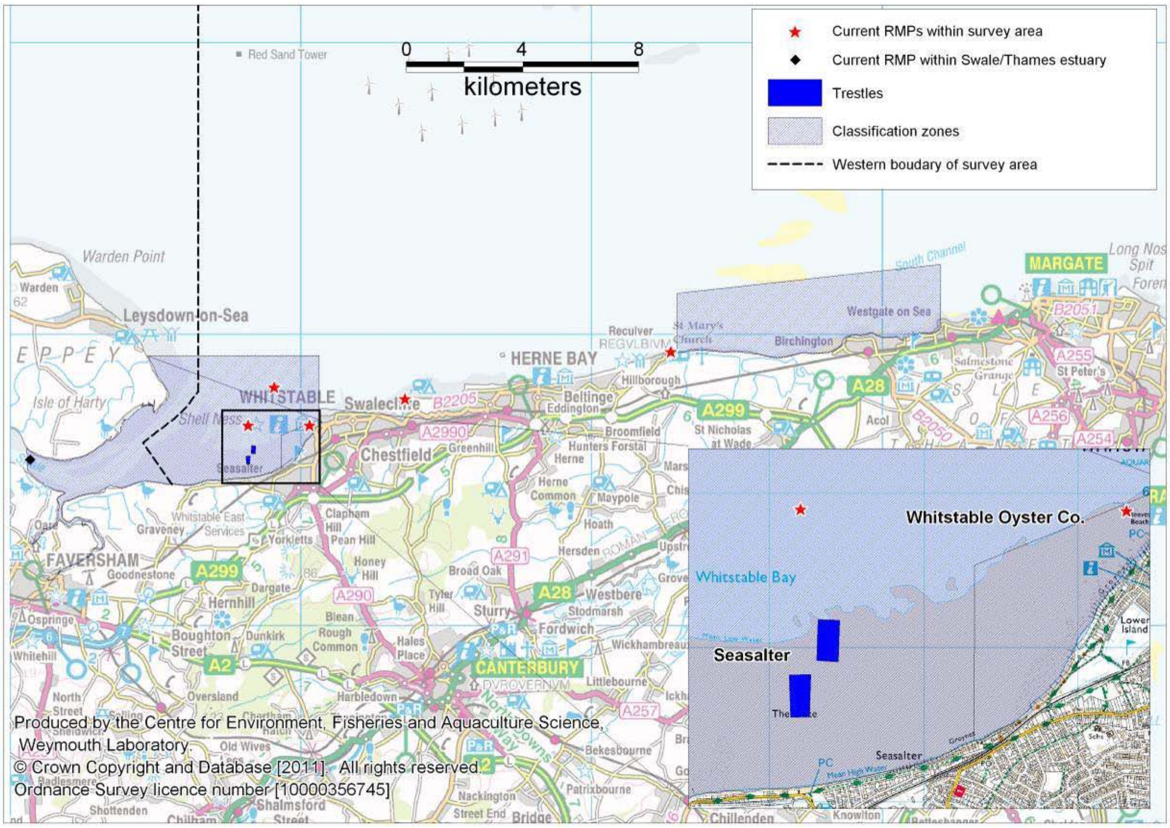


Figure 2.1 Pacific oyster trestle fisheries, classified zones and current RMPs

There are two Pacific oyster trestle culture operations, both at Whitstable. The location of the trestles is shown on Figure 2.1. Seasalter Shellfish owns the Pollard Ground off Whitstable, where there are two large areas of trestles which are used for growing seed from their hatchery at Reculver to a larger size before they are sold on as larger seed of 'half-ware' for ongrowing. At present this trestle site is not in production due to an outbreak of Oyster Herpes Virus (OHV). The Whitstable Oyster Company owns another stretch of privately owned foreshore, just to the east of the Pollard Ground. Here Pacific oysters are ongrown to market size to supply a few local restaurants on a very small area of trestles located at the RMP at the eastern end of the inset map. The Whitstable Oyster Company also operate a shellfish purification and despatch centre at Whitstable Harbour. The exact boundaries of the private grounds could not be confirmed at the time of writing.

Naturally occurring Pacific oysters are present at varying densities all along the north Kent coast. The full extent of these beds is uncertain so is not shown on Figure 2.1. They are generally found in the intertidal zone in places where there are suitably solid substrates for them to attach to. Concerns over their potential impact on the North East Kent European Marine Sites prompted a detailed survey of their status on the north Kent Coast (Natural England, 2009). The survey sites were from Swalecliffe through to Margate, then round as far as Sandwich Bay. They were found on sea defences, chalk reefs, rocks, pebbles and mussel beds. Animals of a range of sizes were found (12 – 168mm), indicating that regular recruitment has occurred in recent years. High numbers and densities were generally found between Swalecliffe and Nayland

Rock in Margate. Mussel beds situated between Birchington and Westgate were found to host the peak volumes of Pacific oysters, in some cases to the extent that the potential for formation of oyster reefs was indicated. Generally, abundance was greater in the mid shore zone than in the lower shore zone apart from where dense mussel beds were present in the lower shore zone.

It is therefore concluded that the entire length of the north Kent coast as far as Nayland Rock at Margate will require classification for this species, extending out to about 2km offshore. The classification zone for this species extends into the Swale and up Faversham Creek, outside of the area considered in this survey. An existing RMP is sampled for native oysters and is also used for the classification of Pacific oysters within the Swale, and this arrangement will continue, covering a slightly larger area encompassing the classified areas outside of the survey area.

NATIVE OYSTERS

Native oyster beds lie offshore to the east of the Isle of Sheppey, both within private grounds and public areas, extending roughly as far as Reculver. The area of oyster beds indicated in Figure 2.2 is based on recent consultations with fishermen undertaken in support of an Environmental Statement for the Kentish Flats Wind Farm Extension (Vattenfall, 2011). They are subject to a seasonal dredge fishery which runs from September to April. About 10 boats participate in this fishery, generally on a part time basis, with the majority only participating when other fisheries are closed or unviable. The volumes of oysters taken are not large. The area referred to as The Street has been declassified due to low stock hampering sample collection. There is little or no commercial harvesting here due to the low stocks and poor appearance of specimens. Native oysters may be ongrown or held temporarily before harvest at the trestle areas off Whitstable and Seasalter.

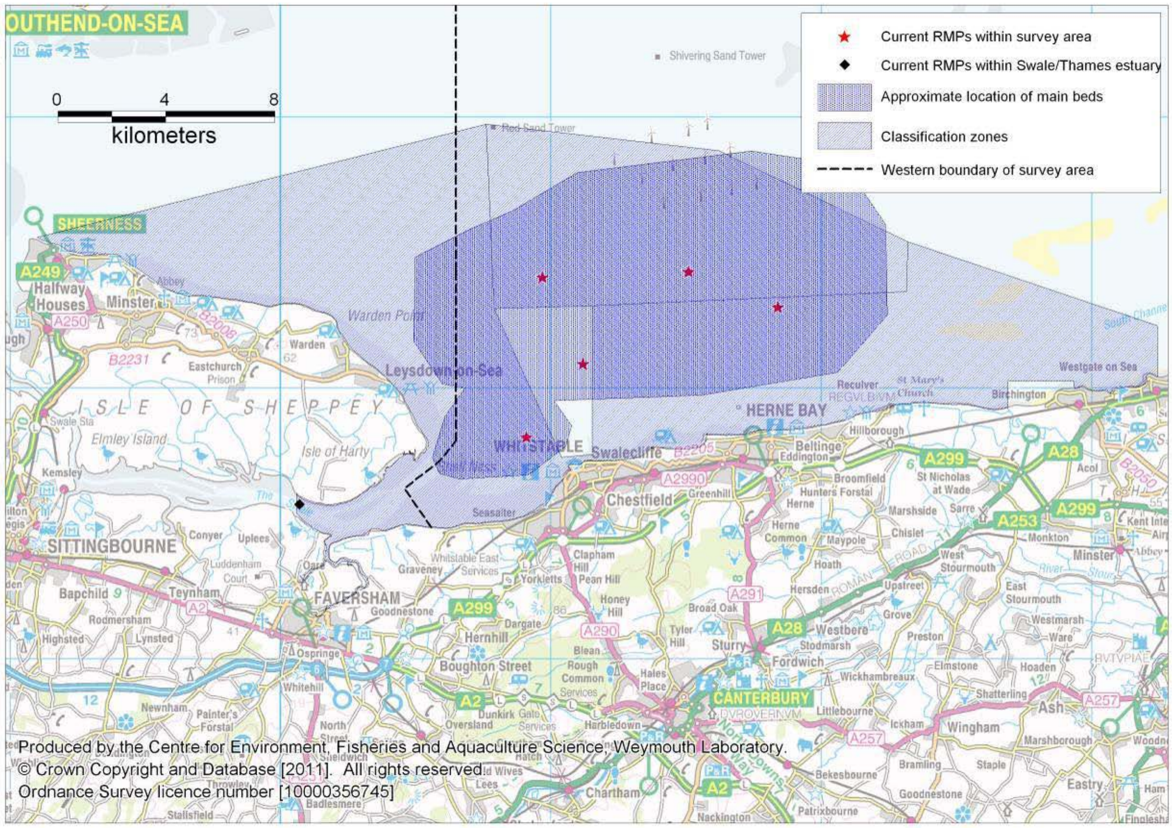


Figure 2.2 Native oyster classified zones and current RMPs

There are existing monitoring arrangements for this species within the Swale, but the parts of the beds lying adjacent to Sheppey and outside of the survey area are currently classified on the basis of monitoring results from the RMPs within the Canterbury District (North Kent production area). Whilst the classification zone extends up to Sheerness, the commercial concentrations of shellfish do not extend far out of the survey area.

COCKLES

There is a significant dredge fishery for cockles throughout the outer Thames estuary. The main cockle beds within the survey area lie off Leysdown, on the Hamm grounds, off Whitstable on the Pollard grounds, at Minnis Bay from the intertidal zone and offshore on Hook Spit and Margate Sands, although they may be present anywhere with a suitable sandy substrate. Some hand gathering occurs at the intertidal bed at Minnis Bay, but not on a commercial basis. The shellfish bed locations presented in Figure 2.3 are taken from historic datasets held by Cefas.

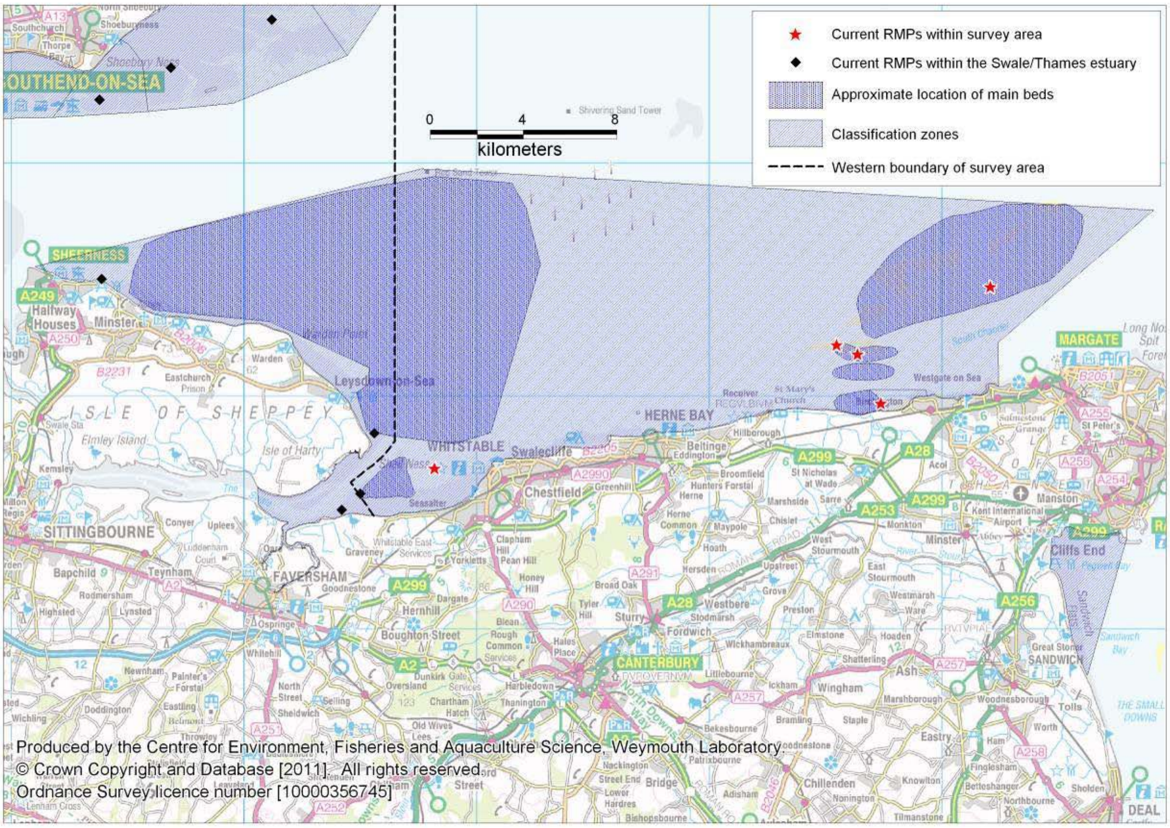


Figure 2.3 Cockle classified zones and current RMPs

The location of the main cockle beds is relatively stable year on year. Stock structure and abundance within these beds fluctuates significantly. In 2010 for example there was little stock in the beds off Minnis Bay, and stocks at Leydown/Ham (at the mouth of the Swale and to the east of Sheppey) were dominated by juveniles (Bailey *et al*, 2010).

There are four monitoring points representing cockles in the Swale and southern half of the Thames estuary. One of these is at the south western extremity of the Pollard bed and whilst this RMP (B076G) is assigned to the Swale production area it actually falls just inside the Canterbury district boundaries. This RMP will not be considered further in this report, but will be addressed when the Swale is subject to sanitary survey.

MUSSELS

There are widely distributed but patchy intertidal and subtidal stocks of mussels off the North Kent Coast. The vast majority of stock comprises undersized 'seed' mussels, although some larger animals are present in places. Stocks on hard substrates tend to include a wider range of sizes (including those of a harvestable size, and tend to be relatively stable in terms of their location. These stocks are however not accessible to dredge fisheries. Mussel beds on softer substrates which are accessible to dredgers are more ephemeral and tend to be almost exclusively seed mussels. (Wright & Bailey, 2009). The area of subtidal mussel beds indicated in Figure 2.4 is based on recent consultations with fishermen undertaken in support of an Environmental

Statement for the Kentish Flats Wind Farm Extension (Vattenfall, 2011). These areas may be exploited via dredging.

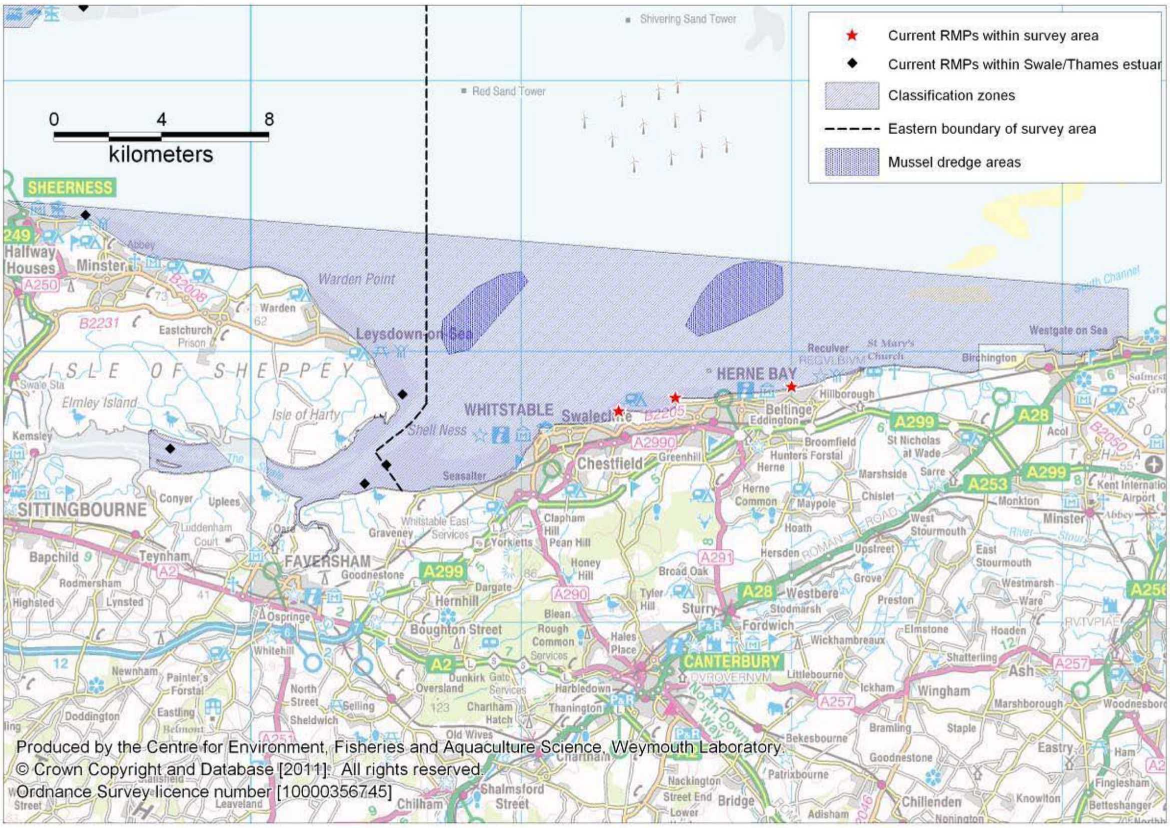


Figure 2.4 Mussel classified zones and current RMPs

There is little commercial mussel harvesting within the area, although at the time of shoreline survey the manager of the Seasalter hatchery indicated some mussels were being ongrown on the Pollard grounds. It is uncertain how successful this will be as poor results attributed to sediment covering the relaid stocks there have been previously reported in this vicinity (Kent & Essex IFCA, pers comm.). It is possible that some casual gathering occurs in places. Fishing for seed mussels to be relaid for ongrowing has historically occurred, but interest in this fishery is not currently strong. No applications to dredge seed mussels from the north Kent coast have been received by the K&E IFCA in the last 2 years. The Thames estuary, including the entire north Kent coast lies within a bonamia (a notifiable oyster disease) control zone, so no bivalve molluscs can be transported out of this area and relaid in uninfected areas, and there are significant seed resources in other parts of the country which are unaffected by such controls.

There are five RMPs within the Swale and adjacent to Sheppey used for classifying these areas for mussels. One of these is located at the south western extremity of the Pollard bed (B076G) and the species sampled is cockles, which parallel monitoring here have demonstrated to be suitably representative and protective.

MANILA CLAMS

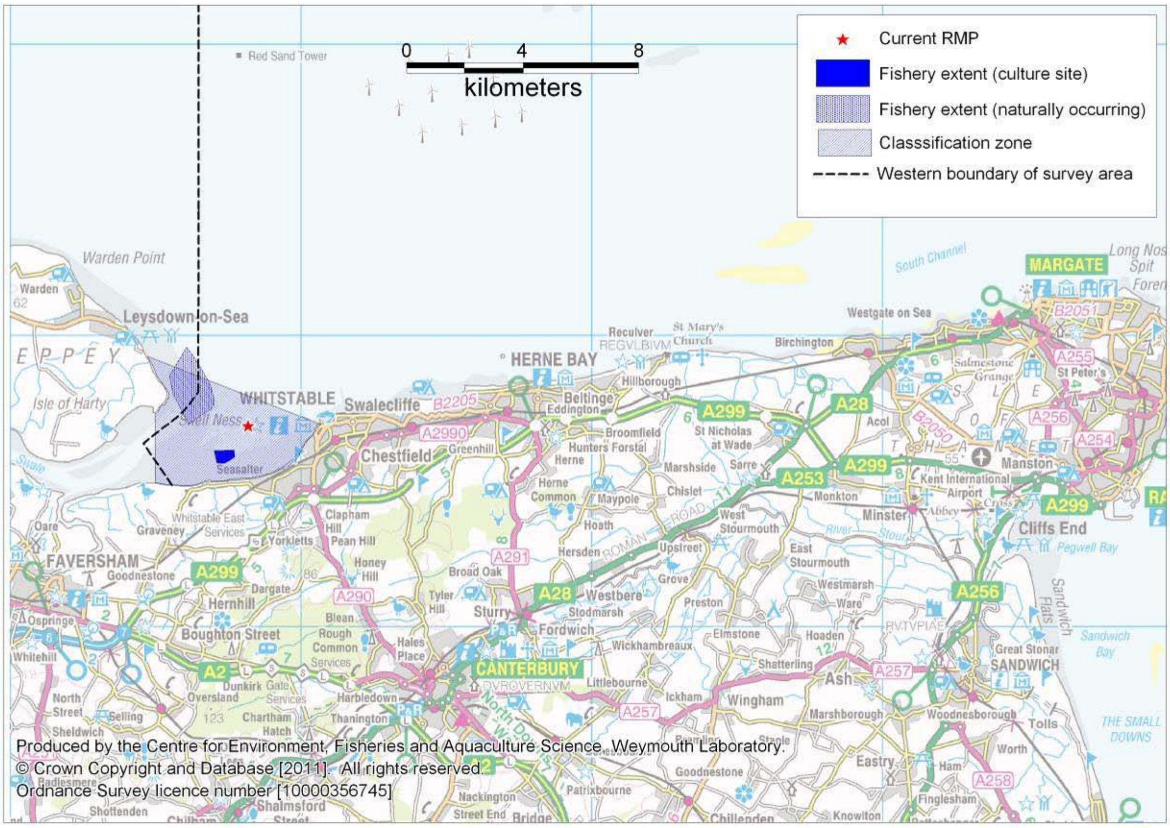


Figure 2.5 Manila clam fishery, classified zone and current RMP

A Manila clam culture site has been in operation for several years on the Pollard grounds, where seed stock from the Reculver hatchery is grown under netting. This fishery was formerly very successful, but has recently been affected by high levels of unexplained mortalities. These problems are under investigation by the fishery owners, and its continued classification is requested by the LEA so harvesting can start again as soon as these problems are remedied. There is however no stock of this species available for sampling at this site. An area supporting commercial densities of naturally occurring Manila clams just off the Pollard has recently been identified for which the LEA has requested classification so these can be dredged. The LEA advises that small quantities of Manila clams may also be present under some mussel beds, such as those by Hampton pier, but these are only subject to non-commercial casual gathering. Nevertheless, a sampling plan covering the wider area may be required at some point in the future.

OTHER SPECIES

Other bivalve species known to be present in the area include razors (*Ensis* spp.) and various species of clams. Little is known about their status, and although some casual gathering of these is believed to occur, no interest in harvesting these other species commercially has been expressed.

2.2 GROWING METHODS AND HARVESTING TECHNIQUES

Pacific oysters are both naturally occurring and cultured in bags on trestles. Seed for culture sites may originate from hatcheries, or from naturally occurring stock collected from the foreshore. Harvesting may be by hand or by dredge. Cockles are wild, and are harvested by suction dredge in the main, with some non-commercial hand gathering undertaken on intertidal beds at Minnis Bay. Mussels are wild, and may be harvested by hand or by dredge, although there is currently no commercial interest in these stocks. As well as occurring naturally, Manila clams are cultured from hatchery seed laid in the sediment under netting, and harvested by hand.

2.3 SEASONALITY OF HARVEST, CONSERVATION CONTROLS AND DEVELOPMENT POTENTIAL

PACIFIC OYSTERS

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, although increased interest from local shellfish boats is likely to arise during the closed season for cockles (November to May inclusive). Dredging not permitted on conservation grounds in some areas where these stocks are present, namely the chalk reefs which are found towards the eastern end of the north Kent coast although hand gathering here is permitted. Pacific oyster stocks have become more numerous and widespread in recent years throughout the entire outer Thames estuary, and it is likely that their expansion will continue on the whole, although some areas may be cleared through exploitation.

NATIVE OYSTERS

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. Major changes in the distribution and status of these stocks are not anticipated in the immediate future.

MUSSELS

There is no closed season for mussels. There is a maximum dredge front opening size of 2m for vessels fishing for mussels. A maximum of 13.6 m^3 of mussels may be retained per vessel per day. No more than 10% by weight of a representative sample of the catch can pass through a space 18mm in width. Any fishing for seed mussels requires prior written authorisation from the K&E IFCA. The populations of mussels on harder substrates tend to be reasonably stable, whereas the populations on softer substrates are more variable in their locations and tend to be of smaller seed stocks. In some places mussel beds may be undergoing displacement by Pacific oysters.

COCKLES

The cockle beds farthest offshore are regulated via the Thames Estuary Cockle Fishery Order 1994, whereas the inshore areas (extending to about

5km off the north Kent coast) which cover the majority of the beds considered in this report are regulated via K&E IFCA Byelaws. K&E IFCA Byelaws indicate a maximum vessel size (14m) and specify permissible dredge configurations, including a minimum bar spacing of 16mm. The fishery is open to any suitable boats but a permit and prior approval of the vessel and gear via an annual inspection is required. A maximum of 13.6 m^3 of cockles may be retained per vessel per day. Hand gatherers using rakes also require a permit. No more than 10% by weight of a representative sample of the catch can pass through a space 16mm in width. The fishery is only opened at the discretion of the K&E IFCA, based on stock status and other considerations. It was not opened in either 2010 or 2011 to prevent boats from other areas affected by unexplained cockle mortalities from fishing the area and potentially importing diseases. When the fishery does open, it is within the June to November (inclusive) window at which point meat yields are best, most typically during the latter half of this period.

Within the Thames Estuary Cockle Fishery Order only a limited number of licences (14) are issued to dredge for this species. Quotas are assigned on the basis of quarterly stock surveys. The exact timing of the open season varies from year to year but again falls within the June to November window. Effort limitations (days per week) and gear restrictions apply. Specific areas may be closed on the basis of stock survey information. Whilst the fishery is in progress effort is actively managed by the K&E IFCA with the aims of maximising yield without depleting stocks.

Cockle stocks tend to fluctuate in their size and distribution from year to year. Success of spatfalls may vary greatly between years, and storms, temperature extremes, diseases, predation and of course exploitation can all affect them. Whilst the stock biomass fluctuates significantly from year to year, the locations of cockle beds within the Thames estuary tend to be reasonably stable.

MANILA CLAMS

Harvest of this species may occur at any time of the year, and the fishery (both wild and cultured) is not subject to any specific conservation controls such as minimum landing size.

ALL BIVALVES

Any wild shellfish bed (excluding native oysters) may be closed at any time by the Kent and Essex IFCA for reasons of fishery management and control of exploitation. A summary of seasonal openings and closures for each commercial species is given in Table 2.1 below

Table 2.1 Seasonality of harvest summary.

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Species	Cockles												
	Manilla clams												
	Mussels												
	Native oysters												
	Pacific oysters												

Red = closed season; Green=harvesting period.

2.4 HYGIENE CLASSIFICATION

Annual hygiene classifications as at the 1st of September each year are shown in Table 2.2 below followed by Table 2.3 which summarises criteria for classification and the post-harvest treatment required before bivalve molluscs can be sold for human consumption.

Table 2.2 Historic hygiene classifications from 2001

BED NAME	BED ID	SPECIES	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Pollard	B17AW	Cockles	A*	A*	B	B[4]	B-LT[1]	B-LT[1]	B-LT[1]	B-LT	B-LT	B-LT	B - LT
Kentish Flats	B17AW	Cockles	B	B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
North of Hook	B17AC	Cockles	B	B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
South of Hook	B017W	Cockles	B	B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
Margate Sands	B17AB	Cockles	B	B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
Minnis Bay	B17BD	Cockles	B	B	B	B[4]	P	C	C[1]	C	C	C	C
Pollard	B17AX	Manila clams	A*	A*	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
Herne Hampton	B017E	Mussels	B	B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
Herne Reculver	B017G	Mussels	B										
Beltinge Bay	B017E/F	Mussels	B	B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
Herne	B017E/F	Mussels		B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
Reculver	B017E/F	Mussels		B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
Swalecliffe	B017D/H	Mussels	B[4]	B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
East Last Bank	B017D/E/F	Mussels	B	B	B[1]	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
Clite Hole	B017D/E/F	Mussels	B	B	B[1]	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
The Street	B017C	Mussels	B	B	B[1]	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
Minnis Bay	B17AD	Mussels	B	B	B	B[4]	P						
Whitstable	B017AV	Mussels											B - LT
East Last Bank	B017D/E/F	Native oysters	B	B	B[1]	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
Clite Hole	B017D/E/F	Native oysters	B	B	B[1]	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
The Street	B017AL/Z	Native oysters	B	B	B[1]	B	A	A	A[1]	A			
Kentish Flats	B017R/AL/AF	Native oysters	A	A	A	A	A	A	A[1]	A	A	A	A
Whitstable Bay	B17BO	Native oysters											B - LT[1]
Pollard	B17AM	Pacific oysters	A*	A*	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B - LT
Whitstable Bay	B17AV	Pacific oysters											B - LT[1]

** - seasonal classification applies.*

1 - Classification was provisional due to insufficient sample results, either in number or period of time covered.

4 - Area classified at higher level due to results close to the tolerance limit. A downgrade may be possible if further failures are returned.

LT - Long-Term classification system applies. N.B. Long-Term (LT) classification system was introduced in England and Wales alongside the annual classification system, and applies to class B areas only. New class B areas will initially be given annual classification until they meet criteria for a long-term classification

Table 2.3 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* 100g^{-1} Fluid 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* 100g^{-1} FIL in more than 10% of samples. No sample may exceed an upper limit of 46,000 *E. coli* 100g^{-1} 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* 100g^{-1} FIL	Relaying for, at least, two months in an approved relaying area or cooking by an approved method
Prohibited	>46,000 *E. coli* 100g^{-1} 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.*

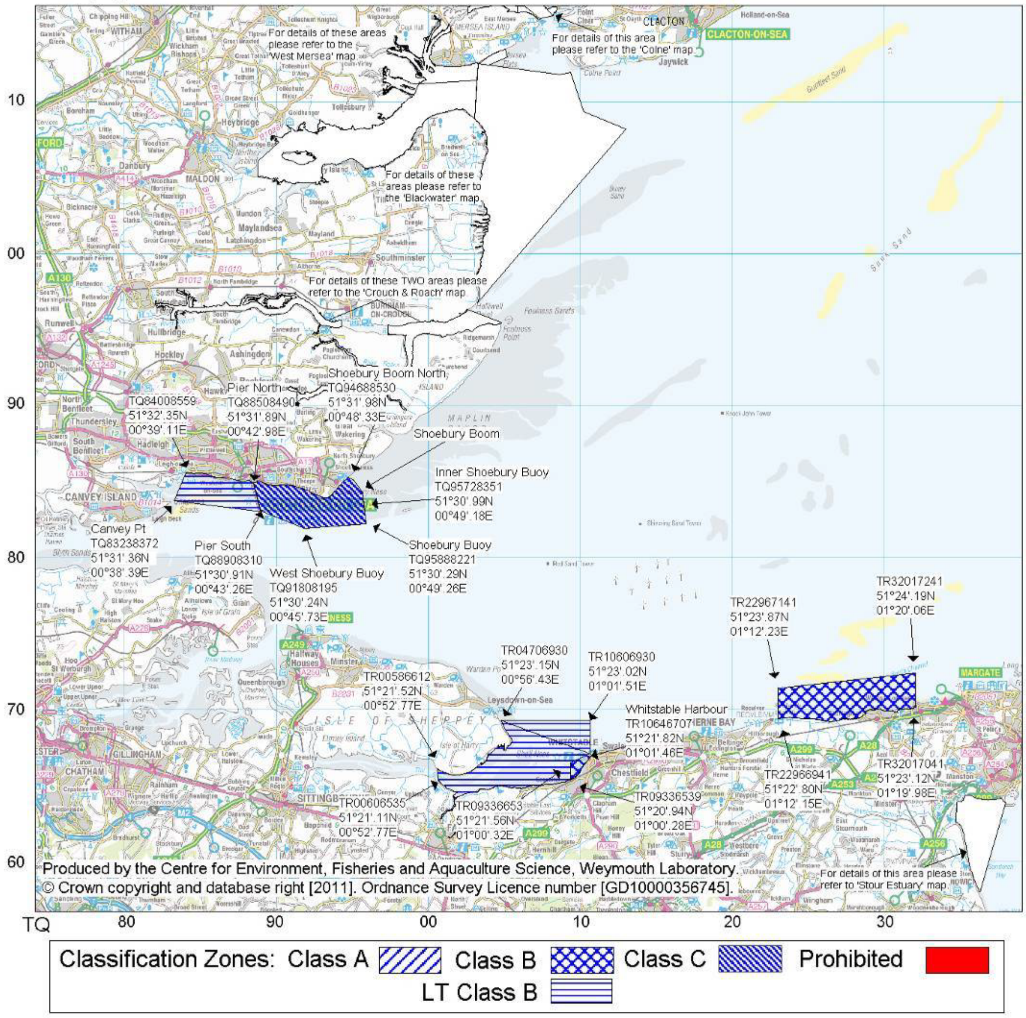
[5] *This level is not specifically given in the Regulation but does not comply with classes A, B or C. The competent authority has the power to prohibit any production and harvesting of bivalve molluscs in areas considered unsuitable for health reasons.*

The current classifications are mainly Bs, with the exception of Minnis Bay cockles (C) and Kentish Flats native oysters (A). Minnis Bay cockles were downgraded from B to prohibited in 2005, and subsequently upgraded to C in 2006 indicating some instability in this area. Native oysters at Kentish flats have been a very stable class A for more than a decade. The current classification zones span more than one production area, extending in some cases into the Swale and/or the Thames Estuary production areas and many of these zones have multiple RMPs.

Figures 2.6 to 2.10 inclusive show the classifications zones classified as at 1st September 2011 for each species

Swale, Thames Estuary & N.Kent Coast - C. gigas

Scale - 1:380000



Classification of Bivalve Mollusc Production Areas: Effective from 1 September 2011

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)

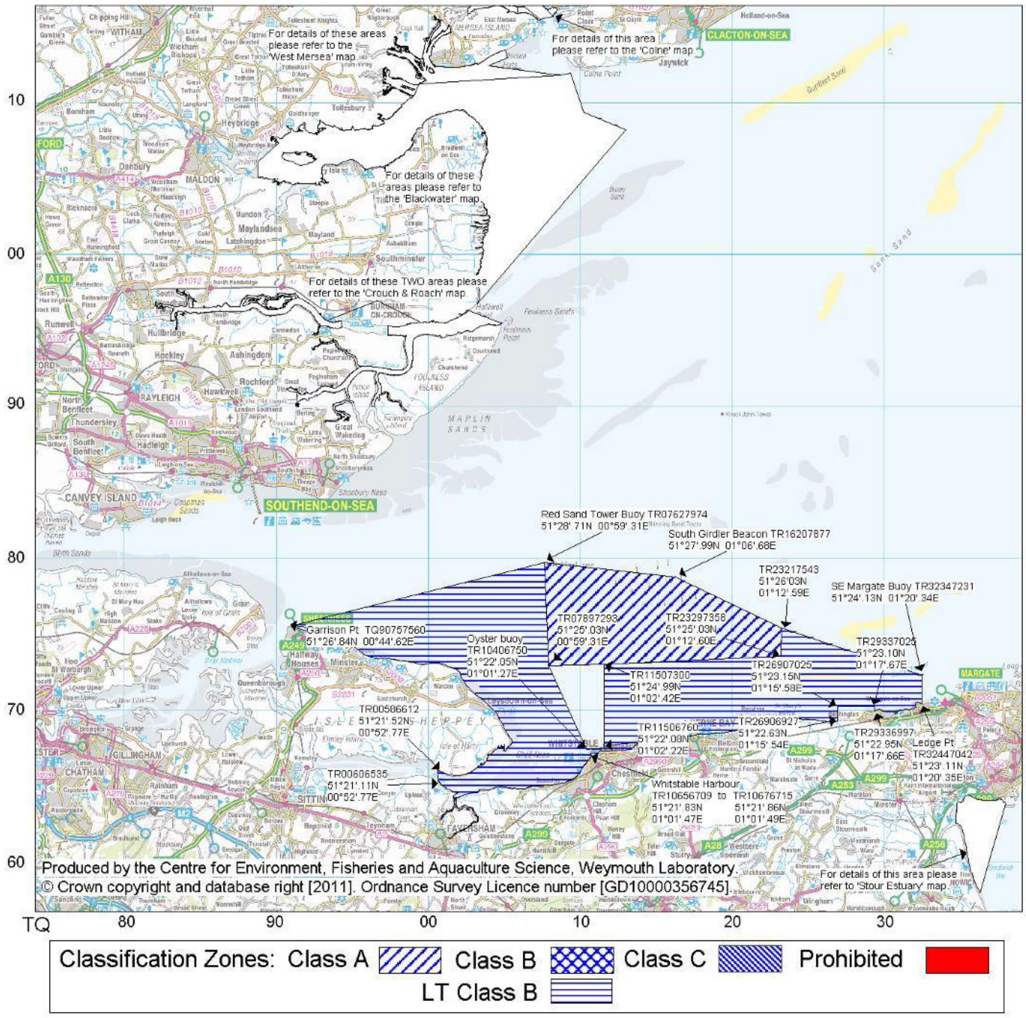
N.B. Lat/Longs quoted are WGS84
Separate maps available for O. edulis, C. edule, Clams (T. philippinarum) and Mytilus spp. for this area

Food Authorities: Swale Borough Council (Swale River and Estuary)
Canterbury City Council (North Kent Coast)
London Port Health Authority (Thames Estuary)

Figure 2.6 Current classifications for Pacific oysters

Swale, Thames Estuary & N.Kent Coast - O.edulis

Scale - 1:380000



Classification of Bivalve Mollusc Production Areas: Effective from 1 September 2011

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)

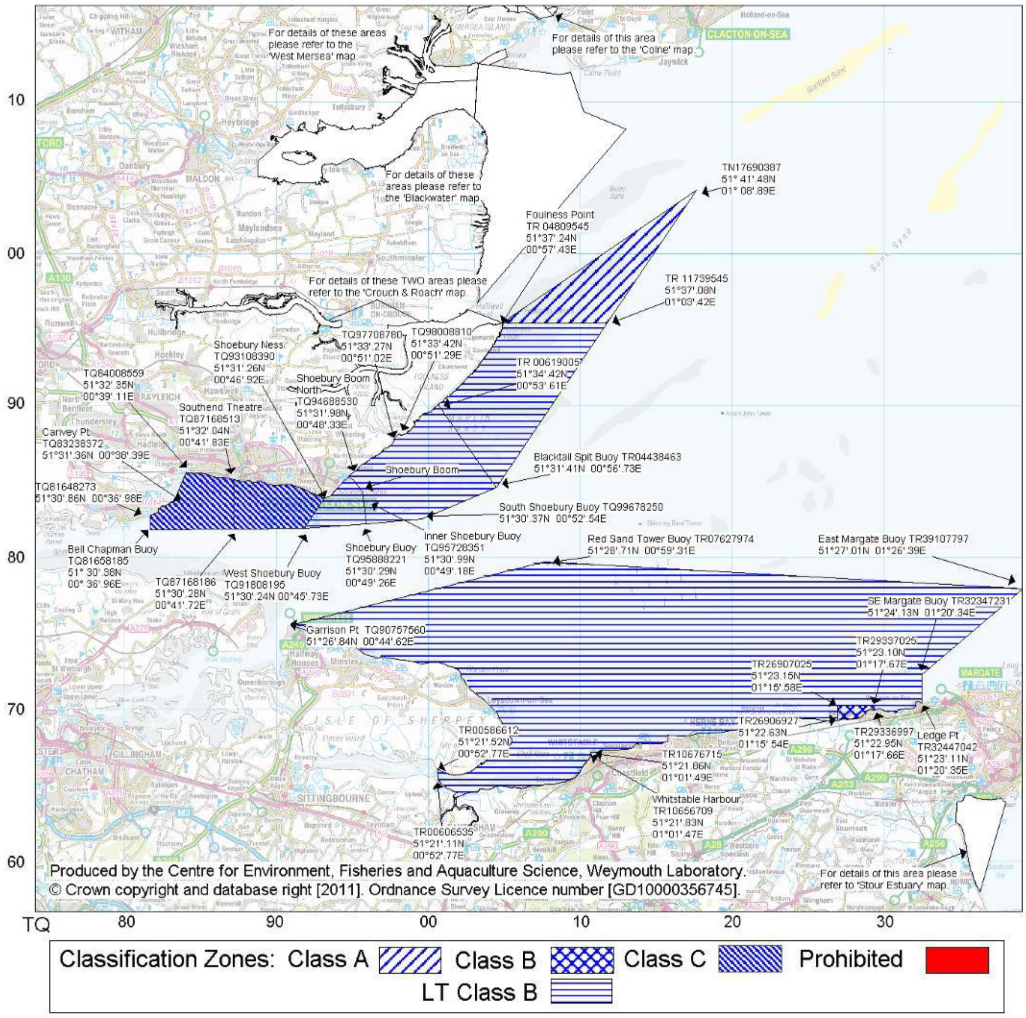
N.B. Lat/Longs quoted are WGS84
Separate maps available for C. gigas, C. edule, Clams (T. philippinarum) and Mytilus spp. for this area

Food Authorities: Thanet District Council (Minnis Bay, North of Hook, South of Hook and Margate Sands)
Swale Borough Council (Swale River and Estuary)
Canterbury City Council (North Kent Coast)

Figure 2.7 Current classifications for native oysters

Swale, Thames Estuary & N.Kent Coast -
C. edule

Scale - 1:380000



Classification of Bivalve Mollusc Production Areas: Effective from 1 September 2011

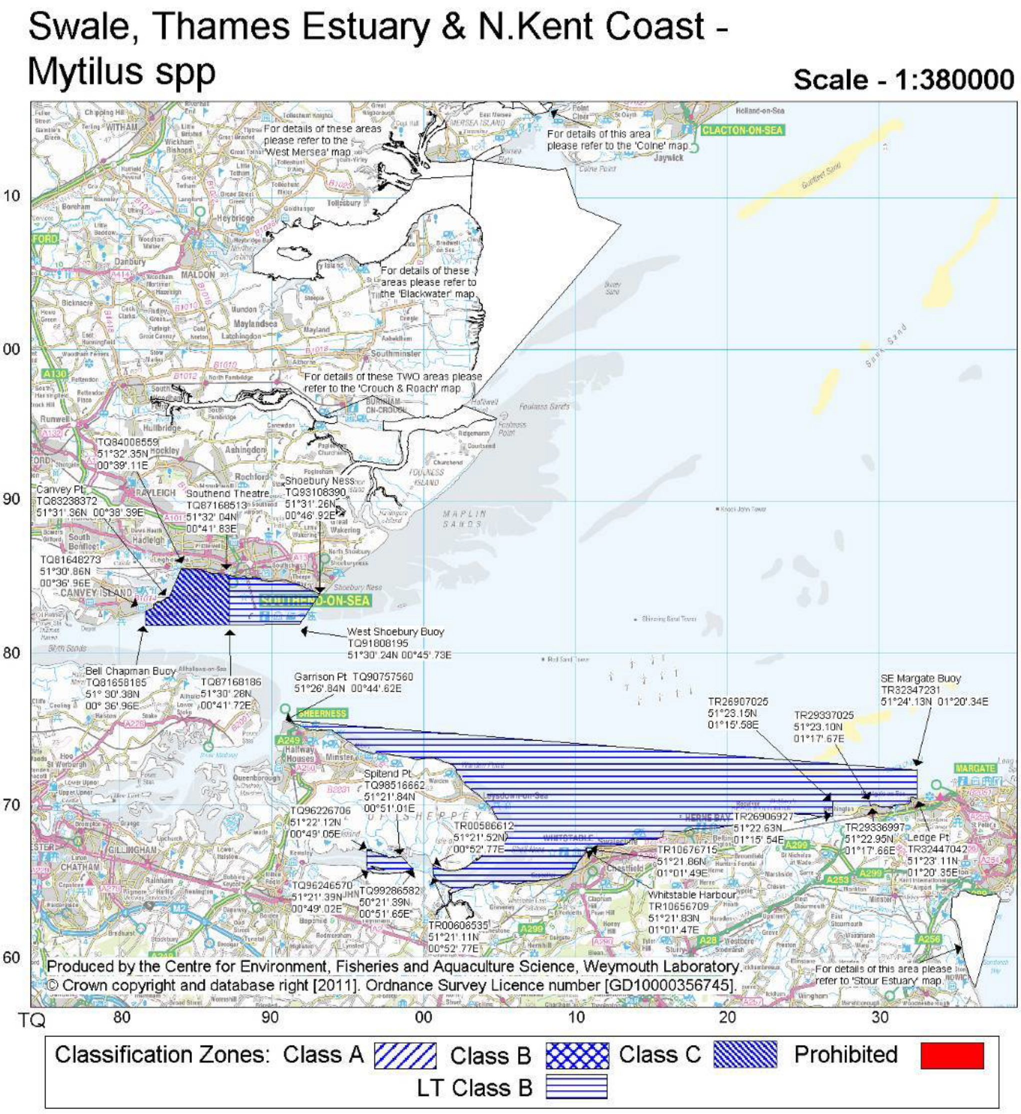
The areas delineated above are those classified as bivalve mollusc production areas under EU Regulation 854/2004

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 maps available for C. gigas, Mytilus spp., Clams (T. philippinarum), and O. edulis for this area

Food Authorities: Thanet District Council (Minnis Bay, North of Hook, South of Hook and Margate Sands)
Swale Borough Council (Swale River and Estuary)
Canterbury City Council (North Kent Coast)
London Port Health Authority (Thames Estuary)

Figure 2.8 Current classifications for cockles



Classification of Bivalve Mollusc Production Areas: Effective from 1 September 2011

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)

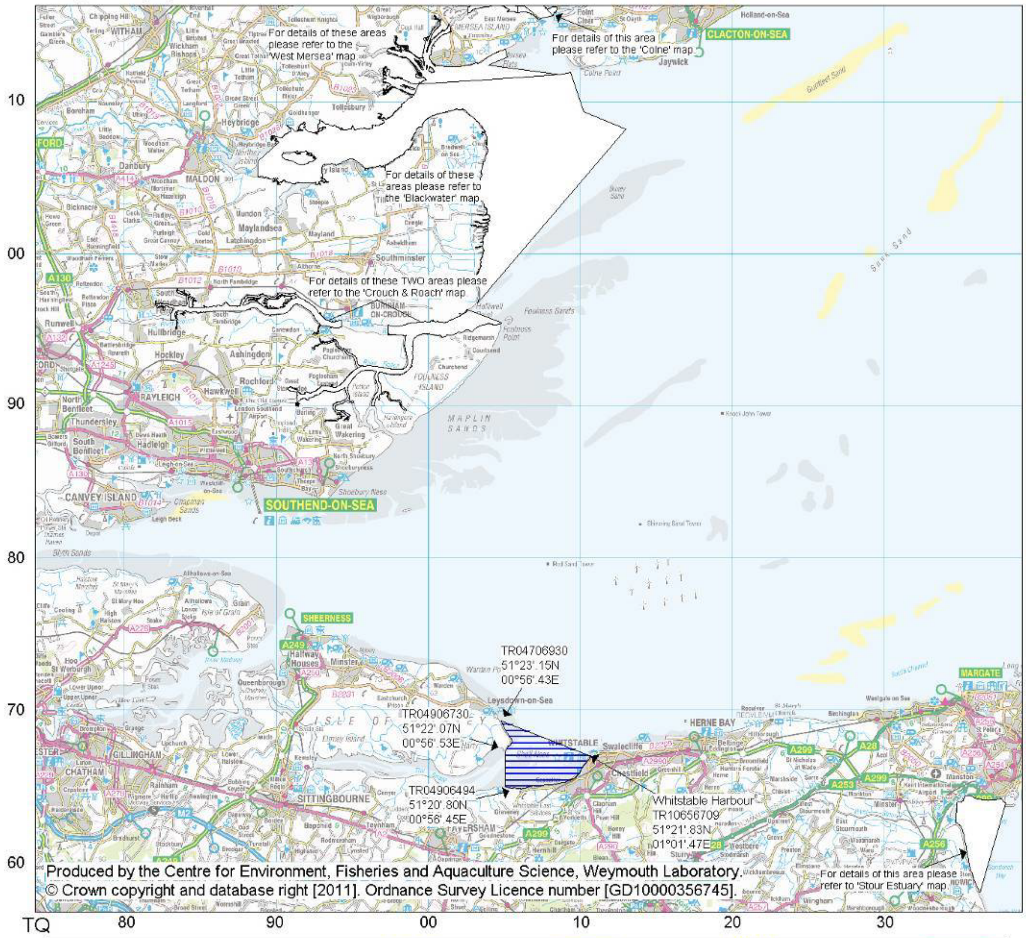
N.B. Lat/Longs quoted are WGS84
Separate maps available for C. gigas, C. edule, Clams (T. philippinarum) and O. edulis for this area

Food Authorities: Thanet District Council (Minnis Bay, North of Hook, South of Hook and Margate Sands)
Swale Borough Council (Swale River and Estuary)
Canterbury City Council (North Kent Coast)
London Port Health Authority (Thames Estuary)

Figure 2.9 Current classifications for mussels

Swale, Thames Estuary & N.Kent Coast - T. philippinarum

Scale - 1:380000



Classification Zones: Class A | Class B | Class C | Prohibited | LT Class B

Classification of Bivalve Mollusc Production Areas: Effective from 1 September 2011

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 maps available for C. gigas, O. edulis, C. edule and Mytilus spp. for this area

Food Authorities: Canterbury City Council (North Kent Coast)

Figure 2.10 Current classifications for Manila clams

3. 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 north Kent coast.

SHELLFISHERIES

PACIFIC OYSTERS

Naturally occurring Pacific oysters are widespread throughout the intertidal and possibly subtidal areas from Ledge Point through to Seasalter. It is anticipated that the size and geographic extent of these stocks will continue to increase on the whole. They are subject to hand gathering and a dredge fishery, and are cultured on trestles at two intertidal sites off Whitstable. Therefore the entire stretch of coast from Ledge Point westwards extending out about 2 km from the low water mark will require classification for this species. Harvesting may occur at any time of the year so year round classification is required. The use of naturally occurring intertidal stocks for sampling is slightly problematic in that stocks are patchy and so may not coincide with the desired RMP locations. Repeated sampling at any particular point is likely to rapidly deplete stocks, and large areas may be cleared quite rapidly by hand gatherers.

NATIVE OYSTERS

Native oyster beds lie offshore to the east of the Isle of Sheppey, extending roughly as far as Reculver. Significant changes to the extent of the native oyster beds are not anticipated in the near future. The classified zone extends into the Thames Estuary production area adjacent to Sheppey, but the zone is classified only on the basis of RMPs within the North Kent production area. The actual area fished does not extend nearly as far outside of the survey area as the classified zone. It is therefore proposed that this arrangement should continue until such time that this part of the Thames Estuary is subject to sanitary survey. Native oysters are subject to a seasonal dredge fishery which runs from September to April inclusive, so only require classification for this period. Sampling this fishery requires significant resources, particularly when the fishery is closed and no boats are operating commercially as they have to be collected by dredge. Native oysters may also be ongrown or held prior to harvest on the trestle areas off Whitstable and Seasalter.

COCKLES

The Thames Estuary as a whole supports a large and lucrative cockle dredge fishery. The main cockle beds within the survey area lie off Leysdown, on the Hamm and Pollard grounds, at Minnis Bay and offshore from there on Hook

Spit and Margate Sands, although they may be present anywhere with a suitable sandy substrate. Some hand gathering occurs at the intertidal bed at Minnis Bay. The location of the main beds are relatively stable from year to year, although stock structure and abundance fluctuates significantly. The fishery is seasonal, only operating in the June to November window, so classification is only necessary for this period. Sampling this fishery requires significant resources, particularly when the fishery is closed and no boats are operating commercially as they have to be collected by dredge.

Mussels

Naturally occurring mussels are also widespread throughout the intertidal and subtidal areas, with a patchy distribution. Some dredging of market sized mussels may occur occasionally. The majority of stocks are undersized seed mussels with most of the larger animals found in populations on harder substrates where it is impractical to dredge. Demand for seed mussels for relaying is low and no requests to take seed mussels have been made to the K&E IFCA in the last two years. Some mussels are currently being ongrown on the Pollard grounds, and Canterbury Council have indicated that continued year round classification of this species is desired. Stocks on hard ground are reasonably stable in their locations, but the areas of juvenile mussels on softer substrates are more ephemeral. There are many locations along the coast where mussels could be sampled from rocks in the intertidal zone.

Manila clams

There is a Manila clam culture site on the Pollard grounds, where seed stock from the Reculver hatchery was grown under netting. This fishery has recently suffered from high levels of unexplained mortalities. These problems are under investigation by the fishery owners, and its continued year round classification is requested by Canterbury Council so harvesting can start again as soon as these problems are remedied. There is, however, no stock of this species available for sampling at this site so cockles are currently used. This arrangement will have to continue, at least until there are mature clams to sample. A patch of naturally occurring Manila clams has recently been identified just off Leysdown, which will also require classification. Manila clams are thought to occur more widely in the area, but there is no information available on their distribution or densities. A sampling plan is provided for the wider area in case it may be required in the future. It will not be possible to confirm whether there are sampleable stocks in the vicinity of any the recommended RMPs without further stock investigations.

Pollution Sources

Freshwater Inputs

Only the relatively narrow coastal strip drains to the north Kent coast so the volumes of freshwater discharged to the north Kent coast are small. The catchment area is drained by a series of small watercourses, most of which were sampled and measured during the shoreline survey to obtain estimates of the bacterial loadings that they convey to coastal waters, albeit under varying rainfall conditions. These drain predominantly urban areas from Whitstable to Herne Bay, and from Birchington to Margate, with the middle section being mainly low lying arable land of the Reculver marshes. Those draining urban areas may be expected to carry higher concentrations of *E. coli* on average. Some receive inputs from sewage discharges, most of which are small private discharges, but notably the Herne Bay STW which discharges to the Reculver marshes.

Despite their small size, some of the measured bacterial loadings were high in relation to estimates of those generated by the two UV treated sewage works discharging to north Kent coastal waters. The most significant of these in terms of measured loadings were the West Brook at Hampton ($1.5x10^{12}$ *E. coli*/day but measured under very wet conditions), the Bishopstone Glen ($2.9x10^{11}$ *E. coli*/day), and two outfalls from the Marshes at Reculver either side of the shellfish hatchery ($4.1x10^{11}$ 2.5 $x10^{11}$and *E. coli*/day). The outfalls at the Whitstable end of the survey area, including those draining the pastures at Graveney marshes were only carrying small amounts of lightly contaminated water at the time of survey. It must be noted that these loadings estimates are only correct for the time of sampling, and are likely to fluctuate significantly depending on factors such as rainfall. For reasons detailed in Appendix III six small surface water outfalls were not sampled and measured including one at Herne Bay harbour, and two at Minnis Bay which drain the eastern end of the Reculver marshes.

The individual freshwater inputs of the sizes draining to the north Kent coast may cause small localised ‘hotspots’ of contamination in their immediate vicinity, particularly during wet weather. Their cumulative effects may result in a slight increase in *E. coli* levels along the north Kent coast, and on the basis of their locations and loadings this may be felt most acutely in the vicinity of Reculver (from Bishopstone Glen and the two marsh outfalls), in the small embayment where West Brook discharges, by Swalecliffe Brook, and possibly at Minnis Bay. RMPs situated in inshore locations within these areas would be best placed to capture the effects of surface runoff

HUMAN POPULATION

The north Kent coastal strip is heavily populated throughout most of its length with a total resident population of about 150,000 mainly within the towns of Whitstable, Herne Bay and Margate. It is a popular holiday destination with numerous caravan parks and hotels. Design calculations for the Margate STW indicate that Southern Water anticipate a peak summer population of about 20% higher than the normal resident population, so increased volumes of sewage effluent will be discharged during the summer.

SEWAGE DISCHARGES

There are two major sewage works discharging to coastal waters off North Kent, both of which are UV treated and discharge via long sea outfalls. The Margate STW discharges about 1.8km off Foreness Point in Margate, and the

Swalecliffe STW discharges about 1.7km off Swalecliffe. Estimates of the bacterial loadings generated by these are low at 8.2×10^{10} and 2.1×10^{10} *E. coli* per day respectively. However, these estimates are based on average values for this treatment type rather than bacteriological results from the final effluents from these works, and the actual loading generated is likely to fluctuate. Should problems arise in the UV plant these discharges have the potential to generate much higher bacterial loadings, although in the absence of final effluent testing data it is not possible to assess how effective and consistent this treatment is. Also, UV treatment is more effective against bacteria compared to viruses such as norovirus. These discharges therefore present a significant risk to shellfisheries in their vicinity. There are two other sewage works which may impact on the coastal waters of north Kent. The Herne Bay STW provides secondary treatment and discharges within the Reculver marshes, which in turn drain to the sea via three outfalls just east of Reculver. It generates an estimated bacterial loading of 9.5×10^{12} *E. coli* per day. The Faversham Abbey Fields STW also provides secondary treatment and discharges an estimated bacterial loading of 2.3×10^{13} *E. coli* per day to Faversham Creek, about 10km west of Seasalter. There are no continuous water company sewage discharges to the north or east shore of Sheppey, or to watercourses draining there.

A series of intermittent sewage discharges are associated with the sewerage networks serving the area, mainly located at Whitstable/Herne Bay and Margate. Most spills from these were minor and of short duration, although significant spills may potentially occur from any of these intermittent discharges. The Swalecliffe STW overflow was responsible for most of the recent spills to the area of more than 12 hours duration during the period from 2008 to 2010. In the first 7 months of 2011 a significant number of spills of more than 12 hours were recorded from the three outfalls serving Margate STW. Therefore the Swalecliffe and Margate STW outfalls appear to be the most significant overflow discharges. Sewage related debris was seen at a number of locations during the shoreline survey. Cotton buds were frequently sighted along the entire coast but these are persistent and may have originated from distant sources. Debris of more recent origin (rag) was recorded at Whitstable, Reculver and Herne Bay, suggesting spills of untreated sewage had occurred somewhere along this stretch of coast.

In addition to water company sewerage networks, there are 102 small private domestic or trade discharges to the coastal strip. Just under half of these drain to soakaway so would be expected to have no impact on coastal waters. The majority of those discharging to watercourses are found from Reculver westwards and may be expected to make a contribution to *E. coli* loadings carried by watercourses draining this area. One discharges to Whitstable Harbour.

It is therefore concluded that although the bacterial loadings generated by the two long sea outfalls from Margate and Swalecliffe STWs will usually be small, they carry overflow discharges on a regular basis and should problems arise in their UV plants the loadings they generate will increase greatly. Ideally, exclusion zones should be set round these outfalls to prevent the harvesting of grossly contaminated shellfish. However, policy in this regard is yet to be developed, so small classification zones should be set around such outfalls covering the area where their impacts are most acute, with RMPs located in such a position they are most exposed to the plume. Contamination from the Herne Bay STW will be carried into coastal waters via the outfalls from the Reculver marshes, so RMPs should be placed by these to best capture contamination from this source. Faversham STW discharges 10km west of Seasalter so its impacts are anticipated to be relatively minor and mainly confined to the western end of the survey area. Although significant spills may potentially occur from any of the other intermittent discharges in the area, available records suggest that spills are generally infrequent and minor. Small private discharges are likely to make a contribution to levels of *E. coli* in some watercourses but overall impacts from these are anticipated to be minor.

AGRICULTURE

Within the north Kent coast catchment area most agricultural land is used for arable farming. It is likely that organic fertilisers (manures, slurries and sewage sludge) may be spread on these areas, although the extent of and temporal and geographic profiles of any such applications is uncertain. Should spreading be followed by high rainfall elevated levels of contamination would be anticipated in neighbouring watercourses such as those draining the marshes at Reculver. There are some livestock within the catchment area but overall numbers and densities are low. The only large area of pasture is on the Graveney Marshes, at the western end of the survey area where sheep and cattle are grazed. Therefore watercourses draining this area, which lies at the western extremity of the survey area, are likely to be impacted by grazing livestock, although shoreline survey measurements indicated little flux of *E. coli* from these. Numbers of livestock on pastures will be highest during the summer months, so peak levels of contamination may arise from this source 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. RMPs set at the mouths of watercourses draining agricultural land would be best placed to capture contamination from agricultural sources.

BOATS

The main shipping channels through the Thames estuary are some distance to the north of the area considered in this report, and Merchant Shipping is prohibited from discharging within 3 nautical miles of land, so no impacts from larger vessels are anticipated. There are small harbours at Whitstable, Herne Bay and Margate, the largest of which is Whitstable, where 11 fishing vessels were recorded during the shoreline survey. No areas of yacht moorings were identified. In the summer a large number of small leisure craft (small sailing dinghies, jet skis etc.) use the inshore waters here although they would not generally be expected to make any overboard discharges. Yachts and fishing vessels frequently navigate closer inshore along the north Kent coast and may make overboard discharges whilst doing so. Overboard discharges may be more common in the summer as there will be more yachts passing through the area. Inputs from boating traffic are likely to be relatively minor and spatially unpredictable, so have no material bearing on the sampling plan.

Wildlife

The most significant wildlife aggregation is around 75,000 wildfowl and waders which overwinter in the Swale. No bird counts are undertaken within the survey area, but it is likely that a similar but smaller influx occurs here. Shoreline survey observations support this, with small aggregations of gulls and waders recorded in intertidal areas, and a flock of 2-300 geese seen on the marshes at Reculver. Some birds are in residence year round, and the main seagull breeding area is at Birchington where 515 pairs were recorded in 2000. Therefore, it is likely that some proportion of the *E. coli* found within shellfish samples is of avian origin, more so during the autumn and winter months. Direct deposition by birds foraging in the intertidal zone is likely to be the main route via which contamination from birds is conveyed to shellfish beds. Therefore, RMPs in the intertidal zone may be best placed to capture contamination of avian origin. It is possible that inputs may be higher towards the Swale estuary at the western end of the survey area during the winter and in the vicinity of the main gull breeding site at Birchington during the summer, but these animals are highly mobile so impacts will be widespread throughout the area.

Small numbers of seals are likely to frequent the area, and so potentially represent a diffuse source of pollution to all shellfish beds. They may use some of the offshore sandbanks such as Margate Sands as low tide haulout sites, so cockle beds there may be most at risk from this possible source. RMPs set at the highest point of offshore sandbanks may be best placed to capture contamination originating from seals. Away from possible haulout sites these animals are likely to forage over wide area and impacts are likely to be minor at most, and unpredictable in spatial terms.

No other wildlife species which have a potentially significant influence on levels of contamination within shellfish on the north Kent coast have been identified.

Domestic animals

Dogs are exercised on the beaches along the north Kent coast and so also represent a potential source of diffuse contamination primarily through direct deposition in the upper intertidal zone. It is likely that the intensity of this is greatest on beaches adjacent to urban areas. Whilst residents are likely to engage in these activities year round, a slight increase in impacts due to visitors to the area may be expected during summer months. RMPs set in the intertidal zone within urban areas may be best placed to capture inputs from dogs. There is an equestrian centre at Plumpudding, just inland from Minnis Bay so some impact from horses may be anticipated in watercourses draining this area.

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 3.1 and Figure 3.1. There are two continuous UV treated sewage works which discharge to north Kent coastal waters via long sea outfalls. If functioning correctly these should generate relatively minor bacterial loadings, but these loadings may increase greatly if problems arise in the UV plants, and intermittent overflows of untreated sewage are reported to occur regularly from both. A series of other intermittent overflow discharges are located in the nearshore zone through Margate and Herne Bay/Whitstable, although spills from those for which records were available were generally minor and infrequent. There are two further STWs which only provide secondary treatment (and hence much greater bacterial loadings). One discharges inland within the Reculver marshes, the other discharges to Faversham Creek in the Swale estuary about 10km west of the survey area. The former will be carried into coastal waters via the surface water outfalls from the western end of the marshes, and the latter will be carried towards the Seasalter/Whitstable area as the tide ebbs from the Swale estuary.

The impacts of the series of small watercourses are likely to be of local significance to the nearshore region. Some carry urban runoff, others agricultural runoff (arable in the case of the Reculver marshes and pasture in the case of the Graveney marshes) and some receive sewage inputs, notably those draining the western end of the Reculver marshes. The bacterial loading carried into coastal waters by these watercourses is likely to be much higher during wet weather. Diffuse inputs from birds and dogs, whilst they may be a significant contaminating influence to the nearshore region are considered a diffuse input so will be of lesser relevance to the sampling plan. It is possible that minor impacts from seals may be felt towards the top of offshore drying sandbanks if they are used as haulout sites.

Table 3.1 Qualitative assessment of changes in pollution load on the North Kent coast.

Pollution source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Land runoff												
Continuous sewage discharges												
Intermittent sewage discharges												
Birds												
Dogs												
Boats												

Red - high risk; orange - moderate risk; white - low risk

HYDRODYNAMICS

The bathymetry off the north Kent coast is relatively uncomplicated, gently sloping away from the shore. The gradient is less steep at the Whitstable end and the Swale estuary, immediately to the west, is shallow and enclosed so the dilution potential is lower here. Tidal amplitude is relatively large, so tidal streams are likely to dominate patterns of water circulation in the area under most conditions. The tides flood along the north Kent coast in a westerly direction parallel to the shore, and ebb in the opposite direction. Contamination from shoreline sources will therefore travel parallel to the coast, impacting either side of their locations. The magnitude of their impacts will decrease with distance as the plume spreads and becomes more diluted. Contamination from shoreline sources may be carried several km along the shore during the course of a flood or ebb tide, so impacts may potentially be felt a considerable distance away. Contamination from offshore sources such as long sea sewage outfalls may be carried upwards of 10km on spring tides.

Superimposed on tidal circulation are density and wind effects. There is little in the way of freshwater inputs along the north Kent coast. The coastal waters here are unenclosed so density effects are unlikely to modify water circulation here. Sewage discharged from long sea outfalls, being less dense than the receiving seawater, will tend to rise to the surface and away from benthic shellfish beds. Strong winds will modify surface currents on the north Kent coast, driving surface water currents in the same direction as the wind and creating return currents either lower down the water column or along sheltered margins. The prevailing south westerly wind direction will tend to advect contamination in the upper part of the water column away from the shore and out towards the North Sea. Onshore winds will create wave action which may resuspend any contamination held within the sediments of the intertidal zone.

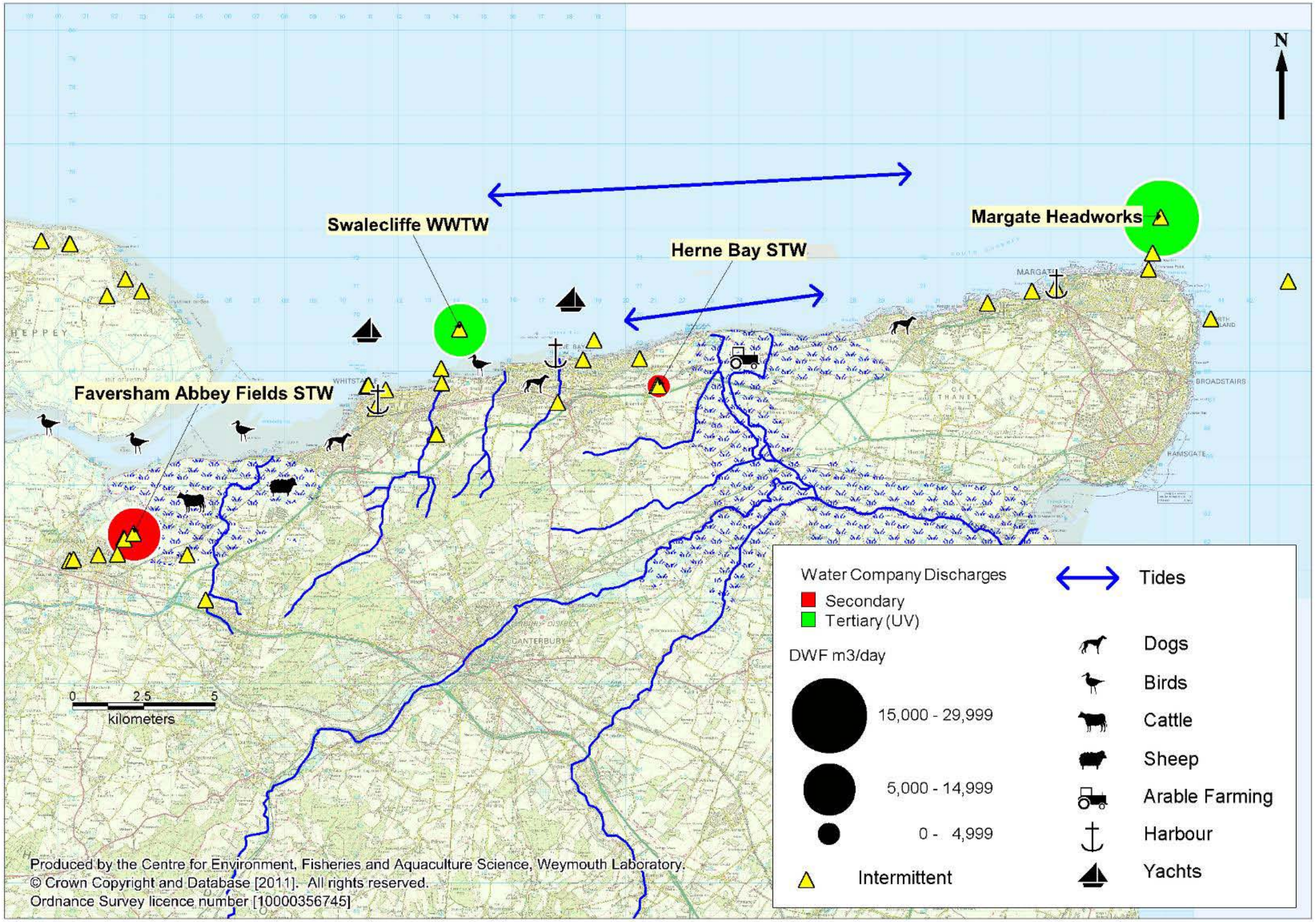


Figure 3.1 Significant sources of microbiological pollution to the north Kent coast.

SUMMARY OF EXISTING MICROBIOLOGICAL DATA

Microbiological monitoring data from the bathing waters monitoring programme, the shellfish waters monitoring programme, and from shellfish classification monitoring were available for this area. These are analysed in detail in Appendices XI and XII, and the main points arising are summarised and their implications for the sampling plan highlighted in this section. Only results from 2008 onwards were considered as significant sewerage upgrades took place in 2007.

Water samples were taken under the bathing waters programme from 11 sites from West Beach in Whitstable through to Botany Bay in Margate from May to September. Local peaks in average results were seen at Herne Bay and at Fulsam Rock in Margate. Positive correlations between levels of faecal coliforms and recent rainfall were found for all sites eastwards of West Bay (on the western outskirts of Margate), and to a lesser extent for one site in central Margate (Fulsam Rock).

Thirteen water samples were taken under the shellfish waters programmes from two locations, one about 1.3km west of the Margate STW long sea outfall, and one about 1km east of the Swalecliffe STW long sea outfall. This would place them in the path of tidal streams carrying the effluent from these outfalls. Results were consistently very low at Margate, and more variable in the vicinity of Swalecliffe. At Swalecliffe, the highest results arose whilst the tide was ebbing suggesting that the discharge (or another source to the west) was responsible.

The hygiene classification monitoring provides a comprehensive dataset of flesh sampling results from 21 RMPs. When assessing the results of these the RMPs were classified into four broad zones; offshore (>2km offshore from MLWS), nearshore (within 2km of MLWS) and intertidal. *E. coli* results from mussels from four RMPs in the intertidal zone from South Oaze, at Seasalter through to Bishopstone were compared. Results were very similar at all four sites in terms of average levels and ranges, and varied in a consistent manner when paired same day sample results were compared indicating that intertidal mussels in this stretch were subject to similar sources of contamination.

Six of the seven native oyster RMPs sampled fell into the offshore category, and levels of *E. coli* recorded at these were all similarly low and lacking in variability. The lack of variability in results prevented meaningful comparisons of paired (same day) samples to ascertain if results from the different RMPs varied in a similar manner over time in the way they did for intertidal mussels. The seventh native oyster RMP was located in the nearshore area off Whitstable and had significantly higher levels of *E. coli* than at the offshore locations.

Pacific oyster samples were collected from two nearshore and two intertidal locations from Swalecliffe westwards. Results were highest on average at the two intertidal sites. The geometric mean result for Long Rock was slightly lower for Pacific oysters than for mussels taken from the same site very tentatively suggesting sampling mussels alone from this site may be sufficient to classify both species although sample numbers were low.

Cockle samples were taken from three offshore sites (Hook and Margate Sands), one nearshore site (Pollard), and one intertidal site (Minnis Bay). The three offshore sites showed very similar levels of contamination, and results varied in a consistent manner over time indicating that these RMPs were subject to similar sources of contamination. Results at the nearshore site were higher on average, and results at the intertidal site highest of all.

Broadly similar patterns of seasonal variation were found throughout the area and species with highest average results arising in the winter. Significant correlations with recent rainfall were only found for the three intertidal mussel sites with sufficient sample numbers for this analysis, which were located between Swalecliffe and Herne Bay. No correlation with rainfall was found for any of the nearshore or offshore RMPs, or at the other intertidal RMP with sufficient sample numbers for analysis (Minnis Bay cockles). *E. coli* results at most RMPs did not vary significantly in relation to either the spring/neap or high low/tidal cycles, and when they did patterns were weak and/or unclear. The one exception to this was B17AW (cockles at Pollard), where the pattern of highest results on ebbing spring tides implied that sources to the west of the RMP and several km distant, such as Faversham STW, may be of importance.

A series of 12 Pacific oyster samples was taken during the shoreline survey, and all but one contained less than 1000 *E. coli* MPN/100g. The one exception was a sample taken during very *w*et weather in the small embayment to which West Brook discharges, which contained 3500 *E. coli* MPN/100g.

Finally, a bacteriological survey was carried out where 10 samples of Pacific oysters were taken from three sites at Reculver, Minnis Bay and Ledge Point in Margate. Results were very similar from all three sites, with no significant difference between mean result. Minnis Bay had the highest overall result, highest mean result and highest proportion of results over 230 *E. coli* MPN/100g. Results of paired samples were not however correlated on a sample by sample basis in the same ways as for the mussel intertidal RMPs.

Taken together, these findings have the following implications for the sampling plan:

- Zonation and monitoring of the fisheries should primarily be based on division between offshore and nearshore/intertidal areas as there is a clear decrease in levels of *E. coli* within shellfish as distance from shore increases. Therefore, intertidal RMPs may be used to classify the fishery from a public health perspective, although this would not be appropriate where differing classifications between the zones may be anticipated (i.e. in the case of cockles and native oysters).
- The number of RMPs used for the offshore cockle and native oyster fisheries could be reduced as results are very similar at the different RMPs within these two fisheries.

- *E. coli* levels in intertidal mussels were similar throughout the Canterbury District, and fluctuated in a similar manner over time implying they are subject to sources of similar types and magnitudes.
- *E. coli* levels in Pacific oysters were similar from Reculver through to Margate, but were not correlated on a sample by sample basis.
- Bathing waters monitoring results showed that levels of faecal coliforms during the summer were broadly similar throughout the entire coastline, but with slight peaks in average levels at Herne Bay and at Fulsam Rock in Margate implying some partitioning of intertidal/nearshore classification zones on the east west plane is appropriate.
- Recent rainfall was associated with higher levels of contamination within intertidal mussels in the Canterbury district, and higher bathing waters results throughout all sites from the west of Margate, implying that land runoff is a significant influence west of Margate.
- Patterns of results in relation to the tidal cycle for cockles at Pollard suggest sources in the Swale may be an influence at this site.
- For cockles results were generally highest during the winter and lowest during the spring, and slightly lower on average during the early part of the harvesting season (summer) than the later part of the harvesting season (autumn).
- There was little seasonal variation in native oyster results, but they were slightly higher on average during the winter, which is the middle of the harvesting season.

USE OF SURROGATE SPECIES

An investigation into the relative levels of *E. coli* accumulation in different bivalve species was recently carried out by Cefas on behalf of the FSA (Younger & Reese, 2011). Comparisons of paired sample results supported the use of mussels as a surrogate for Pacific and native oysters, and the use of Pacific or native oysters to represent each other. Although cockles and Manila clams accumulated *E. coli* at broadly similar levels to mussels, they appeared to show a tendency for more extreme high results than mussels. Therefore mussels should not generally be used to represent cockles or clams without a period of parallel monitoring to ascertain whether this would be appropriate on a site specific basis. Extrapolating from this, cockles may be used to represent Manila clams and vice versa. The use of cockles to classify oysters and mussels may potentially give a worse classification than if they were monitored separately.

Formal guidelines for the use of surrogate species are however yet to be developed and accepted. As the acceptable surrogate species generally accumulate *E. coli* to similar or slightly higher levels, the use of surrogate species for classification of areas where class A compliance is possible should not be adopted to avoid potentially disadvantaging the industry. Objections from the industry may also be expected where class B compliance is borderline.

Therefore, on the north Kent coast, mussels could be used as a surrogate species for Pacific and native oysters in the intertidal zone where class A compliance is highly unlikely. Cockles may be used as to classify both clams and cockles as is current practice on the Pollard ground. The use of cockles to classify mussels and oysters (as proposed by the LEA for the Pollard area) will be protective of public health but may return a worse classification than would be obtained if oysters and mussels were monitored themselves. Mussels may potentially be used as a surrogate for inshore cockles and clams (i.e. at Pollard and Minnis Bay), but only after a period of parallel monitoring to confirm that this is appropriate. Native oysters should continue to be sampled for the offshore fishery where class A compliance is a strong possibility. It will be necessary to continue sampling the offshore cockle fishery.

REDUCED SAMPLING EFFORT FOR SEASONAL CLASSIFICATIONS/CLOSURES

The cockle fishery is open during the July to November window (5 months of the year) and the native oyster fishery is only open from September to April (8 months of the year). Classification of these species for commercial harvest is only required whilst the fisheries are open. Current classification protocols (Cefas, 2011) indicate that a minimum of 10 samples per year are generally required for classification, but do not indicate that further reductions in sampling effort may be made to reflect seasonally inactive fisheries. Therefore, sampling of native oysters via dredge during the two months after the season finishes (May and June) may be stopped without affecting the classification. Sampling of the offshore cockle dredge fishery may also be reduced to 10 occasions per year so sampling for this fishery is only necessary for the months from January to November inclusive. It should be noted that the 10 samples are the minimum requirement for classification so if any of these samples are missed or rejected by the laboratory resampling would be necessary.

OVERALL CONCLUSIONS RELATING TO SAMPLING PLAN

Within the intertidal and nearshore zone, a series of relatively small watercourses, intermittent sewage discharges and birds and dogs are identified as the main sources of contamination. The latter two are diffuse sources so will not influence the location of the RMPs. The watercourses are likely to be the most consistent contaminating influences so RMPs should be set near their mouths. Spills from the intermittent discharges to the intertidal zone have been infrequent and minor in recent years, although they do offer the potential for larger spill events and ideally RMPs should be located to capture any spills but there are too many individual overflows for this to be practical. There may be slightly higher background levels emanating from the enclosed Swale estuary than from the open sea so any shellfish beds in the Seasalter area should have RMPs towards their western extremities. As around 30km of shore requires monitoring, several intertidal RMPs will be required to adequately capture contamination from the different sources in spite of the similar levels of *E. coli* found throughout the stretch.

Further offshore contamination from shoreline sources drops away to low levels via dilution with cleaner seawater. The main identified risk here is the outfall from Swalecliffe STW. If the use of exclusion zones is incorporated into the FSA's classification policy, such a zone should be set around this outfall as although it is UV treated it has significant potential to generate increased *E. coli* loadings either through overflows or through failures of the UV plant. Until this happens, a small zone around this where the impacts are likely to be most acute should be defined and monitored separately, assuming the LEA is willing to classify such a zone. The Margate STW outfalls do not fall within any of the areas for which classification is required but may have the potential to impact on them under certain conditions. The other possible source to offshore fisheries is overboard discharges from boats but these are not predictable so will not influence the location of the RMPs. Aside from around the Swalecliffe STW outfall levels of *E. coli* in shellfish are likely to be quite consistent over large areas, and this is supported by historical classification monitoring results. Therefore, despite the large area requiring classification, a reduction in the number of offshore RMPs may be justifiable.

Mussels are reasonably widespread and accessible in the intertidal zone and may be used to classify both the Pacific oyster and mussel stocks. Separate monitoring would be required for cockles/clams, and also for native oysters within the offshore areas where class A compliance is possible. For seasonal fisheries (native oysters and cockles) a slight reduction in sampling is proposed.

4. RECOMMENDATIONS

4.1 PACIFIC OYSTERS

4.1.1 It is recommended that the Pacific oyster classification zone extends at least 2km offshore from the high water mark from the western boundary of the survey area as far as the Nayland Rock in Margate. This zone should be subdivided into seven sub-zones along the east-west plane so each contains one RMP.

4.1.2 It is recommended that a series of intertidal RMPs should be sampled for classification. These are to be located at Nayland Rock, Minnis Bay, Reculver, Hampton Pier, Swalecliffe, the Whitstable Oyster Company trestles at Westbeach, and at South Oaze. The LEA advise that at present stocks at South Oaze are undersized so cannot be sampled, and that the most practical alternative would be for the Pollard cockle RMP (4.3.2) to be used instead. A tolerance of 100m should be sufficient to allow repeated sampling of wild stocks from these locations. If bagged mussels are used then a tolerance of 10m should be applied.

4.1.3 A further small classification zone should be set to encompass the Swalecliffe STW outfall and the surrounding area where the main impacts are anticipated. For this zone and RMP should be set at the outfall location where bagged mussels should be sampled from the seabed. A tolerance of 10m should be applied. The LEA may decide whether this zone merits sampling and classification.

4.1.4 The species sampled should be mussels (excepting South Oaze/Pollard) as these are more available and are deemed to be representative of Pacific oysters. The use of bagged mussels may be appropriate at some locations, namely Whitstable Oyster Company trestles at Westbeach, and Swalecliffe Outfall. However, the LEA has advised that Whitstable Oyster Company do not want bagged mussels on their trestles, and have indicated that Pacific oysters should be sampled here. This means the zone cannot be classified for mussels as well. Where bagged mussels are used they should be allowed to equilibrate *in situ* for 2 weeks before sampling.

4.1.5 These RMPs should be sampled on a monthly basis to maintain a year round classification.

4.1.6 After one year of sampling under this plan, the possibility of removing some of these RMPs may be considered on the basis of the sample results and a recommendation made by the Sanitary Survey and Classification teams at Cefas to the FSA.

4.2 Native oysters

4.2.1 It is recommended that the classification zone be redefined as shown in Figure 5.2, and divided into two intertidal, two nearshore and one offshore zone. This extends the classification zone recommendations outside of the survey area and replaces the current zoning arrangements adjacent to the east and north coasts of Sheppey. Existing monitoring arrangements for this species within the Swale should continue.

4.2.2 New RMPs for the classification of the nearshore zones should be created at Whitstable Bay, and on the Ham Ground off Leysdown. The latter would ideally be located at the south western corner of this zone but the LEA advise that at present there are insufficient stocks here, so an alternative location about 3km to the east will have to be used instead. The existing RMP at Btwn Leysdown and Spaniard (B17AL) may be used for the classification of the offshore zone. A tolerance of 100m around these RMPs is recommended to allow for sampling via dredge. The species sampled should be native oysters. A minimum of 10 samples per year will be required for classification of this species, and monitoring should take place from July to April inclusive. A standard approach is to not sample the two months immediately after the seasons closes (May and June). However, the LEA indicated that sampling in July and August is problematic due to weed growth, and have requested that these two months are not sampled instead of May and June.

4.2.3 The RMPs at Pollard cockles (4.3.2) and Whitstable Oyster Company (4.1.2) should be used to classify their two respective intertidal zones. The mussel samples from Whitstable Oyster Company and cockle samples from Pollard cockles may be used to classify native oysters.

4.2.4 A further small classification zone should be set to encompass the Swalecliffe STW outfall and the surrounding area where the main impacts are anticipated. For this zone an RMP should be set at the outfall location where bagged mussels should be sampled from the seabed. A tolerance of 10m should be applied. The LEA may decide whether this zone merits sampling and classification.

4.3 Cockles

4.3.1 It is recommended that the classification zone be redefined as shown in Figure 5.3, and divided into two intertidal/nearshore and two offshore zones.

4.3.2 Within these zones, RMPs should be set at Pollard, Minnis Bay, South Hook Bcn (B017W) and off Leysdown. However, the LEA advise that sampling cockles off Leysdown would not be possible to resource as a cockle dredging boat would be required. Also, such a location may fall within the Faversham Oyster Company private grounds where permission to dredge may be difficult to obtain. A possible alternative may be the use of the mussel RMP Swale BC8 (B076H) in the neighbouring Swale production area, although this falls outside the zone boundaries and mussels are not properly representative of cockles. A tolerance of 100m around the offshore RMPs is recommended to allow for sampling via dredge. A tolerance of 50m should be set around the intertidal RMPs to allow sufficient stock for repeated sampling.

4.3.3 The species sampled should be cockles. Due to the differences in *E. coli* accumulation between cockles and mussels, it is not recommended that mussels are used as a surrogate if at all possible for Off Leysdown.

4.3.4 A minimum of 10 samples per year will be necessary to classify these fisheries. The harvesting season runs from June to November, so monitoring should take place from February to November inclusive. The months of December and January need not be sampled, except in the case of Pollard and Off Leysdown (or Swale BC8 if off Leysdown cannot be sampled) which may also be used to classify Manila clams (4.5.2) which is a year round fishery so monthly sampling will be required at these RMPs.

4.3.5 A further small classification zone should be set to encompass the Swalecliffe STW outfall and the surrounding area where the main impacts are anticipated. For this zone an RMP should be set as close to the outfall location as possible. The species sampled should be wild cockles via dredge. A tolerance of 100m should be applied. The LEA may decide whether this zone merits sampling and classification.

4.4 Mussels

4.4.1 It is recommended that the mussel classification zone extends sufficiently far offshore to encompass the areas of possible interest to mussel dredgers, and from the western end of the survey area as far as the Nayland Rock in Margate. This zone should be subdivided into seven sub-zones along the east-west plane so each contains one RMP.

4.4.2 It is recommended that a series of intertidal RMPs should be sampled for classification. These are to be located at Nayland Rock, Minnis Bay, Reculver, Hampton Pier, Swalecliffe, Whitstable Oyster Company and at South Oaze. The LEA advise that at present stocks at South Oaze are undersized so cannot be sampled, and that the most practical alternative would be for the Pollard cockle RMP (4.3.2) to be used instead. They also advise that the Whitstable Oyster Company do not want bagged mussels on their trestles, there are no wild stocks here, and this zone does not require classification for mussels. A tolerance of 100m should be sufficient to allow repeated sampling of wild stocks.

4.4.3 The species sampled should be mussels (excepting South Oaze/Pollard) and the same samples taken for the classification of other species may be used.

4.4.4 A further small classification zone should be set to encompass the Swalecliffe STW outfall and the surrounding area where the main impacts are anticipated. For this zone an RMP should be set at the outfall location where bagged mussels should be sampled from the seabed. A tolerance of 10m should be applied. The LEA may decide whether this zone merits sampling and classification.

4.4.5 These RMPs should be sampled on a monthly basis to maintain a year round classification.

4.4.6 After one year of sampling under this plan, the possibility of removing some of these RMPs may be considered on the basis of the sample results and a recommendation made by the Sanitary Survey and Classification teams at Cefas to the FSA.

4.5 MANILA CLAMS

4.5.1 Two classification zones should encompass the present culture site with adequate room for some expansion, and the naturally occurring clam bed off Leysdown.

4.5.2 The cockle RMP at Pollard (4.3.2) should also be used to classify Manila clams at the culture site on the Pollard, and the proposed cockle RMP off Leysdown (4.3.2) should ideally be used to classify the naturally occurring concentration of clams here. However, the LEA advise that sampling cockles off Leysdown would not be possible to resource as a cockle dredging boat would be required. Also, such a location may fall within the Faversham Oyster Company private grounds where permission to dredge may be difficult to obtain. A possible alternative may be the use of the mussel RMP Swale BC8 (B076H) in the neighbouring Swale production area, although this falls outside the zone boundaries and mussels are not properly representative of Manila clams. Sampling should be monthly.

4.5.3 A further six zones from Whitstable to Nayland Rock are included in the sampling plan for this species. There is currently no need to classify these zones as no commercial harvesting of this species occurs at present outside of the two zones identified in 4.5.1.

4.5.4 A series of five intertidal RMPs located at Swalecliffe, Hampton Pier, Reculver, Minnis Bay and Nayland Rock as well as an offshore RMP at Swalecliffe Outfall should be sampled to classify these six zones. For Minnis Bay and Swalecliffe Outfall the existing cockle RMPs can be used (4.3.2). For the other four intertidal RMPs, either Manila clams or cockles may be sampled. A nominal tolerance of 50m should be applied, although it is recognised that sampleable stocks may not be present within this tolerance. Sampling should be monthly.

5. SAMPLING PLAN

GENERAL INFORMATION

Location Reference

Production Area:	North Kent
Cefas Main Site Reference:	M017
Cefas Area Reference:	North Kent coast
Ordnance survey 1:25,000 map:	OS Explorer 150
Admiralty Chart:	1607 (Thames Estuary Southern Part)
Imray Chart:	2000.1 (Thames Estuary South)

Shellfishery

Species/culture	Pacific oysters (*Crassostrea gigas*)	Wild & cultured
	Native oysters (*Ostrea edulis*)	Wild
	Mussels (*Mytilus* spp.)	Wild & relaid
	Cockles (*Cerastoderma edule*)	Wild
	Manila clams (*Tapes* spp.)	Wild & cultured
Seasonality of harvest	Open season within June to November window for cockles, Open season from September to April (native oysters)	

Local Enforcement Authorities

Name	Commercial Health Section Canterbury City Council Military Road Canterbury Kent CT1 1YW
Environmental Health Officer	Sarah Maloney
Telephone number ☎	01227 862216
Fax number	01227 450847
E-mail	sarah.maloney@canterbury.gov.uk
Name	Environmental Health Thanet District Council Offices PO Box 9 Margate Kent CT9 1XZ
Environmental Health Officer	Deborah Huckstep
Telephone number ☎	01843 577183
Fax number	01843 577340
E-mail	debbie.huckstep@thanet.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 2017. The assessment may require review in the interim should any significant changes in sources of contamination come to light, such as the upgrading or relocation of the major discharges. Further review with the aim of rationalisation of RMPs may be considered following collection and assessment of one years sampling data under this plan.

Table 5.1 Number and location of representative monitoring points (RMPs) and frequency of sampling for the north Kent coast.

Classification zone	RMP	RMP name	NGR	Latitude & Longitude (WGS84)	Species	Growing method	Sampling method	Tolerance	Frequency	Comments
Nayland Rock (mussels) and Nayland Rock (Pacific oysters)	B17BY	Nayland Rock	TR 3446 7106	51°23.41'N 01°22.11'E	Mussels	Wild	Hand	50m	Monthly	Represents mussels and Pacific oysters at Nayland Rock
Minnis Bay (mussels) and Minnis Bay (Pacific oysters)	B17BZ	Minnis Bay	TR 2723 6953	51°22.76'N 01°15.83'E	Mussels	Wild	Hand	50m	Monthly	Represents mussels and Pacific oysters at Minnis Bay.
Reculver (mussels) and Reculver (Pacific oysters)	B17CA	Reculver	TR 2294 6945	51°22.82'N 01°12.14'E	Mussels	Wild	Hand	50m	Monthly	Represents mussels and Pacific oysters at Reculver. To be located as close as possible to the Reculver marsh outfall.
Hampton Pier (mussels) and Hampton Pier (Pacific oysters)	B17CB	Hampton Pier	TR 1570 6805	51°22.23'N 01°05.85'E	Mussels	Wild	Hand	50m	Monthly	Represents mussels and Pacific oysters at Hampton Pier. To be located as close as possible to West Brook.
Swalecliffe (mussels) and Swalecliffe (Pacific oysters)	B17CC	Swalecliffe	TR 1349 6766	51°22.07'N 01°03.94'E	Mussels	Wild	Hand	50m	Monthly	Represents mussels and Pacific oysters at Swalecliffe. To be located as close to Swalecliffe Brook as possible.
Swalecliffe outfall (mussels), Swalecliffe outfall (Pacific oysters), Swalecliffe outfall (native oysters)	TBA	Swalecliffe outfall	TR 1415 6953	51°23.06'N 01°04.57'E	Mussels	Bagged	Hand	10m	Monthly	Represents mussels, Pacific and native oysters in a small zone around the Swalecliffe STW outfall. LEA to decide if classification of this small zone of potentially decreased water quality is necessary.

Westbeach (Pacific oysters) and Westbeach (native oysters)	B17BS	Whitstable Oyster Company	TR 1029 6690	51°21.73'N 01°01.16'E	Pacific oysters (or mussels)	Wild/ cultured	Hand	100m	Monthly	Represents native and Pacific oysters at Whitstable Oyster Company Westbeach. For continued classification of this zone for mussels, mussels will also need to be sampled.
South Oaze (mussels), South Oaze (Pacific oysters) and South Oaze (native oysters)	B17CD	South Oaze	TR 0652 6513	51°20.86'N 00°57.85'E	Mussels	Wild	Hand	50m	Monthly	Preferred option to represent mussels, native and Pacific oysters at South Oaze. However stocks are undersized here at present. Pollard cockles represents the most suitable alternative RMP for classification of these species within this zone at present.
Whitstable Bay (native oysters)	B17CE	Whitstable Bay	TR 0789 6754	51°22.13'N 00°59.11'E	Native oysters	Wild	Dredge	100m	Monthly from July to April inclusive	Represents native oysters at Whitstable Bay. No sampling needed for May or June.
Off Leysdown (native oysters)	B17CF	Off Leysdown	TR 0793 7295	51°25.05'N 00°59.34'E	Native oysters	Wild	Dredge	100m	Monthly from July to April inclusive	Represents native oysters off Leysdown. No sampling needed for May or June. Should ideally be in the south west corner of the zone, but low stock levels here preclude this at present.
Kentish Flats (native oysters)	B17AL	Btwn Leysdown & Spaniard	TR 0970 7410	51°25.63'N 01°00.90'E	Native oysters	Wild	Dredge	100m	Monthly from July to April inclusive	Represents Native oysters at Kentish Flats. No sampling needed for May or June.
Pollard (cockles) and Pollard (Manila clams)	B17CG	Pollard	TR 0699 6561	51°21.11'N 00°58.27'E	Cockles	Wild	Hand	50m	Monthly	Represents cockles and manila clams at Pollard

Minnis Bay (cockles) and Minnis Bay (Manila clams, if required)	B17CH	Minnis Bay	TR 2740 6970	51°22.85'N 01°15.99'E	Cockles	Wild	Hand	50m	Monthly from February to November inclusive	Represents cockles and Manila clams at Minnis Bay. No sampling needed in December or January if only cockles are to be classified.
Swale Entrance (cockles) and Swale Entrance (Manila clams)	B17CI	Swale Entrance	TR 0660 6814	51°22.48'N 00°58.03'E	Cockles	Wild	Dredge	100m	Monthly	Preferred option to represents cockles and Manila clams Swale entrance. However resource and permissions constraints mean the LEA cannot sample here. A possible alternative may be the use of the mussel RMP Swale BC8 (B076H, at TR 0560 6840) in the neighbouring Swale production area, although this falls outside the zone boundaries and mussels are not properly representative of Manila clams.
Swalecliffe outfall (cockles) and Swalecliffe Outfall (Manila clams)	TBA	Swalecliffe outfall	TR 1415 6953	51°23.06'N 01°04.57'E	Cockles	Wild	Dredge	100m	Monthly	LEA to decide if classification of this small zone of potentially decreased water quality is necessary. Represents cockles and Manila clams at Swalecliffe outfall. No sampling needed in December or January if only cockles are to be classified.
Hook & Margate Sands (cockles)	B017W	South Hook Bcn	TR 2550 7220	51°24.24'N 01°14.45'E	Cockles	Wild	Dredge	100m	Monthly from February to November inclusive	Represents cockles at Hook and Margate Sands. No sampling needed in December or January.

Swalecliffe (Manila clams	TBA	Swalecliffe	TR 1349 6766	51°22.07'N 01°03.94'E	Manila clams or cockles	Wild	Hand	50m	Monthly	Represents Manila clams at Swalecliffe. To be located as close to Swalecliffe Brook as possible. Classification not required at present.
Hampton Pier (Manila clams)	TBA	Hampton Pier	TR 1570 6805	51°22.23'N 01°05.85'E	Manila clams or cockles	Wild	Hand	50m	Monthly	Represents Manila clams at Hampton Pier. To be located as close as possible to West Brook. Classification not required at present.
Reculver (Manila clams)	TBA	Reculver	TR 2294 6945	51°22.82'N 01°12.14'E	Manila clams or cockles	Wild	Hand	50m	Monthly	Represents Manila clams at Reculver. To be located as close as possible to the Reculver marsh outfall. Classification not required at present.
Nayland Rock (Manila clams)	TBA	Nayland Rock	TR 3446 7106	51°23.41'N 01°22.11'E	Manila clams or cockles	Wild	Hand	50m	Monthly	Represents Manila clams at Nayland Rock. Classification not required at present.

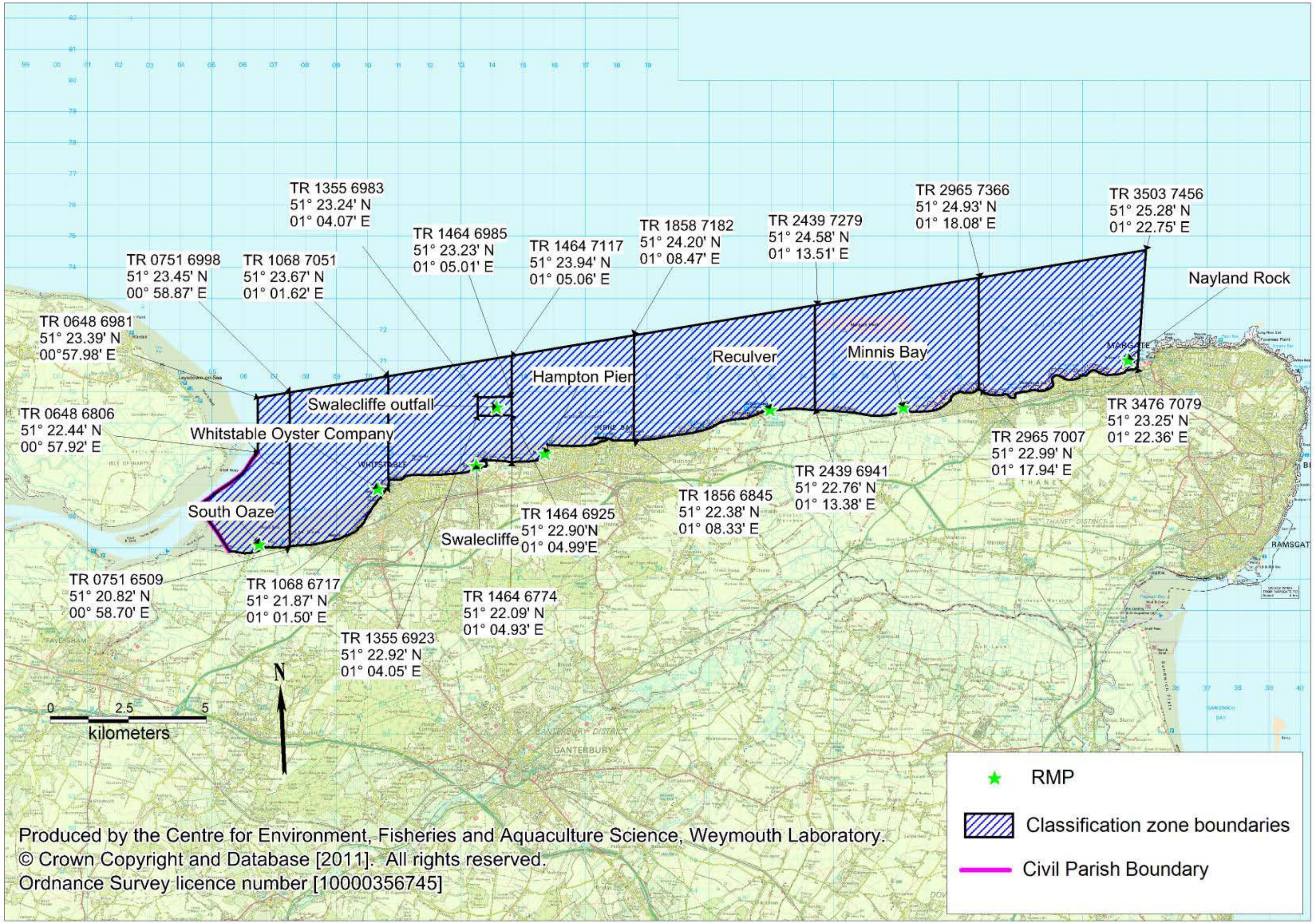


Figure 5.1 Recommended classification zone boundaries and RMP locations for Pacific oysters.

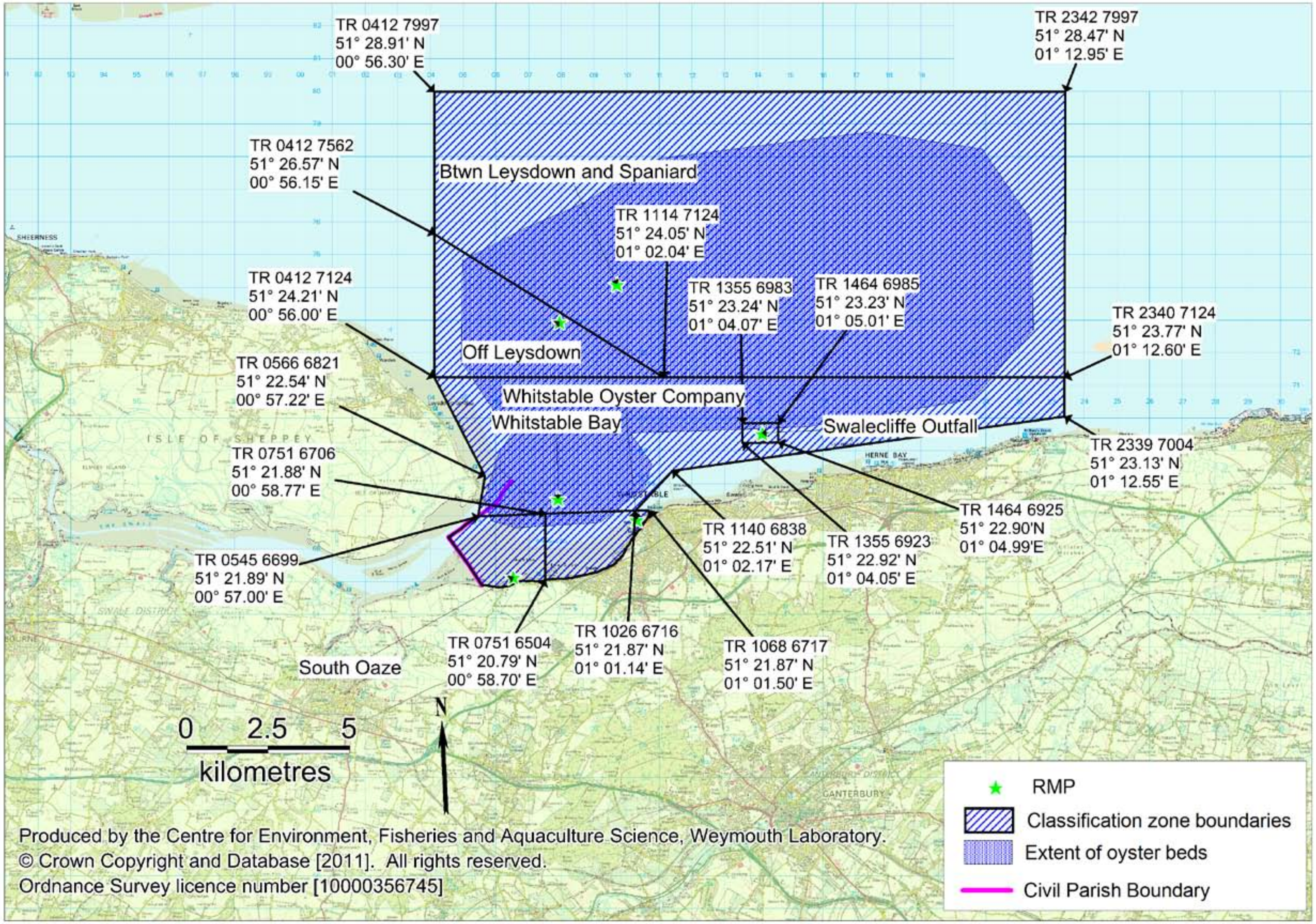


Figure 5.2 Recommended classification zone boundaries and RMP locations for Native oysters.

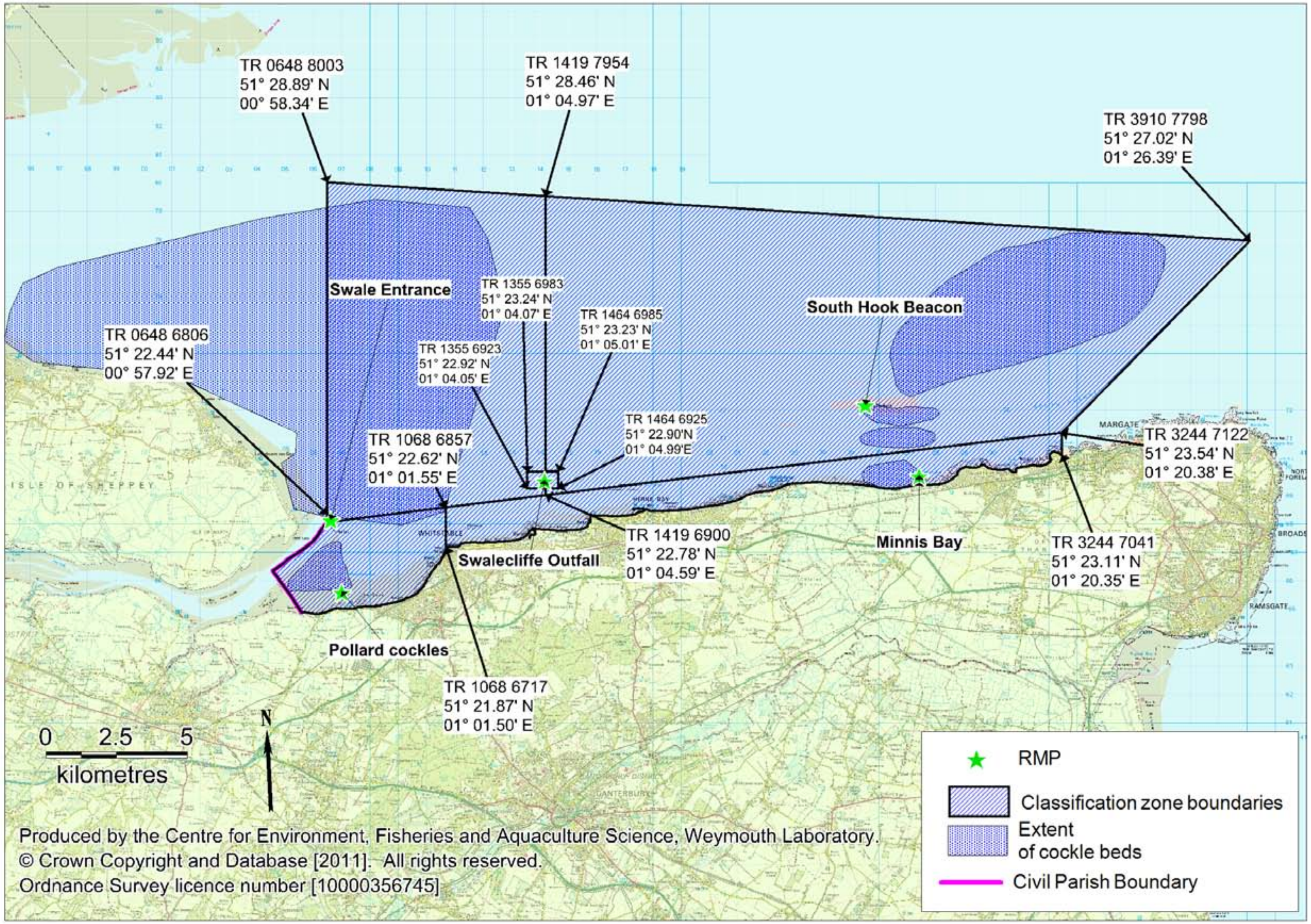


Figure 5.3 Recommended classification zone boundaries and RMP locations for cockles.

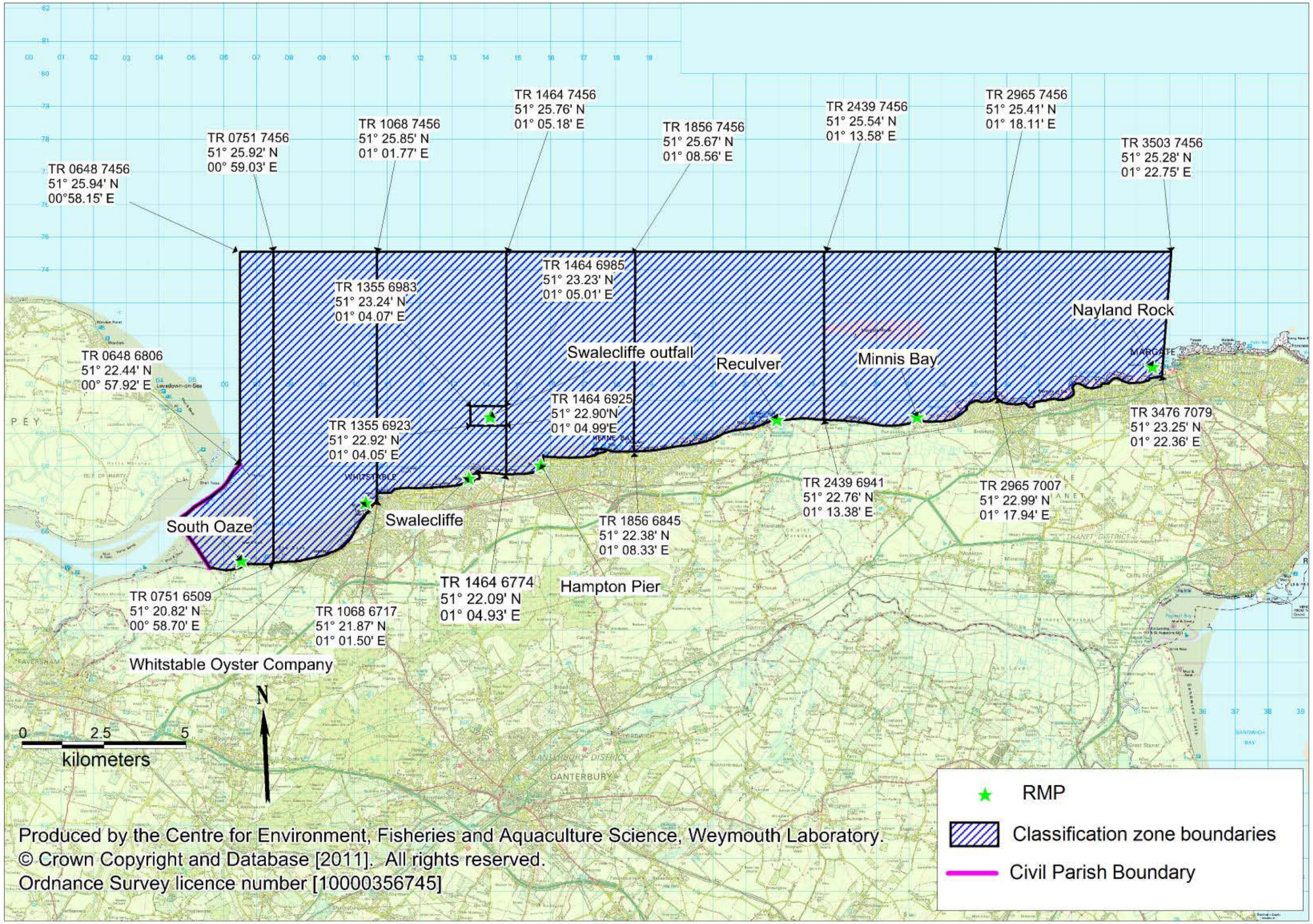


Figure 5.4 Recommended classification zone boundaries and RMP locations for mussels.

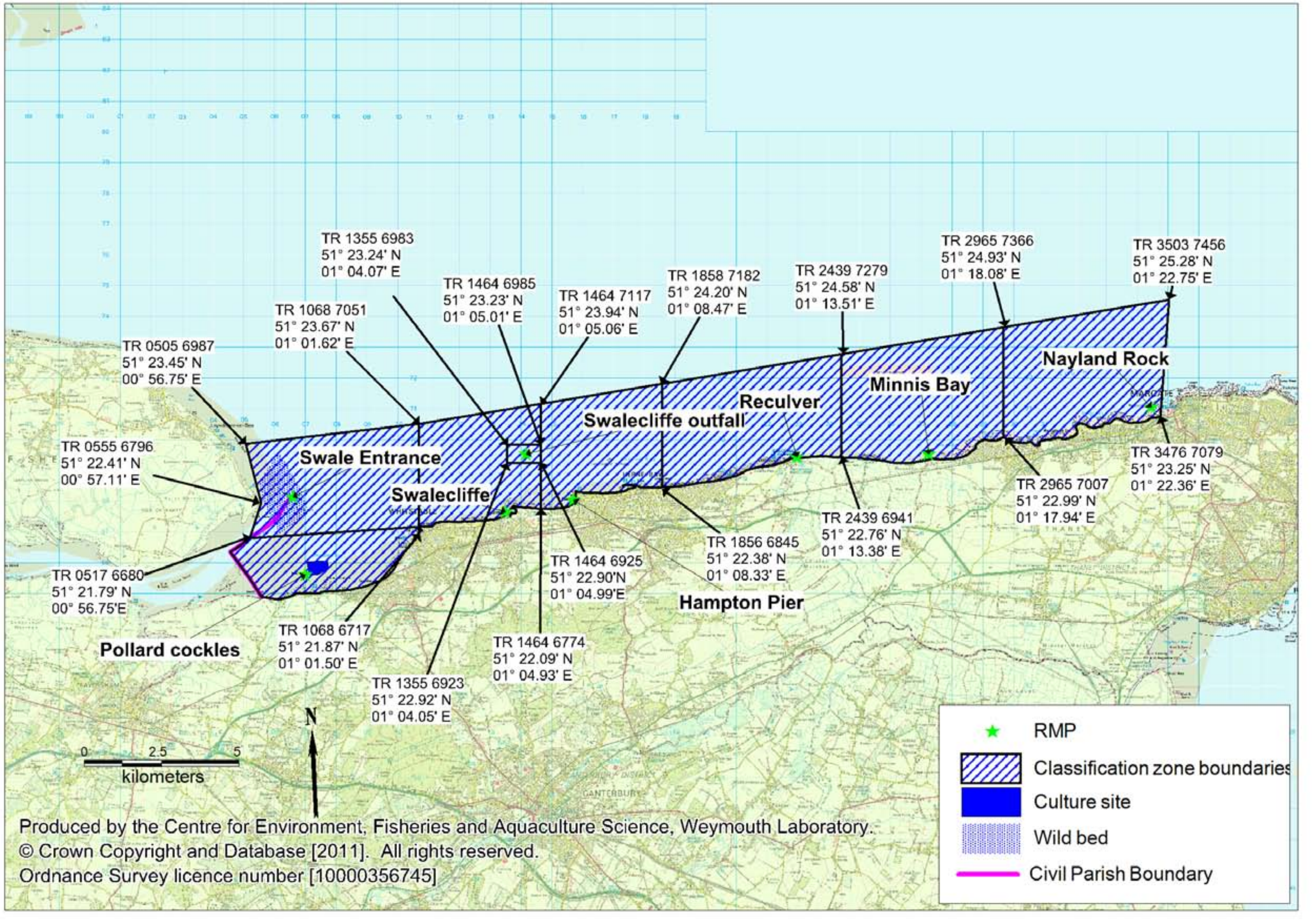


Figure 5.5 Recommended classification zone boundaries and RMP locations for Manila clams.

APPENDICES

APPENDIX I
HUMAN POPULATION

The distribution of resident human population by Super Output Area Boundary within the hydrological catchment area of the north Kent coast is shown in Figure I.1.

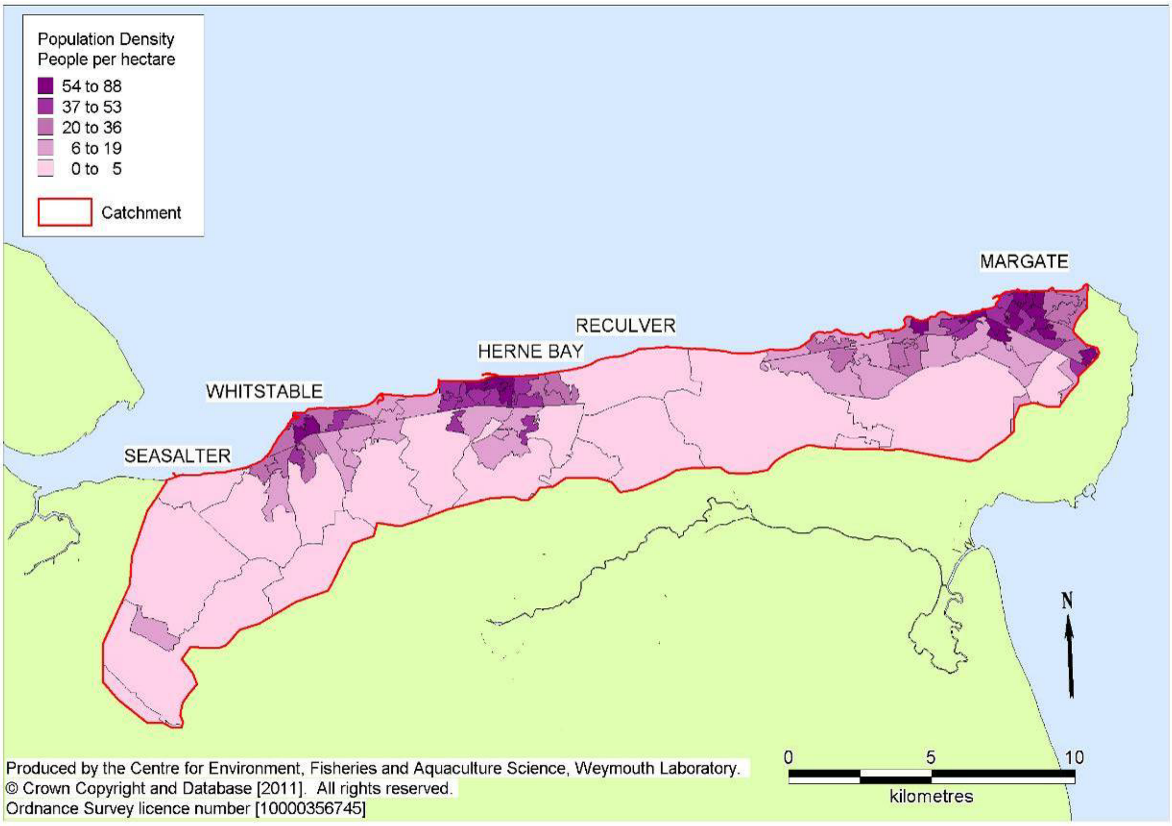


Figure I.1 Human population density on the north Kent coast.
Source: ONS, Super Output Area Boundaries (Middle layer). Crown copyright 2004. Crown copyright material is reproduced with the permission of the Controller of HMSO.

The main population centres of Whitstable, Herne Bay and Margate lie on the coast. The total resident population in the area shown in Figure I.1 is just over 150,000. The north Kent coast is a popular holiday destination, with numerous visitor accommodation including caravan parks and hotels. Margate in particular is a traditional seaside resort. Southern Water Services estimated that the peak tourist population of Margate will be 13,200, in addition to a resident population of 63,120 in 2015 in their design calculations for the Margate sewerage scheme. Therefore, a population increase of roughly 20% is anticipated within the survey area during the peak summer holiday period. Visitors to the area will increase the amount of sewage discharged, so overall volumes will be correspondingly higher during the summer months.

APPENDIX II
HYDROMETRIC DATA: RAINFALL

Due to its sheltered location relative to rain-bearing weather systems feeding in off the Atlantic, the North Kent Coast is one of the drier areas of the UK, typically receiving less than 650mm of rain a year. The Atlantic Lows are more vigorous in autumn and winter and bring most of the rain that falls in these seasons. In summer, convection caused by solar surface heating sometimes forms shower clouds and a large proportion of rain falls from showers and thunderstorms then (Met Office, 2011). Figure II.1 presents a boxplot of daily rainfall records by month at the Herne Bay STW, which is located within the marshes just inland from Reculver.

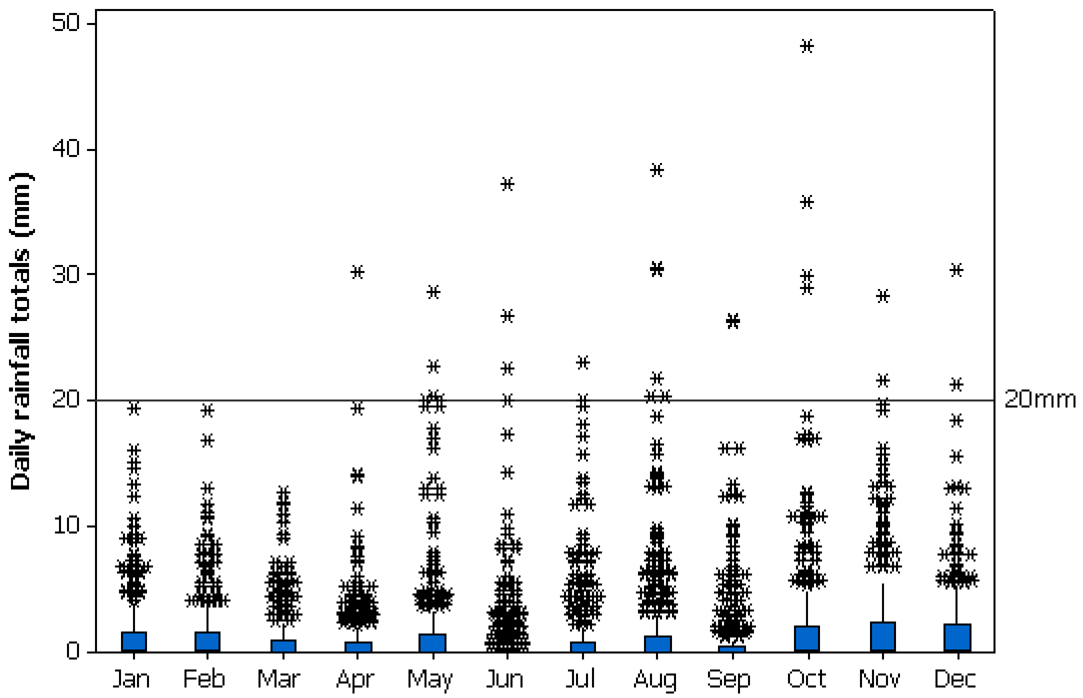


Figure II.1 Box and whisker plots of daily rainfall totals recorded at Herne Bay STW, January 2000-January 2011.
Data from the Environment Agency.

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.

Rainfall records from the Herne Bay STW, which is representative of conditions in the vicinity of the shellfish beds indicate average rainfall is highest from October to December, but peak rainfall events (over 20mm), although infrequent, tend to occur any time from May to December.

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 III
HYDROMETRIC DATA: FRESHWATER INPUTS

Only the relatively narrow coastal strip drains to the north Kent coast. South of this lies the Stour catchment, which drains to the east coast of Kent. The coastal strip is drained by a series of small watercourses, almost all of which are modified in some way for flood defence purposes. The only available information on their discharge rates and sanitary content was derived from the shoreline survey, during which spot flow measurements and water samples were taken, where possible. This information is presented in Figure III.1 and Table III.1.

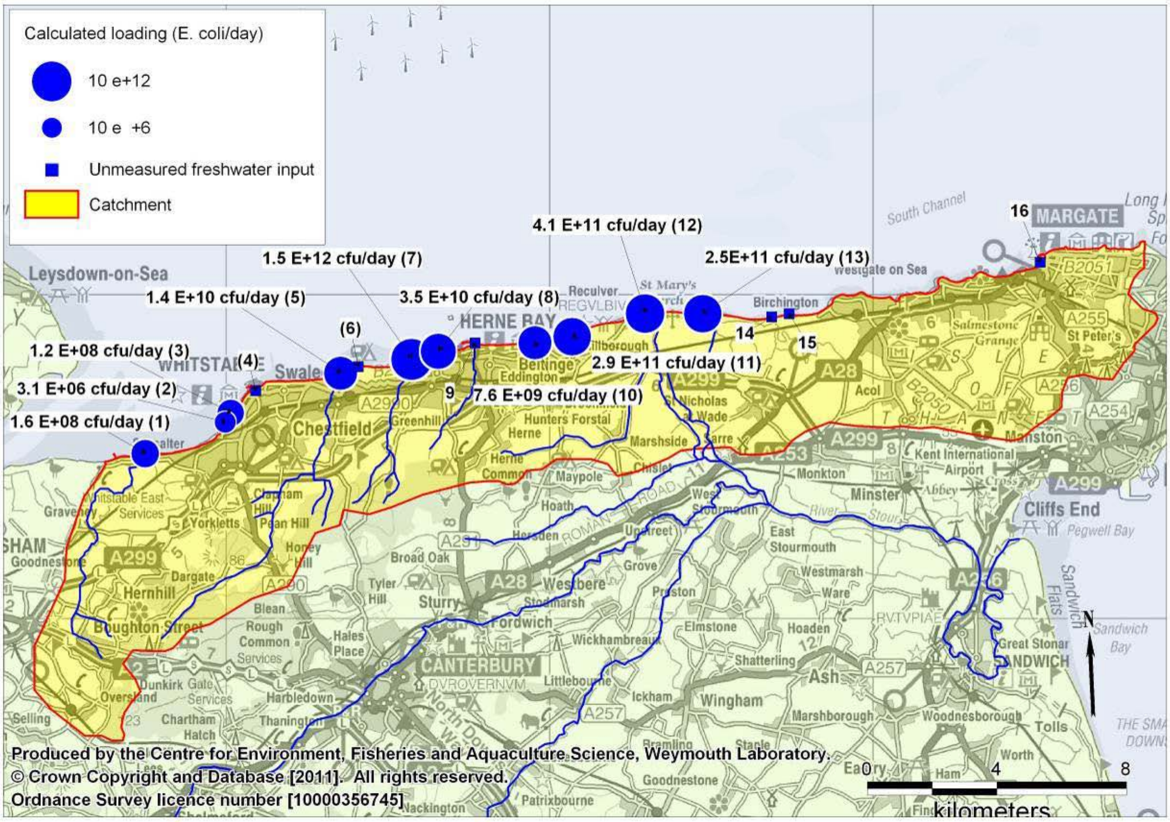


Figure III.1 Freshwater inputs to the north Kent coast.

The volumes of freshwater discharged to the north Kent coast are small. There are three small surface water outfalls to the west of Whitstable harbour discharging small volumes of relatively uncontaminated water (1, 2 and 3). It is understood that there are several surface water outfalls to Whitstable Harbour, but these were not seen (4). Swalecliffe Brook and West Brook are the main watercourses draining the Swalecliffe to Hampton stretch. They are of a similar size, but the latter was sampled and measured under wet conditions, which is likely to account at least in part for the higher flow rates and *E. coli* levels found there. This also suggests that the loadings generated by these watercourses are highly rainfall dependent. There is a small culverted stream discharging in the vicinity of Herne Bay harbour, but this was not seen during the shoreline survey. The next potentially significant watercourse is the Bishopstone Glen, which was also sampled and measured during wet conditions. Sanitary debris was observed on the margins of this stream during the shoreline survey, suggesting that it may receive inputs of untreated sewage. Up to this point, all the watercourses flow through urban areas, and so are likely to carry relatively high concentrations of *E. coli* (Kay *et al*, 2008a).

Table III.1 Bacterial loadings from watercourses sampled and measured during the shoreline survey

No.	Position	Name	*E. coli* (cfu/100ml)	Discharge (l/sec)	*E. coli* loading (cfu/day)
1	TR 07486 65100	Unnamed outfall	37	5	$1.6x10^8$
2	TR 09978 66066	Unnamed outfall	5	0.7	$3.1x10^6$
3	TR 10135 66352	Unnamed outfall	140	1	$1.2x10^8$
4	TR 10906 67034	Outfalls to Whitstable harbour (not seen)			
5	TR 13535 67600	Swalecliffe Brook	330	49.5	$1.4x10^{10}$
6	TR 14081 67774	Very small stream unable to access and outfall covered by tide			
7*	TR 15733 68041	West Brook	7000	253.9	$1.5x10^{12}$
8*	TR 16573 68278	Unnamed outfall (pipe)	4400	9.3	$3.5x10^{10}$
9	TR 17700 68510	Culverted stream discharging by Herne Bay harbour (not seen)			
10*	TR 19552 68547	Unnamed outfall (pipe)	35000	0.3	$7.6x10^9$
11*	TR 20702 68721	Bishopstone Glen	6700	50.3	$2.9x10^{11}$
12	TR 22954 69450	Unnamed outfall	2200	215.7	$4.1x10^{11}$
13	TR 24738 69434	Coldharbour outfall	410	704	$2.5x10^{11}$
14	TR 26877 69321	Brooksend outfall sluice (covered by tide)			
15	TR 27417 69416	Minnis Bay surface water outfall pipe, covered by tide			
16	TR 35180 71000	Culverted stream (Tivoli Brook) not seen			

* Sampled and measured during very wet conditions

The stretch from Reculver to Minnis Bay is low lying reclaimed marshland which is mainly used for arable farming, although there is an equestrian centre at the eastern end. The marshes are drained by a series of four surface water outfalls (12-15), of which only the first two could be sampled and measured. The first of these (11) is likely to be the most direct pathway via which effluent from the Herne Bay STW is carried to the sea, and was carrying higher levels of *E. coli* than its neighbour (12) at the time of shoreline survey. The two unmeasured outfalls at the eastern end are likely to be broadly similar to the other two outfalls in terms of discharge rates and *E. coli* levels as they drain a similar area and similar terrain. No significant streams or surface water outfalls were seen during the shoreline survey or are apparent on the 1:10,000 Ordnance survey maps to the east of the Minnis Bay outfall (14), although the Environment Agency identified the presence of a small culverted surface water outfall (Tivoli Brook, 15) in central Margate (Environment Agency, 2011).

It is therefore concluded that whilst these inputs may cause small localised ‘hotspots’ of contamination in their vicinity, particularly during wet weather, they are unlikely to be of widespread significance to the coast as a whole, and of little or no significance to shellfish beds located further offshore. RMPs set in close proximity to the outfalls at Long Rock (5), Hampton Pier (7), Reculver Towers (10-12) and Minnis Bay (13&14) would be best located to capture contamination originating from land runoff. The outfall from the pastures at Graveney marshes (1) may also be of significance at times but was carrying a very low *E. coli* loading at the time of shoreline survey.

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APPENDIX IV
HYDROGRAPHIC DATA: BATHYMETRY

The bathymetry off the north Kent coast is relatively shallow generally less than 10m below chart datum (CD) and often less than 5m below CD within 1km of the shore (Figure IV.1). From Whitstable to Margate, the intertidal zone is between 200 and 1000m in width, with a varying substrate of fine sediment, sand and shingle. From Birchington to Margate there are significant areas of intertidal chalk reefs. Below the low water mark the bathymetry gently slopes away to about 1-2m depth 2km off Whitstable, with slight undulations. The Swalecliffe STW outfall lies in about 2-3m of water. East of Reculver there are areas up to 15m deep within the Gore Channel / South Channel. Further offshore from this channel there are a series of intertidal sandbanks the majority of which are exposed on larger tides. The Margate STW outfall lies in about 15m of water. Off Seasalter, in the mouth of the Swale estuary, the intertidal area is much more extensive, with the Pollard Spit extending about 4km from the shore. The Swale estuary is shallow and enclosed so offers less potential for the dilution of contamination. There is another extensive intertidal area to the north of the Swale estuary channel on the east coast of Sheppey.

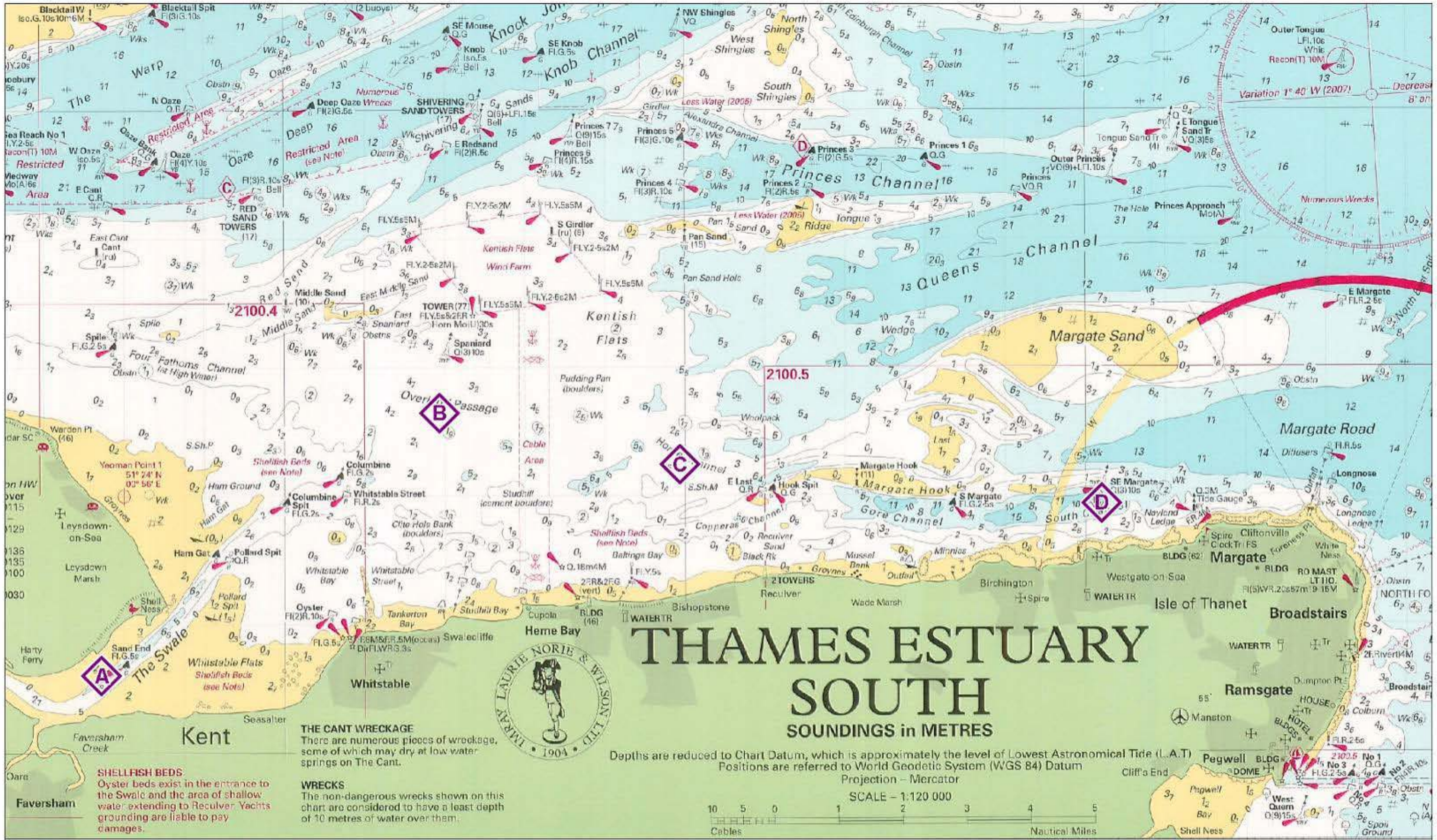

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Figure IV.1 Bathymetry chart of the North Kent coast.

APPENDIX V
HYDRODYNAMIC DATA: TIDES AND CURRENTS

Currents in coastal waters are predominantly driven by a combination of tide, wind and freshwater inputs. Tidal amplitude is relatively large, and tidal streams are likely to dominate patterns of water circulation in the area under most conditions.

Table V.1 Tide levels and ranges on the north Kent Coast.

	Height (m) above Chart Datum				Range (m)	
Port	MHWS	MHWN	MLWN	MLWS	Springs	Neaps
Whitstable Approaches	5.40	4.50	1.50	0.50	4.90	3.00
Herne Bay	5.40	4.30	1.50	0.60	4.80	2.80
Margate	4.76	3.81	1.43	0.48	4.28	2.38

Data from the UK Proudman Oceanographic Laboratory.

Table V.2 presents the direction and rate of tidal streams at four stations off the north Kent coast on spring and neap tides at hourly intervals before and after high water. The location of these stations is shown in Figure IV.1.

Table V.2 Tidal stream predictions for the north Kent Coast.

Time before /after High Water	Station A			Station B			Station C			Station D		
	Direc -tion	Rate (m/s) Spring	Rate (m/s) Neap	Direc -tion	Rate (m/s) Spring	Rate (m/s) Neap	Direc -tion	Rate (m/s) Spring	Rate (m/s) Neap	Direc -tion	Rate (m/s) Spring	Rate (m/s) Neap
HW-6	-	0.00	0.00	W	0.15	0.10	WSW	0.15	0.10	SW	0.05	0.05
HW-5	SW	0.41	0.26	WSW	0.36	0.26	WSW	0.62	0.36	WSW	0.51	0.36
HW-4	WSW	0.62	0.41	WSW	0.46	0.31	WSW	0.72	0.46	WSW	0.67	0.41
HW-3	WSW	0.46	0.31	W	0.46	0.31	W	0.72	0.46	WSW	0.77	0.51
HW-2	SW	0.57	0.36	WSW	0.46	0.31	W	0.72	0.46	WSW	0.87	0.57
HW-1	SW	0.51	0.31	W	0.31	0.15	W	0.51	0.31	WSW	0.57	0.36
HW	NE	0.10	0.05	E	0.05	0.05	NE	0.10	0.05	NE	0.05	0.05
HW+1	NE	0.57	0.36	E	0.46	0.31	E	0.67	0.46	ENE	0.72	0.46
HW+2	NE	0.77	0.51	E	0.62	0.41	E	0.93	0.57	ENE	0.93	0.62
HW+3	NNE	0.67	0.41	ENE	0.51	0.31	E	0.77	0.51	ENE	0.82	0.51
HW+4	NNE	0.41	0.26	ENE	0.36	0.21	E	0.57	0.36	ENE	0.57	0.36
HW+5	NNE	0.21	0.15	ENE	0.15	0.10	E	0.31	0.21	ENE	0.36	0.26
HW+6	NNE	0.05	0.05	NW	0.05	0.05	SW	0.05	0.05	E	0.10	0.05
Excursion (flood)	SW/ WSW	9.3km	5.9km	W/ WSW	7.9km	5.2km	W/ WSW	12.4km	7.8km	WSW	12.4km	8.1km
Excursion (ebb)	NE/ NNE	10km	6.5km	E/ ENE	7.9km	5.2km	E	12.2km	8.0km	ENE	12.8km	8.3km

Data summarised from the Admiralty Chart 1067 (Thames Estuary Southern Part)

The tides flood along the north Kent coast in a westerly direction parallel to the shore, and ebb in the opposite direction. At all stations, this clear bi-directional pattern of tidal streams is apparent. Station A is located inside the main channel of the outer Swale estuary, and tidal streams here align with the orientation of the channel. The other three stations are located off the north Kent coast from Whitstable to Margate, and tidal stream here run parallel to the coast. The flow rates indicate that the tidal excursion (the distance water travels during the course of a flood or ebb tide) is approximately 8-13km on spring tides, and 5-8km on neap tides. These stations are located at least 1km offshore, and whilst the direction of flows in the nearshore and intertidal areas are likely to be the same as offshore, the rates of travel will be slower due to friction. Near bed flows are also likely to be slower than surface flows for the same reason.

Contamination from shoreline sources will therefore travel parallel to the coast, impact either side of their locations, and the magnitude of their impacts will decrease with distance as the plume spreads and becomes more diluted. Contamination from shoreline sources may be carried several km along the shore during the course of a flood or ebb tide, so impacts may potentially be felt a considerable distance away. Contamination from offshore sources such as long sea sewage outfalls may be carried upwards of 10km on spring tides.

Superimposed on tidally driven currents are the effects of freshwater inputs and wind. There is little in the way of freshwater inputs along the north Kent coast, and the coastal waters here are unenclosed so density effects will not modify water circulation here. A density related effect of potential relevance to the fishery is that sewage discharged from long sea outfalls, being less dense than the receiving seawater, will tend to rise to the surface and this will limit their impacts on any benthic shellfish beds in their vicinity to some extent.

Strong winds will modify surface currents on the north Kent coast. Winds 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 will create return currents, either lower down the water column or along sheltered margins. The north Kent coast is most exposed to winds from the north and east. Exact effects are dependent on the wind speed and direction and the state of the tide at the time and so a great range of scenarios may arise. The prevailing south westerly wind direction will tend to advect contamination in the upper part of the water column away from the shore and out towards the North Sea. As well as driving surface currents, onshore winds will create wave action. This 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.

APPENDIX VI
METEOROLOGICAL DATA: WIND

The strongest winds are associated with the passage of deep depressions and the frequency and strength of these depressions is greatest in the winter (Met Office, 2011). As Atlantic depressions pass across England and Wales, the wind typically starts to blow from the south or southwest, but later comes from the west or northwest as the depression moves away. The frequency of gales in south east England is relatively low.

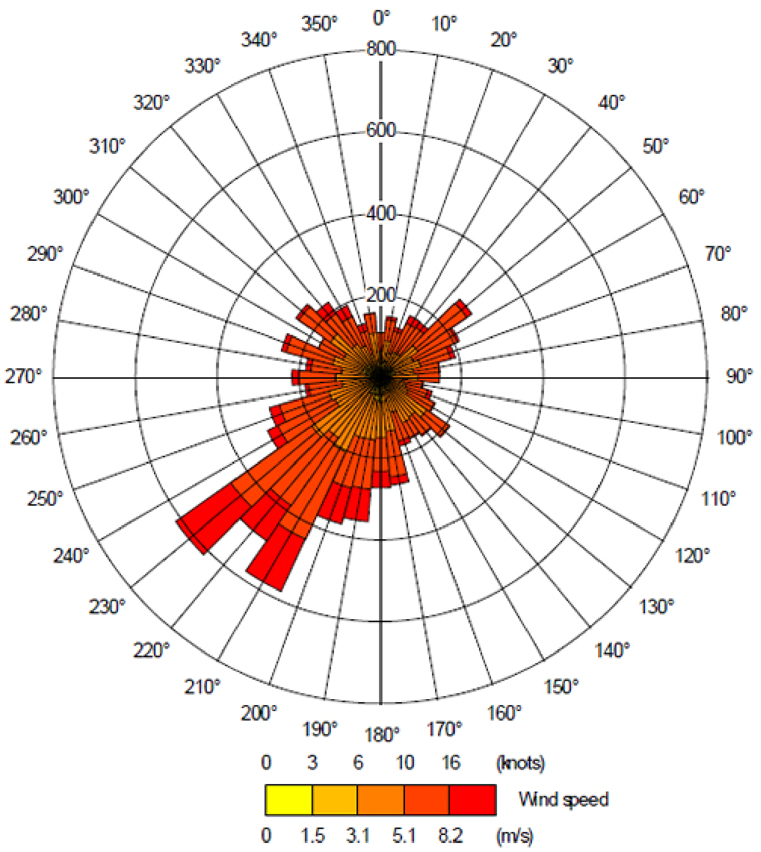

Figure VI.1 Wind rose for Manston Airport, 2006.
Reproduced with permission of Thanet Council

Manston Airport lies on flat ground about 4km south of Margate so should be broadly representative of wind patterns on the north Kent coast. The prevailing wind direction is from the southwest, and the strongest winds usually blow from this direction. A similar pattern may be expected throughout the north Kent coast, although it is most exposed to the north east, so it is possible that wind speeds may tend to be skewed so they are slightly slower from the southern half and slightly faster from the northern half compared to Manston Airport.

APPENDIX VII
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: SEWAGE DISCHARGES

Details of all consented discharges were provided by the Environment Agency from their National Discharge Database in October 2010. There are four water company sewage treatment works in the area which may impact on the shellfisheries, a series of intermittent overflow discharges associated with these sewerage networks, as well as a number of much smaller private discharges. Figure VII.1 presents a map showing the locations of these discharges, and Tables VII.1 and VII.3 present further information on the water company discharges.

Table VII.1 Details of major continuous water company sewage discharges to the area

Name	Location	DWF (m^3/day)	Treatment Level	Bacterial load (faecal coliforms /day)*	Receiving Water
Margate STW	TR 3885 7346	29,120	Tertiary (UV)	$8.2x10^{10}$	North Sea
Swalecliffe STW	TR 1415 6953	7,608	Tertiary (UV)	$2.1x10^{10}$	North Sea
Faversham STW	TR 0268 6233	7,000	Secondary	$2.3x10^{13}$	Faversham Creek
Herne Bay STW	TR 2117 6753	2,867	Secondary	$9.5x10^{12}$	Chislet Marshes

*Based on geometric base flow averages from a range of UK STWs (Table VII.2). These estimates are intended for comparative purposes only, and bacterial loadings generated by each STW are likely to fluctuate significantly.

The two major discharges direct to coastal waters (Margate and Swalecliffe STWs) are both UV treated, and are discharged via long sea outfalls. Therefore the bacterial loading which they emit should be quite low, and any impacts on *E. coli* levels in shellfish will largely confined to the vicinity of their outfalls, away from the intertidal zone. This assumes that the UV treatment is consistently effective and in the absence of final effluent testing data this cannot be confirmed. The Margate sewerage scheme was updated to its present form in 2007, and Swalecliffe in 2001.

Although both employ UV treatment methods it must be noted that UV disinfection is less effective at removing viruses than bacteria, and the majority of reported bivalve related illness outbreaks in the UK are associated with norovirus (e.g. Lees, 2000). STWs with disinfection systems are required to show a 25,000 fold reduction in bacterial loading across the entire works to be consented as such, whereas they are only required to demonstrate a 10 fold reduction in viral loading (Environment Agency, 2001). Should the UV plants fail the *E. coli* loading discharged by these works may increase by about 3 orders of magnitude based on data presented in Table VII.2.

The Herne Bay STW is likely to generate a much larger bacterial loading due to its lower level of treatment. This discharges to a drain within the marshes inland from Reculver, which in turn drain to the sea via three sluiced outfalls just east of Reculver. It is likely that most of this effluent leaves the marshes via the outfall immediately adjacent to the two towers at Reculver. Therefore, greatest impacts from this discharge are expected in the vicinity of Reculver.

Its transit time of through the marshes is uncertain, but the drains appeared very slow flowing when seen on the shoreline survey, so there may be

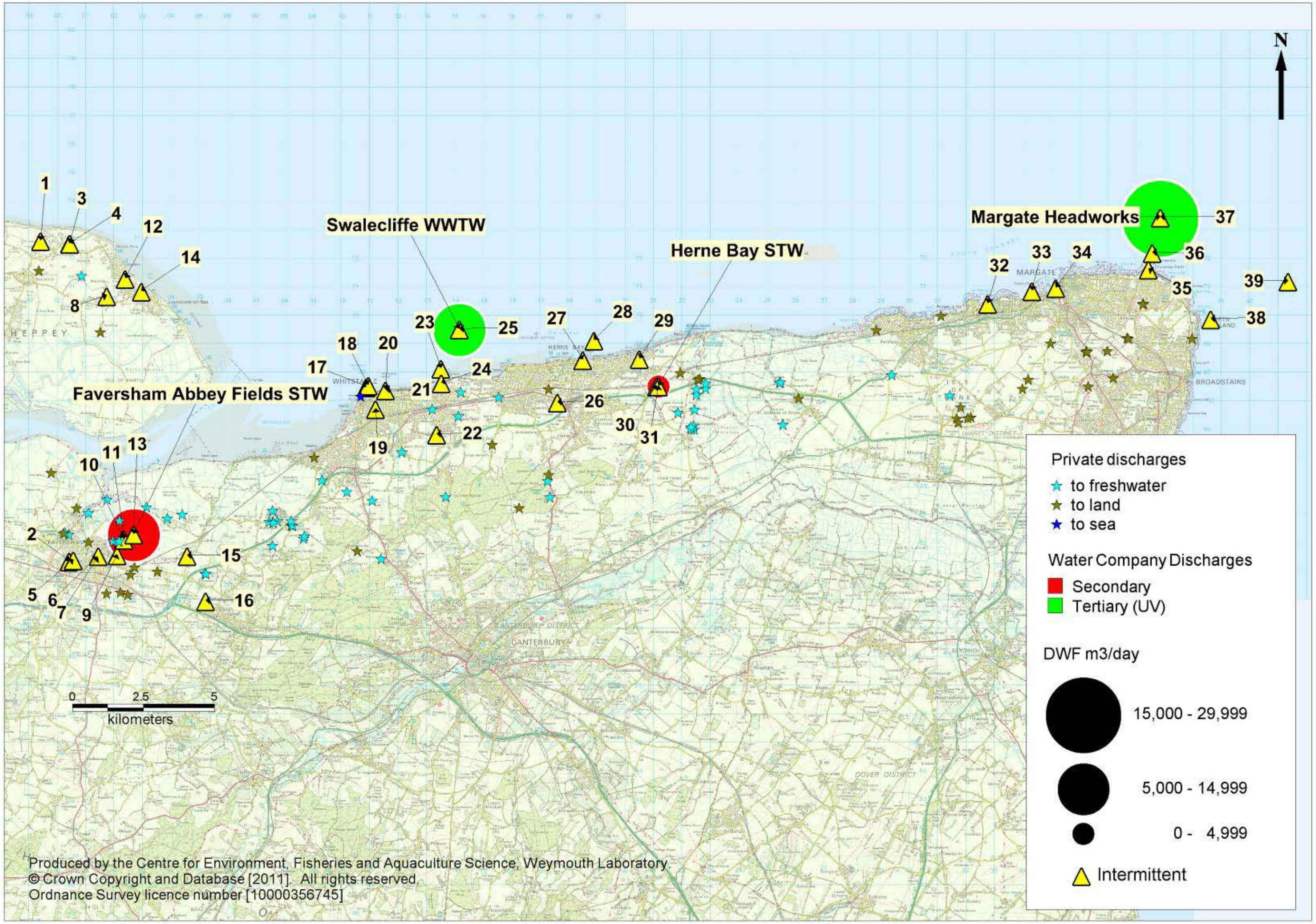

Figure VII.1. Locations and size of continuous and intermittent sewage discharges to the north Kent coastal strip

significant potential for bacterial dieoff during transit particularly during dry conditions when water retention times are likely to be highest. The Faversham Abbey Fields STW is likely to generate the highest loading of all four of these works given its flow rates and level of treatment. This discharges to the tidal waters of Faversham Creek, about 10km via water west of Seasalter. Therefore, greatest impacts from this discharge may be expected at the western end of the survey area, although it is a considerable distance away. There are no continuous water company sewage discharges to the north or east shore of Sheppey, or tributaries thereof.

Table VII.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
Primary (12)	127	$1.0x10^7$	14	$4.6x10^6$
Secondary (67)	864	$3.3x10^5$	184	$5.0x10^5$
Tertiary (UV) (8)	108	$2.8x10^2$	6	$3.6x10^2$

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

In addition to the continuous sewage discharges, there are a large number of intermittent water company discharges within the area (Table VII.3).

Table VII.3 Details of intermittent discharges to North Kent coast

ID	Name	Location	Type
1*	Hens Brook WWPS	TQ 9941 7263	Storm
2*	Hazebrouck Road Faversham WWPS	TR 0041 6138	Storm & Emergency
3	Barrows Brook WWPS	TR 0042 7254	Storm & Emergency
4*	Barrows Brook Eastchurch CEO	TR 0043 7253	Storm & Emergency
5	Faversham SPS	TR 0055 6142	Storm & Emergency
6	North Lane Faversham CSO	TR 0143 6157	Storm & Emergency
7	Abbey Street	TR 0144 6157	Storm
8*	Mustards Road PS	TR 0174 7070	Storm & Emergency
9	Gordon Square SPS	TR 0210 6159	Storm & Emergency
10	Abbeyfields CSO	TR 0232 6216	Storm & Emergency
11*	Cyprus Rd/Whitstable Rd CSO	TR 0234 6213	Storm & Emergency
12	Warden Bay PS	TR 0238 7130	Storm & Emergency
13	Faversham Abbey Field STW	TR 0268 6233	Storm & Emergency
14*	Little Groves Leysdown WWPS	TR 0296 7086	Storm
15	Goodstone PS	TR 0457 6157	Storm & Emergency
16	Boughton PS	TR 0522 5998	Storm & Emergency
17	Gorrell Outfall	TR 1088 6750	Storm
18	Gorrell Storm Sewage	TR 1095 6755	Storm
19*	Diamond Road CSO	TR 1120 6673	Storm & Emergency
20	Tankerton Bay Outfall (outlet 1)	TR 1156 6739	Storm
21	Tankerton Bay Outfall (outlet 2)	TR 1156 6739	Storm
22	Chestfield Storm Tanks	TR 1335 6583	Storm
23	Swalecliffe Storm Outfall	TR 1350 6815	Storm
24*	Brook Road WWPS	TR 1352 6764	Storm & Emergency
25	Swalecliffe WWTW	TR 1415 6953	Storm & Emergency
26	Eddington SPS	TR 1761 6695	Storm & Emergency
27	Kings Hall WPS (outlet 2)	TR 1851 6844	Storm & Emergency
28	Kings Hall WPS (outlet 1)	TR 1889 6914	Storm & Emergency
29	Gainsborough Drive WWPS	TR 2050 6849	Storm & Emergency
30	Herne Bay STW (outfall C)	TR 2111 6752	Storm & Emergency
31	Herne Bay STW (outfall A)	TR 2117 6753	Storm & Emergency
32*	St Mildred's Bay CSO	TR 3277 7043	Storm & Emergency
33	Sea View Terrace CSO	TR 3433 7087	Storm & Emergency
34*	Marine Terrace CSO/PS	TR 3516 7098	Storm & Emergency
35	Margate Headworks (outlet 1)	TR 3843 7163	Storm & Emergency
36	Margate Headworks (outlet 3)	TR 3857 7221	Storm & Emergency
37	Margate Headworks (outlet 2)	TR 3885 7346	Storm & Emergency
38	Broadstairs Headworks (outlet 2)	TR 4062 6988	Storm & Emergency
39	Broadstairs Headworks (outlet 1)	TR 4335 7121	Storm & Emergency

**No spills reported to the EA in 2010*
Discharges highlighted in yellow have spill information presented in Figure VII.2

Records of spill durations for intermittent discharges with telemetry to the North Kent coast were provided by Southern Water for the period April 2005 to September 2010. This information is presented graphically in Figure VII.2.

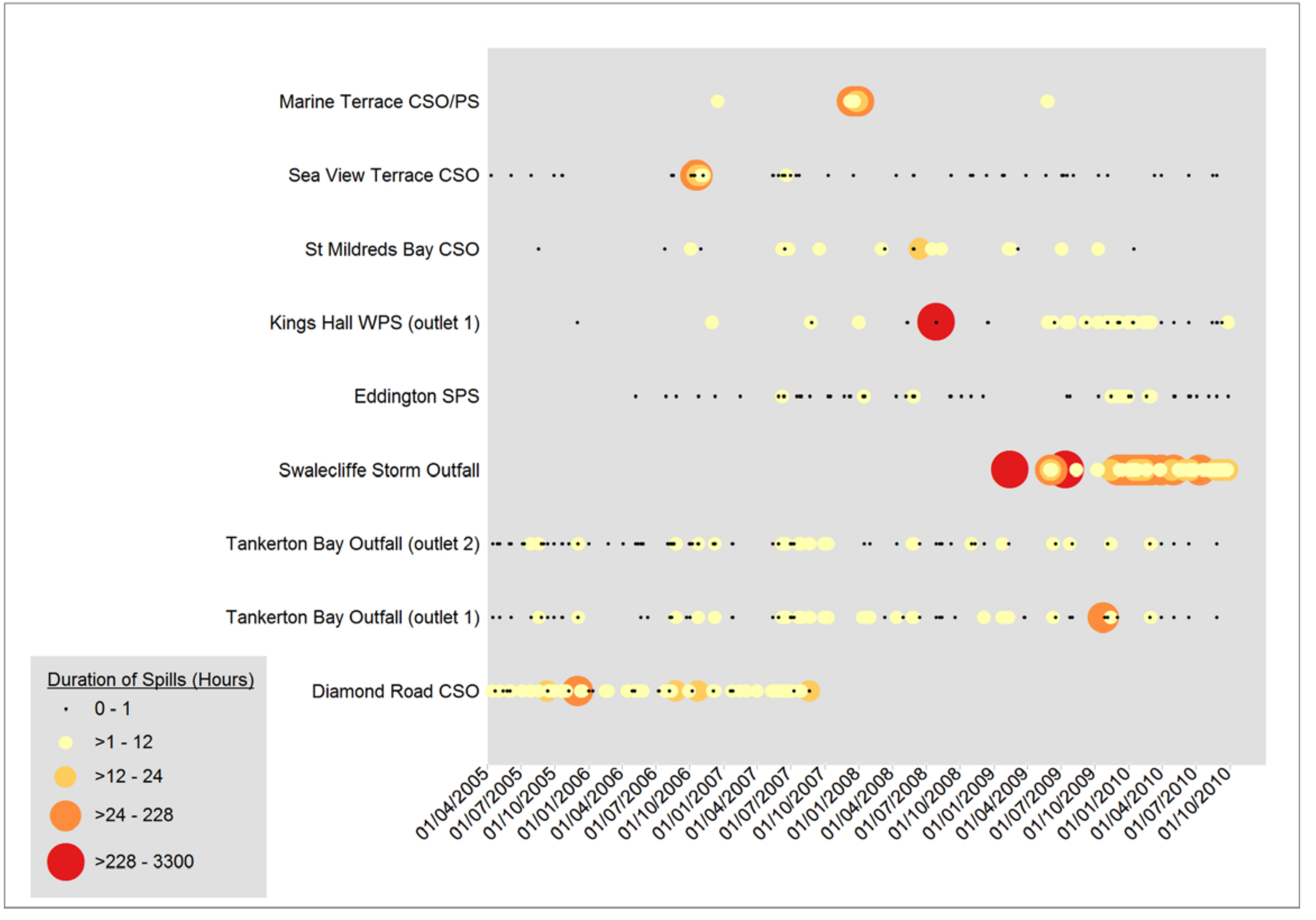

Figure VII.2 Bubble plot of spill duration from intermittent discharges on the north Kent coast.
(Listed in order from west to east)
Data from Southern Water.

The majority of spills recorded were minor, and of short duration. In recent years (2009-2010) it is apparent that the Swalecliffe STW storm outfall has spilled the most, and therefore represents the greatest risk to shellfisheries in the area. Spills from the three Margate sewerage network overflows (Marine Terrace, Seaview Terrace and St Mildreds Bay) were infrequent and generally minor when they did occur. Data provided by the Environment Agency for the Margate STW overflows indicate that spills occurred from this plant for a total of almost 400 hours from 1st Jan to 17th July 2011. This included 3 spills from outlet 3 (the long sea outfall) 4 spills from outlet 2 (the short sea outfall) and one spill from outlet 1 each of over 12 hours duration. It is therefore likely that this outfall may represent a significant risk at times, mainly to the offshore cockle fisheries in the vicinity of Margate Sands and intertidal stocks in Margate. No information is available on spill frequency for many of the intermittent discharges to the north Kent coast, so it is difficult to assess their impact apart from noting their location and potential to discharge untreated sewage.

In addition to water company sewerage networks, there are 102 small private domestic or trade discharges to the coastal strip listed on the database. Of these 45 discharge to soakaway, 56 to watercourses, and one direct to coastal waters (within Whitstable harbour). The majority of those discharging to watercourses are found between Faversham and Reculver and so may be expected to make a contribution to *E. coli* loadings carried by watercourses draining this area. It is not anticipated that those draining to soakaway will have any contaminating effect on coastal waters.

In conclusion, the loadings generated by the Margate and Swalecliffe UV treated discharges are likely to be small, although they do have the potential to generate very large bacterial loadings should problems arise with their disinfection systems, and regular spills of untreated sewage are known/reported to occur regularly from both. The two secondary treated discharges are expected to generate much higher bacterial loadings on average, but neither of these discharge direct to coastal waters. Contamination from the Herne Bay STW is likely to be conveyed to coastal waters via the surface water outfalls from the marshes at Reculver, most likely the one adjacent to Reculver Towers, although the exact pattern of drainage is uncertain. Sluggish flows through the marshes may afford the opportunity for significant bacterial dieoff before the effluent reaches coastal waters. Faversham Abbey Fields STW discharges to Faversham Creek where it is likely to be of high local significance. Its impacts will be greatest at the western end of the survey area, and the extent of these will depend on patterns of water circulation. Some sporadic and localised impacts may arise from spills from the various intermittent discharges associated with the sewerage networks. Those for which spill information was available did not generally spill particularly frequently or for long periods (aside from the Swalecliffe STW overflow already discussed). The small private discharges are likely to make a contribution to levels of *E. coli* in some watercourses but overall impacts from these are anticipated to be minor.

APPENDIX VIII
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: AGRICULTURE

The majority of agricultural land is used for arable farming, but there is an area of pasture at the western end of the survey area on the Graveney Marshes, and there are also some areas of fruit trees or berry plantations further inland from here (Figure 1.2). Numbers and overall densities of livestock as recorded in the 2010 agricultural census are presented in Table VIII.1.

Table VIII.1 Summary statistics from 2010 livestock census within the North Kent coastal strip catchment area

	Number	Density (animals/km^2)
Cattle	850	5.3
Sheep	5259	32.6
Poultry	3647	22.6
Pigs	132	0.8

Data provided by Defra

Numbers and densities of livestock within the area are relatively low, particularly when compared to a human population of around 150,000. The concentration of faecal coliforms excreted in the faeces of animal and human and corresponding loads per day are summarised in Table VIII.2.

Table VIII.2 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).

Shoreline survey observations indicate that sheep are grazed on the Graveney Marshes but the area was not surveyed in detail. According to land cover maps the Graveney Marshes support the only significant area of pasture, so it is likely that the vast majority of cattle and sheep are grazed here in a localised pocket of high livestock density. Therefore watercourses draining this area, which lies at the western extremity of the survey area, are likely to be impacted by grazing livestock. Numbers of livestock will peak during the summer following the birth of lambs and calves in the spring, and decline during the autumn when some animals will be sent to market, so some seasonality in impacts may be expected. Cattle may be housed indoors in winter, and so at this time their manure will be collected and stored for subsequent use as fertiliser. There is an equestrian centre at Plumpudding, just inland from Minnis Bay so some impact from horses may be anticipated in watercourses draining this area.

Arable farmland extends from inland of Whitstable, through the marshes between Reculver and Minnis Bay, and inland of Margate. It is likely that organic fertilisers (manures, slurries and sewage sludge) may be spread on these areas, the timing and extent of which is uncertain and will depend on crop cycles and availability of the material. The limited amounts of manure/slurry generated from the pig and poultry operations, and from any cattle housed indoors during the winter are likely to be applied to farmland locally (Defra, 2009).

In conclusion, the main and most consistent impacts from agriculture are likely to arise from livestock grazed on the Graveney marshes. Contamination will be conveyed into coastal waters by watercourses draining this area, so the inshore western end of the survey area will be most affected. Numbers of these will be highest during the summer months, so 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. Manures, slurries and sewage sludge may be applied to arable land throughout the north Kent coastal strip, but the timing and locations of this are uncertain. Localised impacts from these may therefore occur within any watercourses draining arable land should wet weather arise following its application.

APPENDIX IX
SOURCES AND VARIATION AND MICROBIOLOGICAL POLLUTION: BOATS

Large volumes of shipping pass through the Thames estuary on their way to and from the Port of London. The main shipping channels are some distance to the north of the area considered in this report, and Merchant Shipping is prohibited from discharging within 3 nautical miles of land, so no impacts from larger vessels are anticipated. Yachts and fishing vessels are however likely to pass closer to the north Kent coast on a daily basis, and may make overboard discharges.

Figure IX.1. Harbours on the north Kent coast

On the north Kent coast, there are small harbours at Whitstable, Herne Bay and Margate, all of which dry out at low tide, so are only used by relatively small vessels. Whitstable is the largest of the three harbours, and is mainly used by fishing vessels (11 were seen here during the shoreline survey). Herne Bay and Margate Harbours are only suitable for small craft, although they may be visited by yachts. Six small boats were counted at Herne Bay on the shoreline survey, none of which appeared large enough to have an on board toilet. Margate Harbour was not visited, but is of a similar size and structure to Herne Bay. No areas of moorings were seen during the shoreline survey, but it is possible that passing yachts anchor up by this stretch of coast from time to time. The RYA report that the north Kent coast is a route which receives heavy recreational use (RYA, 2004).

There is a sailing club at Whitstable, but only very small sailing boats rather than yachts were seen here during the shoreline survey. In the summer a large number of small leisure craft use the entire stretch of coast (small sailing dinghys, jet skis etc.) although they would not be expected to make any overboard discharges.

In conclusion, some overboard discharges may be made by fishing boats or yachts on passage through the area, but impacts from boating traffic are anticipated to be minor and spatially unpredictable. Overboard discharges may be more common in the summer as there are likely to be more yachts passing through the area.

APPENDIX X
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: WILDLIFE

There are major aggregations of overwintering waterbirds (wildfowl and waders) in the Swale estuary. An average total count of 75,192 individuals was reported over the five winters up to 2008/9 (Calbrade *et al*, 2010). Counts were not undertaken along the Whitstable to Margate stretch, but it is likely that smaller numbers use this area for overwintering. Shoreline survey observations confirm this, with small aggregations of waders and gulls observed along here and a flock of 2-300 geese seen on the marshes at Reculver.

Of these birds, some species may remain in the area to breed in the summer, but the majority are likely to migrate elsewhere to breed. The seabird 2000 survey carried out counts of breeding seabirds (gulls, cormorants etc) during the early summer of 2000 (Mitchell e*t al*, 2004). The main aggregation of nesting sites was recorded at Birchington (515 pairs of gulls), with other smaller aggregations at Herne Bay (40 pairs of gulls) and Swalecliffe to Seasalter (72 pairs of gulls).

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). Therefore, it is likely that some proportion of the *E. coli* found within shellfish samples is of avian origin, and this may be more significant during the autumn and winter months. Highest impacts are likely to arise towards the western end of the stretch, as the largest overwintering populations are found in the Swale estuary. Summer breeding populations of gulls are concentrated at Birchington. On a smaller spatial scale, this contamination is via direct deposition so may be quite patchy, with some shellfish containing quite high levels of *E. coli* with others a short distance away unaffected.

There is a population of harbour seals which frequent the outer Thames estuary. The Sea Mammal Research Unit reported a total count of 299 harbour seals in Suffolk, Essex and Kent in 2008 (SMRU, 2009). It is therefore likely that they are present at the north Kent coast, but in very small numbers. They are likely to forage throughout the area, and so potentially represent a diffuse source of pollution to all shellfish beds. Given the large area they forage over and their small numbers, impacts are likely to be minor at most, and unpredictable in spatial terms. They may use some of the offshore sandbanks such as Margate Sands as low tide haulout sites, so cockle beds there may be most at risk from this possible source.

No other wildlife species which have a potentially significant influence on levels of contamination within shellfish on the north Kent coast have been identified. Dogs are exercised on the beaches along the north Kent coast and so also represent a potential source of diffuse contamination to the near shore zone. It is likely that the intensity of this is greatest on beaches adjacent to urban areas, and shoreline observations support this. Whilst residents are likely to engage in these activities year round, a slight increase in impacts due to visitors to the area may be expected during summer months.

APPENDIX XI
MICROBIOLOGICAL DATA: WATER

BATHING WATERS

There are 12 bathing waters sites located on the North Kent coast, designated under the Directive 76/160/EEC (Council of the European Communities, 1975), the locations of which are shown in Figure XI.1.

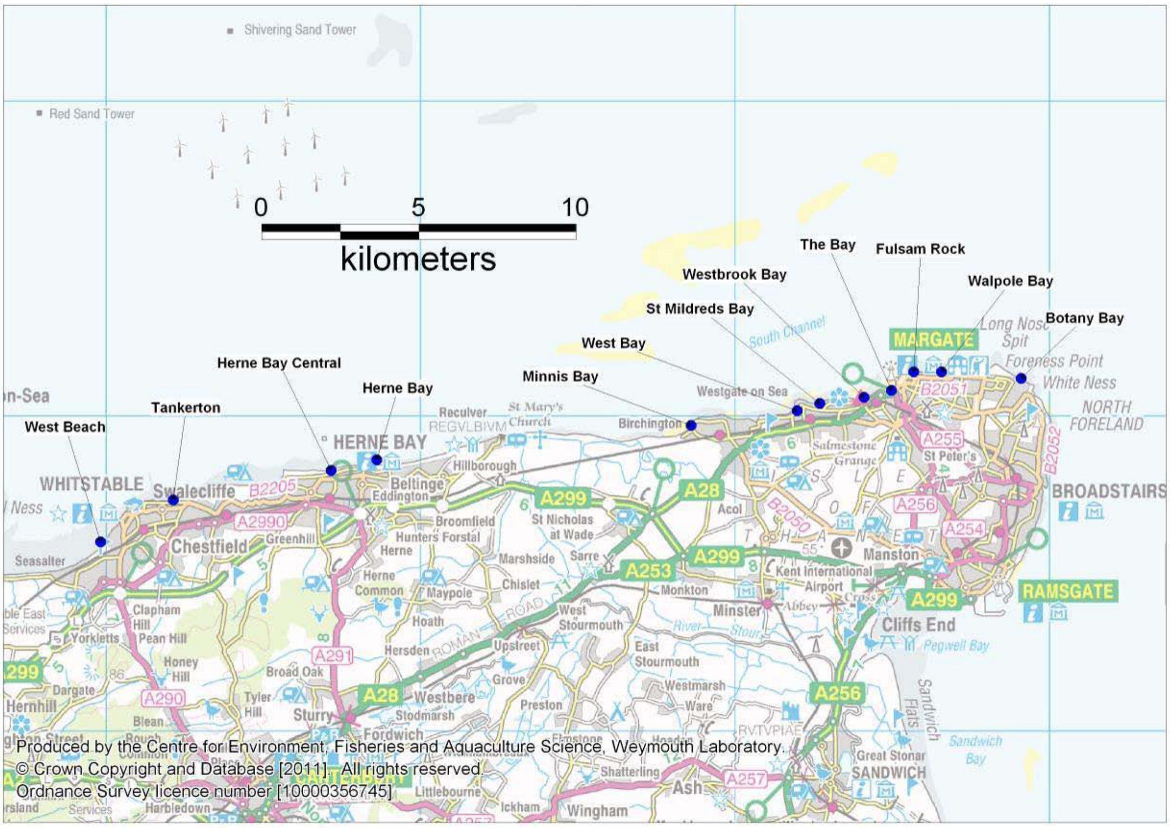

Figure XI.1 Location of designated bathing waters monitoring points on the North Kent coast.

Around 20 samples were taken from each of these sites during each bathing season, which runs from the 15th May to the 30th September. Faecal coliforms (confirmed) were enumerated in all these samples. Figure XI.2 presents box plots of all results from 2008 to 2010 by bathing water (from west to east), and summary statistics are presented in Table XI.1. Results before this period were not considered as the most recent major sewage works upgrade in the area occurred some time in 2007.

Table XI.1 Summary statistics for North Kent bathing waters, 2008-2010

		Faecal coliforms (cfu/100ml)			
Site	**No.**	**Geometric mean**	**Median**	**Minimum**	**Maximum**
West Beach	60	11.5	9.5	<2	1,224
Tankerton	60	11.7	11	<2	6,000
Herne Bay Central	60	20.8	21.5	<2	3,600
Herne Bay	60	25.1	29.5	<2	2,304
Minnis Bay	60	8.3	8	<2	21,600
West Bay	60	10.3	6	<2	1,240
St Mildreds Bay	60	12.6	13.5	<2	500
The Bay	60	15.3	16	<2	1,944
Fulsam Rock	60	16.4	23	<2	381
Walpole Bay	60	12.8	11.5	<2	5,000
Botany Bay	60	6.2	4	<2	538

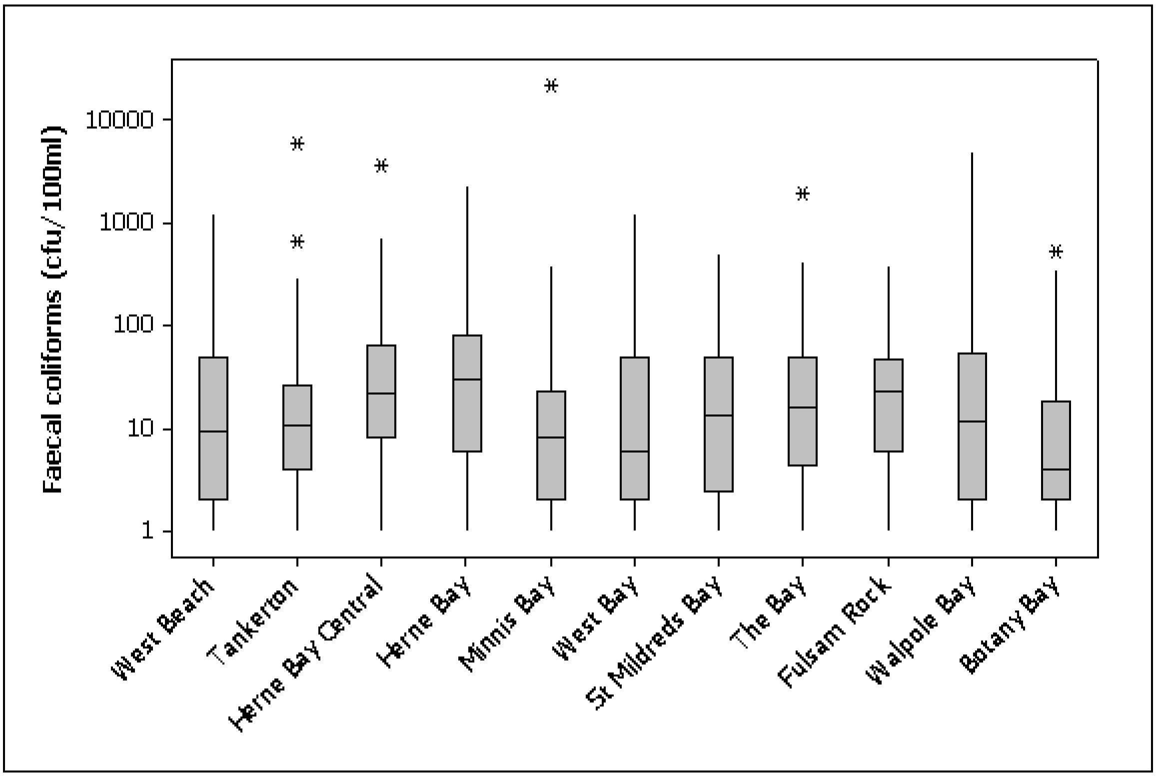

Figure XI.2 Box-and-whisker plots of all faecal coliforms results by site (2008-2010) from west to east

There appear to be minor peaks in average levels of contamination in the vicinity of Herne Bay and to a lesser extent at Fulsam Rock. High results of over 1000 cfu/100ml arose at a range of sites, but were more widespread towards the western end of this stretch of coast. The highest recorded result arose at Minnis Bay.

To investigate the effects of rainfall on levels of contamination Spearman's rank correlations were carried out with total rainfall recorded at Herne Bay (Appendix II for details) over various periods running up to sample collection. These are presented in Table XI.2, and statistically significant correlations ($p<0.05$) are highlighted in yellow.

Table XI.2 Spearman's Rank correlations between total rainfall recorded at Herne Bay over various periods preceding sampling and bathing waters faecal coliforms results

	No.	1 day	2 days	3 days	4 days	5 days	6 days	7 days
West Beach	60	0.091	0.258	0.343	0.368	0.383	0.399	0.299
Tankerton	60	0.169	0.395	0.402	0.456	0.472	0.430	0.380
Herne Bay Central	60	0.427	0.545	0.513	0.536	0.428	0.396	0.302
Herne Bay	60	0.190	0.298	0.376	0.387	0.253	0.255	0.231
Minnis Bay	60	0.153	0.155	0.203	0.235	0.216	0.301	0.221
West Bay	60	0.162	0.205	0.148	0.259	0.289	0.365	0.302
St Mildreds Bay	60	0.052	0.089	0.061	0.093	0.130	0.175	0.085
The Bay	60	0.014	0.031	0.045	0.018	-0.043	-0.075	-0.108
Fulsam Rock	60	0.028	0.060	0.155	0.172	0.178	0.255	0.238
Walpole Bay	60	0.243	0.148	0.104	0.135	0.101	0.075	0.023
Botany Bay	60	0.052	0.087	0.110	0.149	0.182	0.159	0.092

Rainfall totals were correlated with higher levels of faecal coliforms at the six sites in the western half of the survey area, and some limited influence was also found at Fulsam Rock. The response to rainfall was not immediate, with the strongest correlations found with total rainfall over the preceding 2-6 days. Sites with higher average results tended to be more influenced by rainfall. There are no bathing waters sites in the Reculver area.

SHELLFISH WATERS

There are three Shellfish Waters coinciding with the survey area which have been designated under Directive 2006/113/EC as a Shellfish Water since 1999 (European Communities, 2006). These are Swale East, Whitstable and Margate. Figure XI.2 shows their boundaries and monitoring points, and Table XI.3 presents summary statistics for all bacteriological monitoring results for water samples taken from these sites from 2008 onwards. The monitoring point for Swale East lies outside the survey area so results for this are not presented.

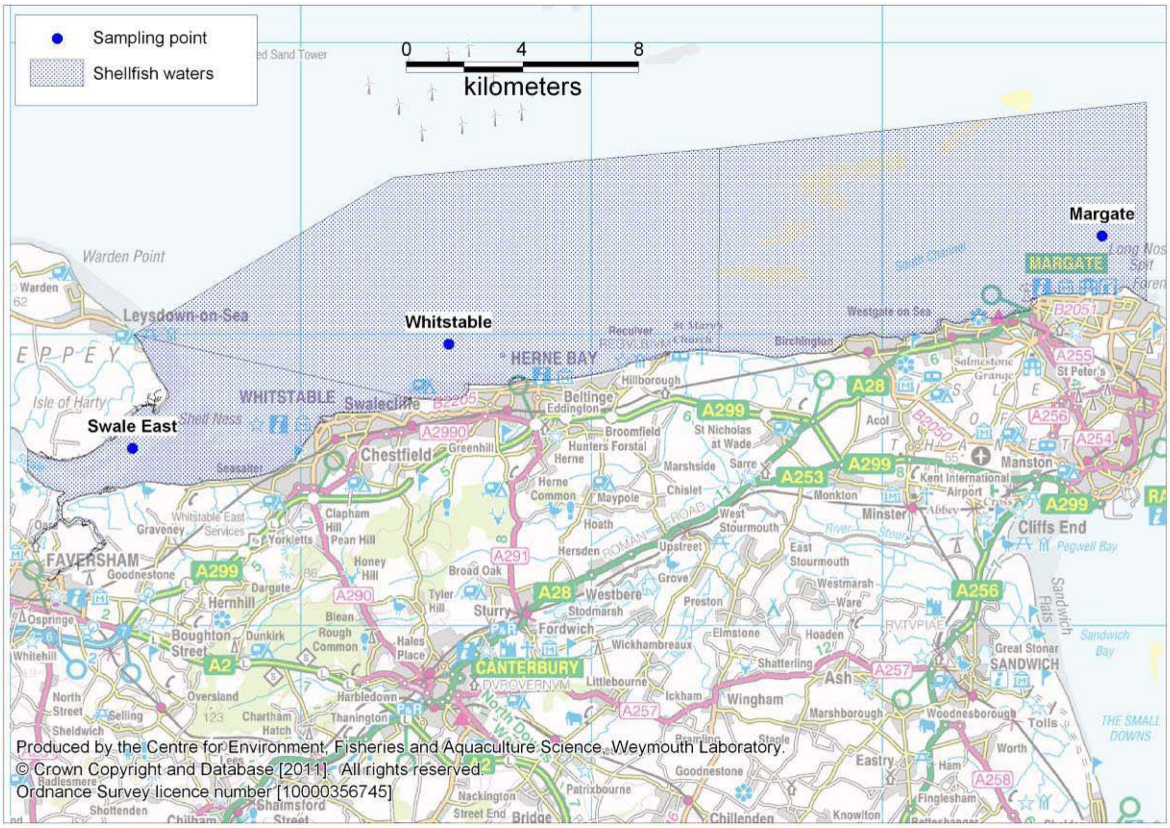

Figure XI.3 Shellfish waters boundaries and sampling points

Table XI.3 Summary statistics for levels of faecal coliforms (cfu/100ml) in surface waters at the Whitstable and Margate shellfish waters.

	Whitstable	Margate
NGR sampled	TR 1510 6967	TR 3758 7339
Matrix	Seawater	Seawater
No. samples	13	13
Minimum	<2	<2
Maximum	658	2
Geometric mean	20.2	<2
Date of first sample	21/02/2008	21/02/2008
Date of last sample	15/11/2010	15/11/2010

Data from the Environment Agency.

Both sampling points lie almost 2km off from the high water mark. Sample numbers considered in Table XI.3 were low. All water samples from Margate contained either 2 or <2 faecal coliforms/100ml, indicating consistently low levels of contamination at the surface at this point, which is 1.3km west of the Margate STW long sea outfall. Results were higher on average and much more variable at Whitstable, where the monitoring point is located 1km east of the Swalecliffe STW long sea outfall. . On a flood tide, water flows in a WSW direction, and on an ebb tide in an ENE direction, so the distribution of results at these points compared to the high/low tidal cycle is of particular interest. To further investigate the possible influence of the Swalecliffe STW discharge on levels of faecal coliforms at the Whitstable monitoring point, results were compared to the state of tide on the high/low tidal cycle (Figure XI.8).

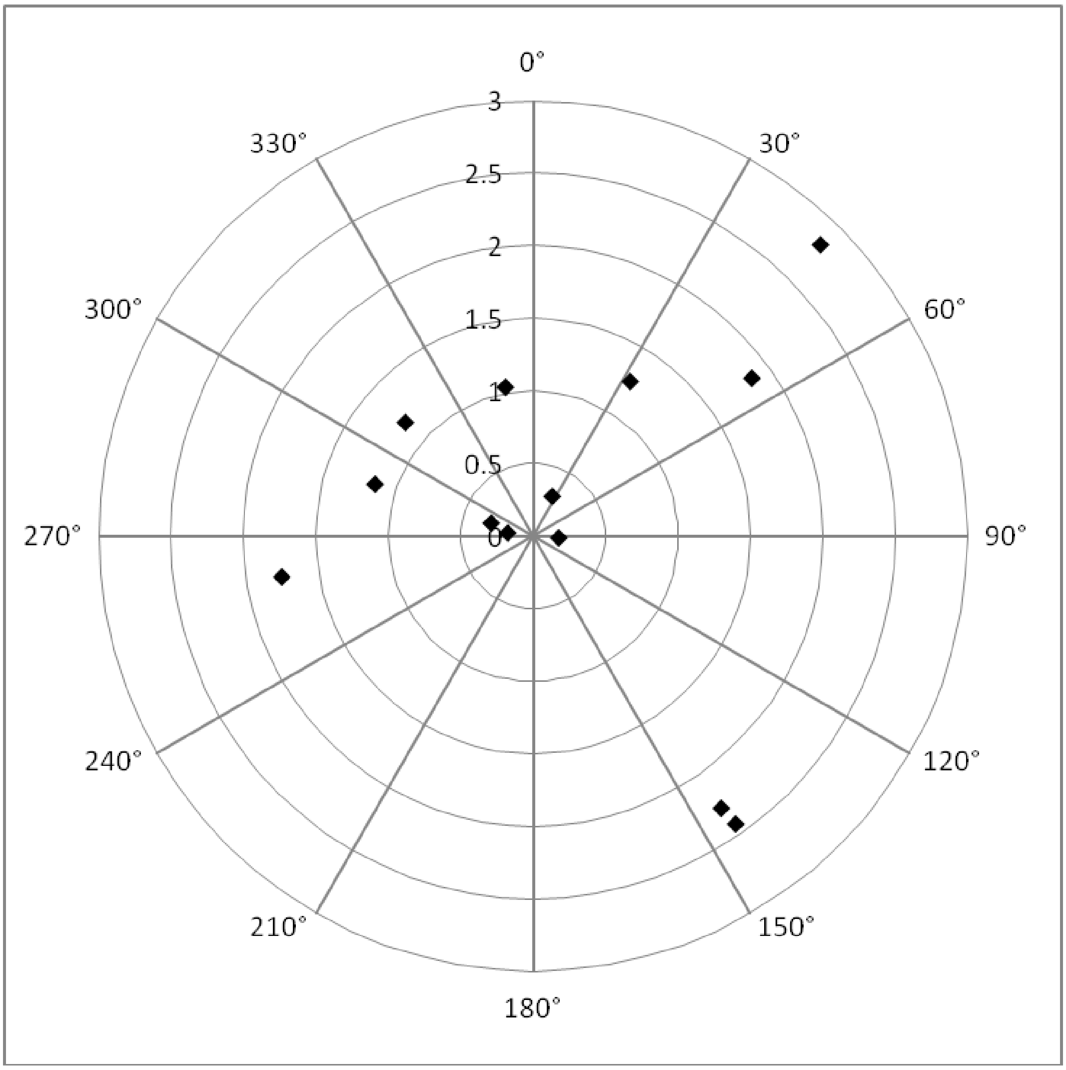

Figure XII.8 Polar plot of $\log_{10}$ faecal coliform results (cfu/100ml) at the Whitstable shellfish waters sampling point against the high/low tidal cycle at Herne Bay. High water is at 0° and low water is at 180°.

Figure XII.8 shows that the four highest individual results arose when the tide was ebbing and hence flowing from the STW in the general direction of the sampling point. Although there was no statistically significant correlation between faecal coliforms result and tidal state (circular-linear correlation, r=0.453, p=0.124) this does very tentatively suggest that a noticeable influence of the Swalecliffe STW may extend to surface waters at least 1km down tide of the outfall at times. None of the three highest results coincided with spills from the Swalecliffe STW overflow.

APPENDIX XII
MICROBIOLOGICAL DATA: SHELLFISH FLESH

Despite a monitoring history stretching back to at least the early 1990s, only data post 2007 was considered in the following analysis as the most recent major sewage works upgrade in the area occurred some time in 2007. Sample results for a total of 21 bed/species combinations were listed on the Cefas Shellfish Hygiene database for this production area post 2007. Figure XII.1 shows RMP location, and Table XII.1 shows summary statistics for *E. coli* results from each sampling point/species combination. In Table XII.1, these RMPs are categorised into broad zones; the intertidal zone, the nearshore zone (below MLWS but within 2 km of it) and the offshore zone (>2km offshore from MLWS).

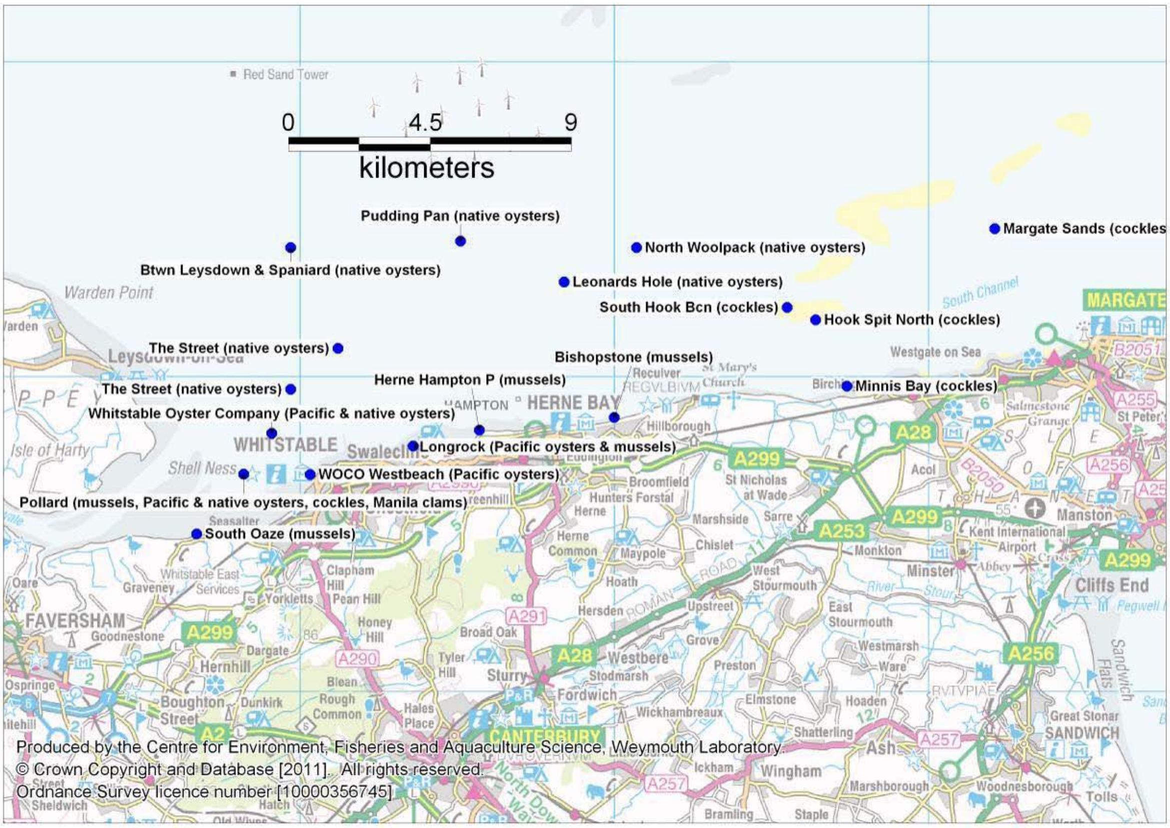

Figure XII.1. Location of hygiene RMPs sampled post 2007

GEOGRAPHICAL VARIATION IN LEVELS OF CONTAMINATION

As different shellfish species are known to accumulate *E. coli* to differing levels, separate geographic analyses were undertaken for each species sampled.

Table XII.1 Summary statistics for E. coli *levels at representative monitoring points (RMPs) on the North Kent coast.*

RMP	Name	Species	Location	Zone	No.	*E. coli* results (MPN/100g) Geometric mean	Median	Min	Max	% exceeding 230 MPN/100g	% exceeding 4600 MPN/100g
B017A	South Oaze	Mussel	TR 0670 6500	Intertidal	16	404	500	20	3,100	69%	0%
B017D	Swalecliffe Longrock	Mussel	TR 1360 6780	Intertidal	35	449	430	<20	6,000	74%	6%
B017E	Herne Hampton P	Mussel	TR 1570 6830	Intertidal	36	423	310	20	16,000	64%	6%
B017F	Bishopstone	Mussel	TR 2000 6870	Intertidal	30	420	465	<20	9,100	63%	7%
B17BL	Pollard	Mussel	TR 0820 6690	Nearshore	1	40	40	40	40	0%	0%
B017P	Leonards Hole	Native oyster	TR 1840 7300	Offshore	27	15	<20	<20	50	0%	0%
B017R	North Woolpack	Native oyster	TR 2070 7410	Offshore	4	17	<20	<20	40	0%	0%
B017Z	The Street	Native oyster	TR 0970 6960	Offshore	5	28	40	<20	110	0%	0%
B17AF	Pudding Pan	Native oyster	TR 1510 7430	Offshore	35	14	<20	<20	130	0%	0%
B17AL	Btwn Leysdown & Spaniard	Native oyster	TR 0970 7410	Offshore	36	16	<20	<20	220	0%	0%
B17BO	Whitstable Oyster Company	Native oyster	TR 0910 6820	Nearshore	27	69	110	<20	1,700	11%	0%
B17BQ	The Street	Native oyster	TR 1120 7090	Offshore	17	22	<20	<20	750	6%	0%
B17AM	Pollard	Pacific oyster	TR 0820 6690	Nearshore	35	145	160	<20	9,100	37%	3%
B17AV	Whitstable Oyster Company	Pacific oyster	TR 0910 6820	Nearshore	28	58	85	<20	750	18%	0%
B17BR	Longrock	Pacific oyster	TR 1360 6780	Intertidal	7	301	460	70	750	57%	0%
B17BS	WOCO Westbeach	Pacific oyster	TR 1032 6689	Intertidal	9	166	230	20	1,400	44%	0%
B017W	South Hook Bcn	Cockle	TR 2550 7220	Offshore	31	233	220	20	5,400	45%	3%
B17AB	Margate Sands	Cockle	TR 3210 7470	Offshore	31	168	220	<20	2,400	45%	0%
B17AC	Hook Spit North	Cockle	TR 2640 7180	Offshore	31	252	250	20	2,400	52%	0%
B17AW	Pollard	Cockle	TR 0820 6690	Nearshore	29	622	500	20	16,000	62%	10%
B17BD	Minnis Bay	Cockle	TR 2740 6970	Intertidal	33	850	750	40	24,000	76%	24%
B17AX	Pollard	Manila clam	TR 0820 6690	Nearshore	7	251	160	40	3,500	43%	0%

MUSSELS

Five locations were sampled for mussels, four of which were in the intertidal, and one of which was in the nearshore zone. The latter (Pollard) was only sampled on one occasion, so could not be included in this analysis. A boxplot of results from the four intertidal sites is presented in Figure XII.2.

Despite the large distance between the sampling sites, the results were very consistent geographically in terms of mean result and the spread of results. No significant difference was found between mean result by site (2-way ANOVA, p=0.450), although a highly significant effect of sampling date was found (2-way ANOVA, p=0.000) indicating that whilst there was little variation geographically, similar temporal fluctuations in levels of contamination arose at these sites.

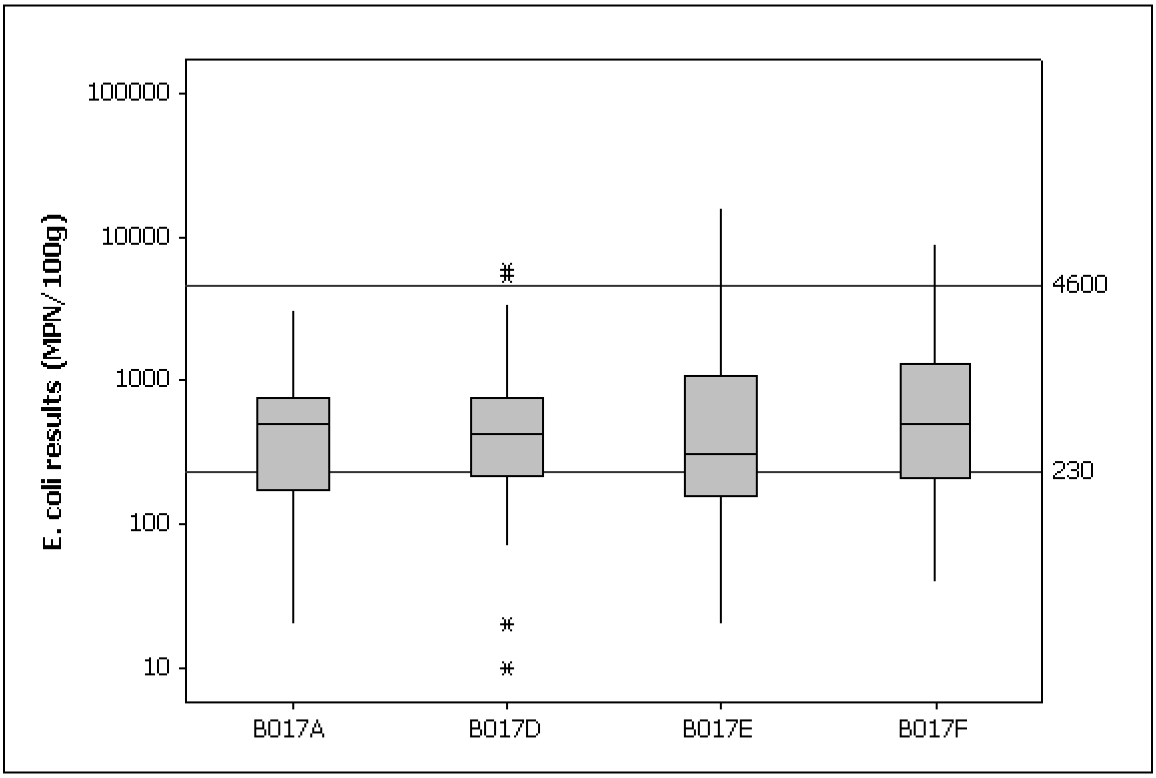

Figure XII.2 Boxplots of mussel* E. coli *results by RMP

Only B017A (South Oaze) recorded no results of over 4600 *E. coli* MPN/100g, but this site was sampled on fewer occasions than the other three. Significant correlations between paired sample results (i.e. those taken on the same day) were found for all site pairings aside from when B017A (South Oaze) and B017E (Herne Hampton P) were compared, although this was almost significant at the 0.05 level. Correlations were generally weakest for B017A (Table XII.2), probably due in part to its location, and in part due to the lower number of samples taken here.

Table XII.2 Pearson correlations (r) and associate p values for paired (same day) E. coli results for the four mussel RMPs, and approximate distances between them.

	B017A	B017D	B017E	B017F
B017A	x	r=0.556, p=0.025	r=0.491, p=0.053	r=0.739, p=0.001
B017D	7.5 km	x	r=0.654, p=0.000	r=0.643, p=0.000
B017E	9.5 km	2 km	x	r=0.668, p=0.000
B017F	14.0 km	6.5 km	4.5 km	x

Therefore, it is concluded that for mussels in the intertidal zone, for the sites sampled (and therefore probably for the majority of the stretch from Seasalter to Bishopstone) levels of contamination are very consistent spatially, and vary in a consistent manner over time.

NATIVE OYSTERS

For native oysters a total of 7 sites were sampled, of which 6 were offshore and one was nearshore and none were in the intertidal zone. A boxplot of these results by sampling location is presented in Figure XII.3. It must be noted that B017R and B017Z were only sampled on four and five occasions respectively.

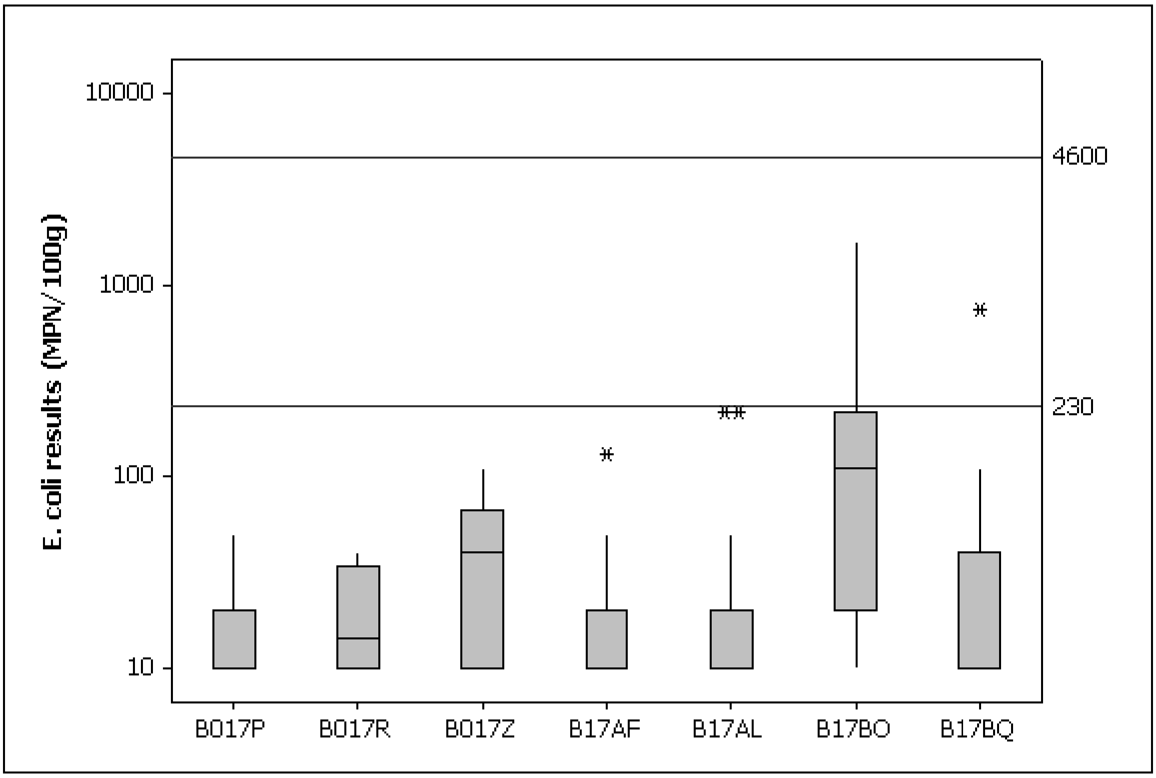

Figure XII.3 Boxplots of native oyster* E. coli *results by RMP

Figure XII.2 highlights the increased levels of contamination experienced at the nearshore site B017BO (Whitstable Oyster Company) compared to the offshore sites. For the offshore sites, only one result exceeding 230 *E. coli* MPN/100g was recorded from 124 samples. A significant difference was detected between the sites (One-way ANOVA, p=0.000) and a post ANOVA test (Tukeys comparison) identified that the results for the nearshore site (B017BO) were significantly higher on average that that for all offshore sites except B017R and

B017Z, which were sampled on too few occasions for a meaningful comparison. Therefore it is concluded that levels of contamination are very similar (and low) at all offshore sites, and distinctly higher at the nearshore site. No significant correlations were found between results of paired samples taken from the offshore area, but this was not unexpected as there was little overall variability in results.

PACIFIC OYSTERS

Four sites were sampled for Pacific oysters, of which two were nearshore sites, and two were intertidal sites. Figure XII.4 presents boxplots of *E. coli* results by site.

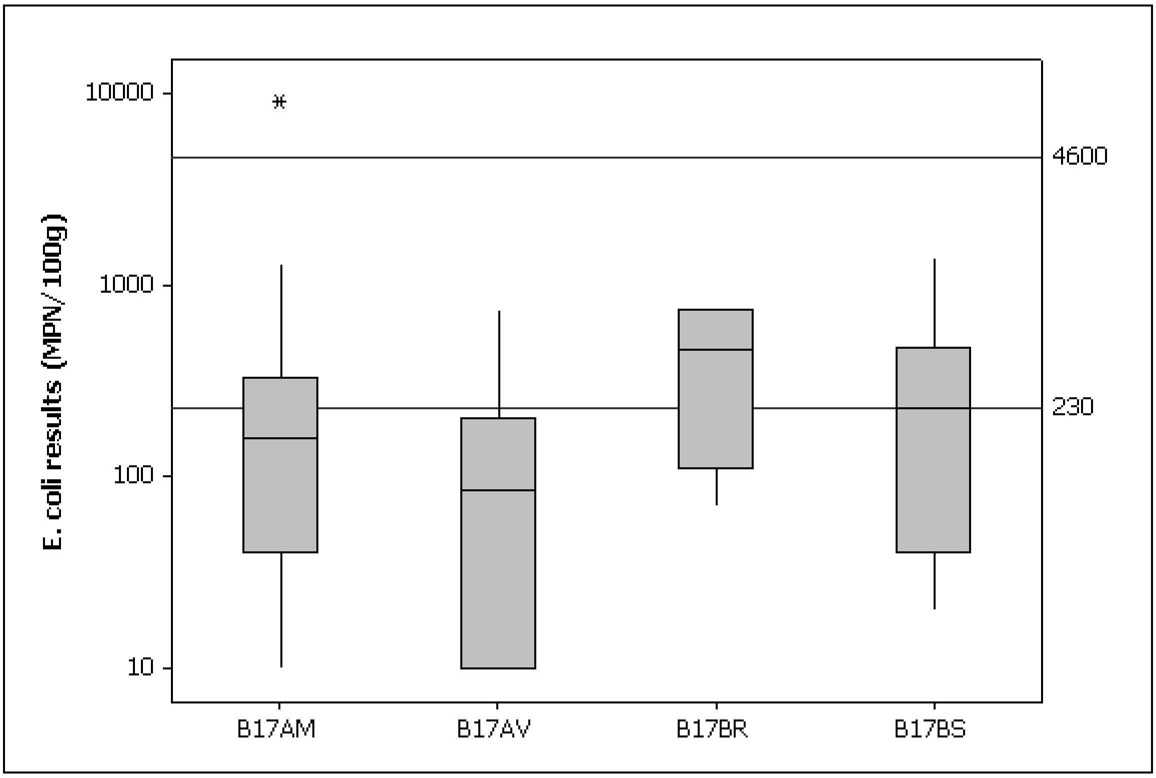

Figure XII.4 Boxplots of Pacific oyster* E. coli *results by RMP

Sample numbers were low for the two intertidal sites (B17BR and B17BS). Results at the two intertidal sites were higher on average than at the two nearshore sites. A significant difference between the RMPs was found (One-way ANOVA, p=0.017) and a post ANOVA test (Tukeys comparison) identified that the results for B17BR were significantly higher than those from B17AV. The only result exceeding 4600 *E. coli* MPN/100g arose at B17AM, but this was the site sampled most frequently and none of the other sites was sampled on this day for direct comparison. No same day paired sample comparisons were possible for this species as multiple sites were sampled on the same day on very few occasions. The geometric mean result for Long Rock was slightly lower for Pacific oysters than for mussels taken from the same site.

COCKLES

For cockles, a total of five sites were sampled, of which three were offshore sites, one was a nearshore site, and one was an intertidal site. Figure XII.5 presents boxplots of *E. coli* results by site.

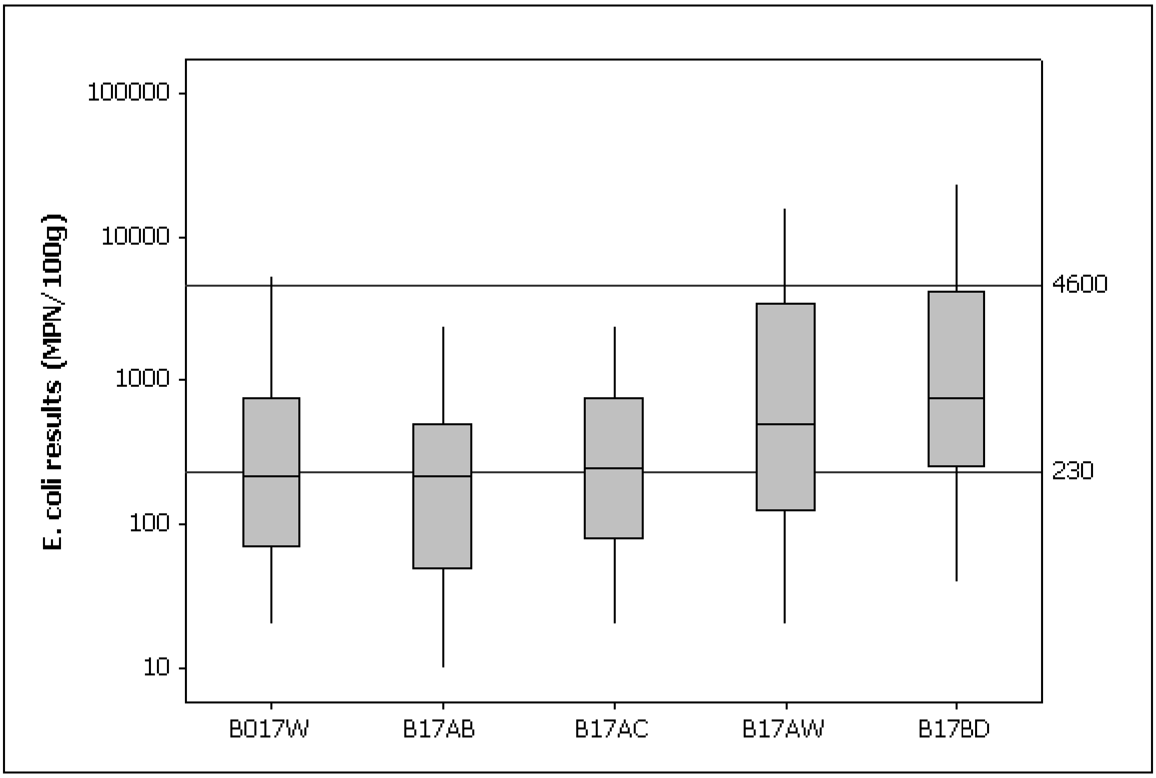

Figure XII.5 Boxplots of cockle* E. coli *results by RMP

A comparison of all cockle results by site found a significant difference in mean result (One-way ANOVA, p=0.000). A post ANOVA test indicated that results for the intertidal RMP at Minnis Bay (B17BD) were significantly higher than for the three offshore RMPs (B017W, B17AB and B17AC), and that results for the nearshore RMP at Pollard were significantly higher than only one of the offshore RMPs (B017AB).

All three offshore RMPs (B017W, B17AB and B17AC) were all sampled on the same day on each of the 31 occasions they were sampled, permitting a more robust comparison of results between these RMPs. No significant difference was found between these three sites (Two-way ANOVA, p=0.150), and strong correlations were found when same day samples were compared for each site pairing (Pearson's correlation, r=0.626 or greater, p=0.000 in all cases). Taken together, these comparisons indicate that the offshore cockle RMPs are subject to very similar levels of contamination, and the levels of contamination at these three RMPs fluctuate in a very similar manner from day to day.

Manila clams were only sampled from one location so no geographic assessment was possible for this species.

SEASONAL VARIATION

Season influences not only weather patterns and water temperature, but patterns of human occupation, and the distribution of livestock and wildlife. All of these can affect levels of microbial contamination, and cause seasonal patterns in results. On the basis of geographic comparisons of sample results, and the numbers of samples taken, seasonal variation was assessed for intertidal mussels, offshore native oysters, nearshore Pacific oysters and offshore cockles.

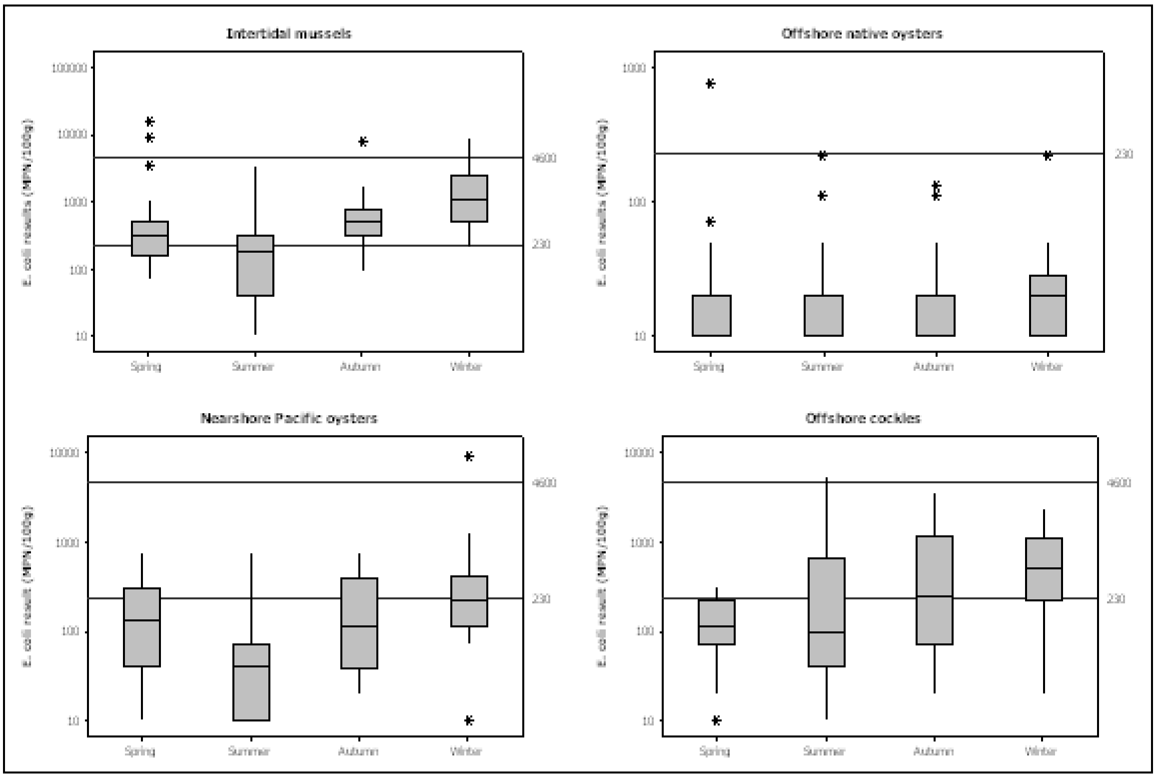

Figure XII.6 Boxplots of* E. coli *results by season for intertidal mussel beds (B017A, B017D, B017E and B017F combined), offshore native oysters (B017P, B017R, B017Z, B17AF, B17AL and B17BQ combined), nearshore Pacific oysters (B17AM and B17AV combined) and Offshore cockles (B017W, B17AB and B17AC combined)

Seasonal variation was fairly consistent between these RMP categories, with results always highest on average during the winter months. For intertidal mussels, results for the winter were significantly higher than those for the summer (One-Way ANOVA, p=0.001, Tukeys comparison). For offshore native oysters, the variation in results was small overall, and no significant seasonal effect was detected (One-Way ANOVA, p=0.688). For nearshore Pacific oysters, results for the winter were significantly higher than those for the summer (One-Way ANOVA, p=0.001, Tukeys comparison). For offshore cockles, results for the winter were significantly higher than those for the summer and the spring (One-Way ANOVA, p=0.002, Tukeys comparison).

INFLUENCE OF RAINFALL

To investigate the effects of rainfall on levels of contamination within shellfish samples Spearman's rank correlations were carried out with rainfall recorded at Herne Bay (Appendix II for details) over various periods running up to sample collection for all RMPs where over 20 samples have been taken post 2007. These are presented in Table XII.2, and statistically significant correlations ($p<0.05$) are highlighted in yellow.

Table XII.2 Spearman's Rank correlations between total rainfall recorded at Herne Bay over various periods preceding sampling and shellfish hygiene* E. coli *results

RMP	B017D	B017E	B017F	B017P	B17AF	B17AL	B17BO	B17AM	B17AV	B017W	B17AB	B17AC	B17AW	B17BD
No.	35	36	30	27	35	36	27	34	28	31	31	31	29	33
Species	Mussel	Mussel	Mussel	N. oyster	N. oyster	N. oyster	N. oyster	P. oyster	P. oyster	Cockle	Cockle	Cockle	Cockle	Cockle
Zone	Intertidal	Intertidal	Intertidal	Offshore	Offshore	Offshore	Nearshore	Nearshore	Nearshore	Offshore	Offshore	Offshore	Nearshore	Intertidal
1 day	0.031	0.273	-0.003	0.295	0.048	-0.068	0.231	0.221	0.310	0.012	-0.007	-0.151	0.064	-0.044
2 days	0.158	0.342	0.028	0.133	0.017	0.141	0.171	0.211	0.041	0.103	0.032	-0.025	0.076	-0.006
3 days	0.224	0.350	0.101	0.177	-0.046	0.118	0.070	0.233	-0.071	0.132	0.059	0.113	0.182	-0.052
4 days	0.355	0.468	0.294	0.133	-0.157	0.058	-0.074	0.197	-0.152	0.213	0.150	0.159	0.191	-0.027
5 days	0.485	0.446	0.381	0.133	-0.182	0.082	-0.055	0.226	-0.294	0.139	0.119	0.026	0.055	0.037
6 days	0.403	0.389	0.426	0.145	-0.067	0.106	-0.094	0.148	-0.353	0.144	0.133	0.063	0.052	0.082
7 days	0.317	0.393	0.428	0.136	-0.057	0.075	-0.118	0.106	-0.388	0.186	0.187	0.061	0.088	0.074

Correlations between *E. coli* results and antecedent rainfall were only observed in mussels from the intertidal zone. The mussel samples were taken along a stretch (Swalecliffe to Herne Bay) which is not sampled for other species, apart from at Longrock, which was also sampled for Pacific oysters but only on 7 occasions. It is therefore difficult to determine to what extent this was more a species or geographic effect. At B017D (Longrock) and B017F (Bishopstone) *E. coli* levels were relatively slow to respond to rainfall. A quicker response was seen at B017E (Herne Hampton P).

INFLUENCE OF TIDE

To investigate the effects of the tidal cycle on levels of contamination within shellfish samples circular-linear correlations were carried out against the spring/neap and high/low tidal cycles for all RMPs where over 20 samples have been taken post 2007. These are presented in Table XII.3, and statistically significant correlations ($p<0.05$) are highlighted in yellow.

Table XII.3 Circular linear correlations between predicted tidal state at Herne Bay on the spring/neap and high/low cycles and shellfish hygiene* E. coli *results

					Circular linear correlation coefficient (r) and p value (p)			
RMP	Name	Species	Zone	No.	r (spring/neap)	p (spring/neap)	r (high/low)	p (high/low)
B017D	Longrock	Mussel	Intertidal	35	0.086	0.789	0.251	0.142
B017E	Herne Hampton P	Mussel	Intertidal	36	0.353	0.016	0.369	0.013
B017F	Bishopstone	Mussel	Intertidal	30	0.265	0.149	0.166	0.475
B017P	Leonards Hole	N. oyster	Offshore	27	0.243	0.241	0.285	0.153
B17AF	Pudding Pan	N. oyster	Offshore	35	0.188	0.323	0.233	0.184
B17AL	Btwn Leysdown & Spaniard	N. oyster	Offshore	36	0.079	0.814	0.151	0.481
B17BO	Whitstable Oyster Company	N. oyster	Nearshore	27	0.142	0.618	0.287	0.137
B17AM	Pollard	P. oyster	Nearshore	34	0.142	0.543	0.087	0.791
B17AV	Whitstable Oyster Company	P. oyster	Nearshore	28	0.220	0.297	0.313	0.086
B017W	South Hook Bcn	Cockle	Offshore	31	0.309	0.069	0.335	0.043
B17AB	Margate Sands	Cockle	Offshore	31	0.292	0.092	0.426	0.006
B17AC	Hook Spit North	Cockle	Offshore	31	0.288	0.098	0.119	0.671
B17AW	Pollard	Cockle	Nearshore	29	0.656	<0.001	0.550	<0.001
B17BD	Minnis Bay	Cockle	Intertidal	33	0.243	0.170	0.224	0.222

E. coli levels at most RMPs did not appear to be influenced by tidal cycles. For those where a correlation was found, polar plots of $\log_{10}$ *E. coli* (MPN100g) against tidal state were produced (Figures XII.7 to XII.9). On plots of 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. For plots of the high/low tidal cycle, high water occurs at 0º, the tide ebbs through to low water at 180º, then floods through to 360º. 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.

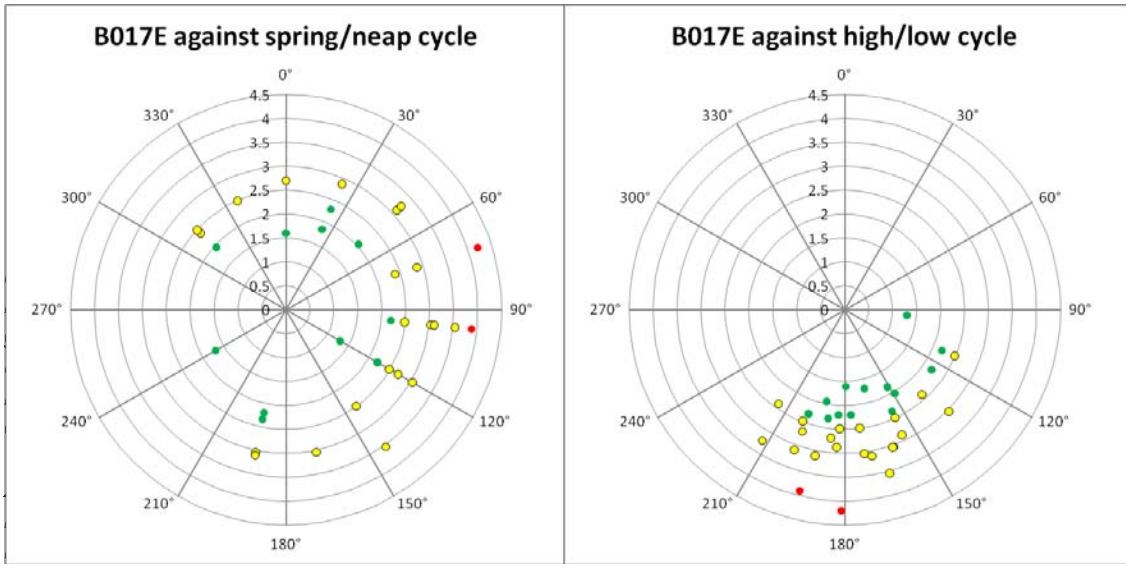

Figure XII.7 Polar plots of log_{10} **E. coli** *results for mussels at Herne Hampton P (B017E) against the spring/neap and high/low tidal cycles*

Correlations with the tidal cycle were weak for mussels at Herne Hampton P. There appears to be a slight tendency for higher results to arise just after the spring tides, tentatively implying that either distant sources, or contamination deposited towards the high water mark may be of some importance. Alternatively, it is possible that there is some alignment between the spring/neap cycle and times of the day when sewage discharges experience peak flows. Sampling was targeted towards low water and no obvious pattern is apparent across the high/low tidal cycle.

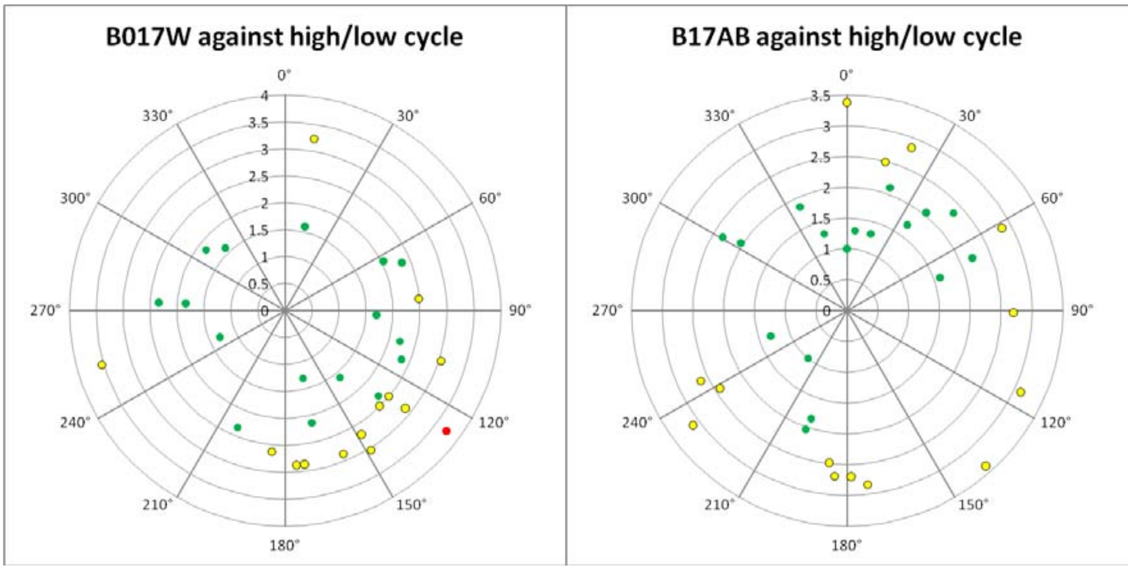

Figure XII.8 Polar plots of log_{10} **E. coli** *results for cockles at South Hook Bcn (B017W) and Margate Sands (B17AB) against the spring/neap tidal cycle*

At both these offshore cockle sites, results appear to increase on average as the tide ebbs, then decrease as it floods, perhaps implying that sources to the west of these sites are of importance, although this pattern is not particularly strong in either case.

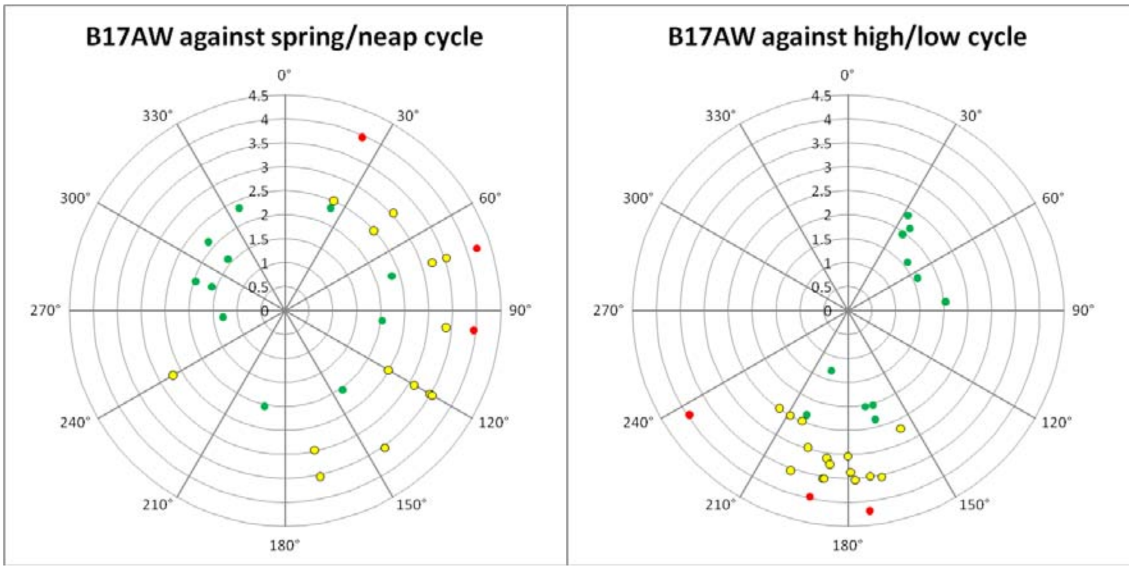

Figure XII.9 Polar plots of log$_{10}$* E. coli *results for cockles at Pollard (B17AW) against the spring/neap and high/low tidal cycles

The strongest correlations were found with both tidal cycles at this RMP. Results were clearly higher on average on and just after spring tides, and lower on average on or just after neap tides. All results within the cluster of samples taken on the early ebb tide were under 230 *E. coli* MPN/100g, and all higher results arose around low water. Taken together this implies that sources to the west of this RMP are of importance, and they are at a distance from the RMP such that they impact more heavily on the larger tides.

APPENDIX XIII
MICROBIOLOGICAL DATA: BACTERIOLOGICAL SURVEY

A bacteriological survey was undertaken to identify spatial variation in levels of *E. coli* in Pacific oysters from Reculver to Ledge Point, and to accrue results which could be used for provisional classification of the area. After undertaking an initial desk-based study and a shoreline survey, the location of three potential representative monitoring points were identified. It was recommended that these points should be sampled at least 10 times at regular intervals not closer than weekly. The location of these points is shown in Figure XIII.1, and results are presented in Table XIII.1 and Figure XIII.2.

Figure XIII.1 Bacteriological survey points

Table XIII.1 Bacteriological survey results

	Ledge Point (C.g)	Minnis Bay (C.g)	Reculver (C.g)
	TR 3230 7060	TR 2716 6952	TR 2275 6942
21/02/2011	130	20	130
07/03/2011	80	110	230
22/03/2011	330	130	230
04/04/2011	400	330	330
11/04/2011	50	2400	20
18/04/2011	170	700	1300
03/05/2011	80	170	70
09/05/2011	70	330	170
15/05/2011	-	-	50
16/05/2011	230	50	-
23/05/2011	1300	50	80
Geometric mean	169	172	140
Maximum	1300	2400	1300

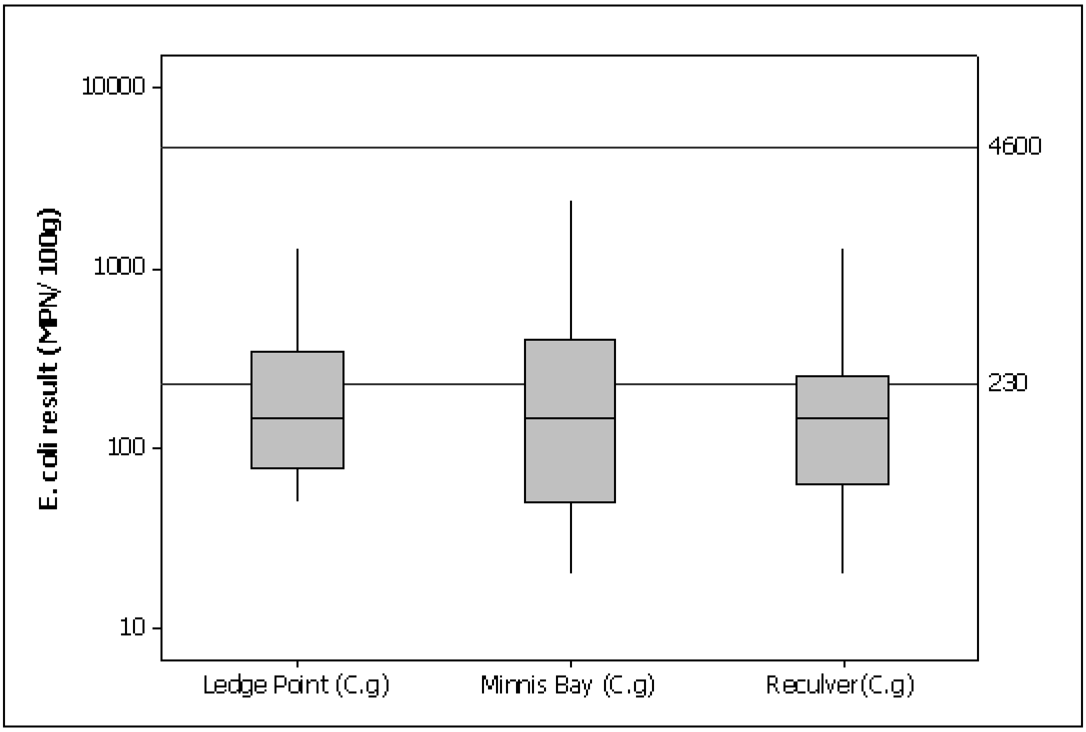

Figure XIII.2 Boxplot of results by site

Results were very similar from all three sites, with no significant difference between mean result by site (2-way ANOVA, p=0.965). On this basis, any of the three RMPs may are likely to adequately reflect levels of *E. coli* along this stretch. Minnis Bay had the highest overall result, highest mean result and highest proportion of results over 230 *E. coli* MPN/100g, and is central to the stretch. Therefore, there is a slight preference for Minnis Bay to be adopted as the best representative RMP, although the locations of sources of contamination and circulation patterns should also be taken into account. Results of paired samples were not however correlated on a sample by sample basis (Pearsons correlation, p>0.2 in all cases).

APPENDIX XIII
SHORELINE SURVEY

Date (time): 9 December 2010 (07:00-11:30 GMT)
5 January 2011 (07:30-14:00 GMT)
6 January 2011 (07:30-12:00 GMT)

Applicant: Canterbury City Council

Cefas Officers: Simon Kershaw (9 December 2010 only), Alastair Cook

Local Enforcement Authority Officers:
Sarah Maloney (Canterbury City Council),
Mark Rodford (Thanet Council, 9 December 2010 only).

Industry: Mr John Gilson, Cardium Shellfish, South Quay, Whitstable Harbour (07:00-07:30 only 9 January)

Area surveyed: North Kent Coast (Graveney Marshes to Margate)

Weather: 9 December 2010 - Wind WNW 7-8 km/h, 1.8 °C, Sunny
5 January 2011 – Wind S 11km/h, 3.5 °C, Overcast
6 January 2011 – Wind N 4km/h, 5 °C, Rain

Tidal predictions (Herne Bay):

Admiralty TotalTide - 0104 Herne Bay 51°23'N 1°07'E England. Times GMT+0000. Predicted heights are in metres above chart datum. MHWS 5.4m, MLWS 0.5m.

9/12/2010		5/1/2011		6/1/2011	
High 02:03	5.1m	High 00:35	5.1m	High 01:14	5.1m
Low 08:31	0.7m	Low 06:59	0.7m	Low 07:41	0.7m
High 14:36	5.1m	High 13:05	5.2m	High 13:45	5.2m
Low 20:31	1.2m	Low 19:03	1.1m	Low 19:40	1.1m

Tidal curves predicted tides and observed tides recorded the Herne Bay Etrometa step tide gauge location 51° 22.9191' N 001° 06.9335' E. Approximate water depth, 0.5m CD are shown below.

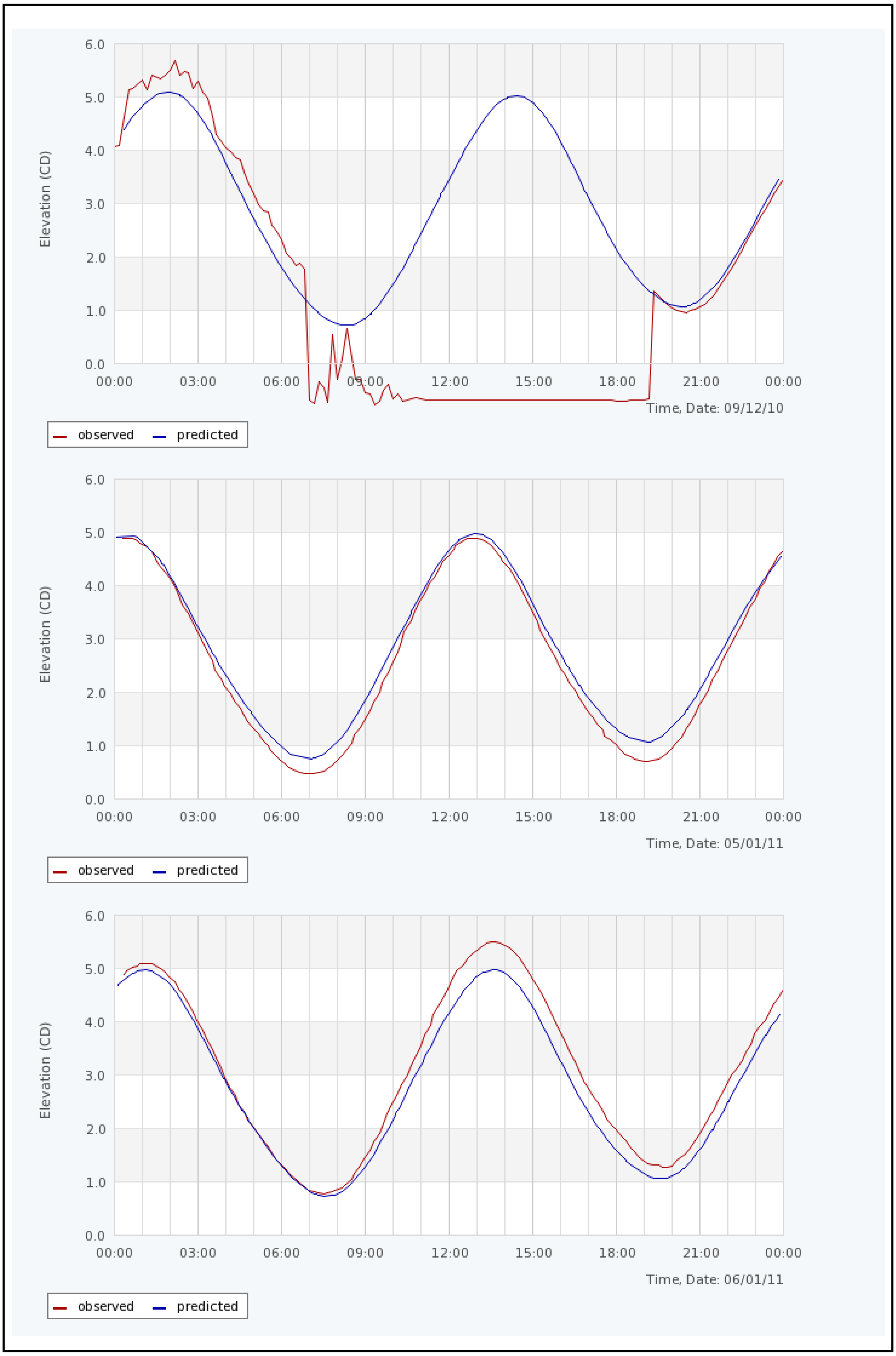

Figure XIII.1. Observed and predicted tides for Herne Bay, North Kent coast during the shoreline survey
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Date	rainfall (mm)
03/12/2010	0.5
04/12/2010	14
05/12/2010	0
06/12/2010	0
07/12/2010	0
08/12/2010	0.3
09/12/2010	0
30/12/2010	0.3
31/12/2010	0
01/01/2011	0.5
02/01/2011	0
03/01/2011	0
04/01/2011	0.8
05/01/2011	0.3
06/01/2011	15.2

Table XIII.1. Rainfall recorded at Margate, Broadstairs before and during the shoreline surveys

Objectives:

This sanitary survey was initiated by Canterbury Council in order to obtain classification for wild Pacific oyster stocks between Reculver and Nayland Rock, and also to rationalise the existing classification monitoring arrangements for the entire north Kent coast.

The shoreline survey aims to; (a) establish the geographical extent of the fisheries and its *modus operandus*; (b) obtain samples of shellfish, seawater and freshwater inputs to the area for bacteriological testing; (c) identify any additional sources of contamination in the area and; (d) initiate a bacteriological survey for Pacific oysters from Reculver to Nayland Rock.

A full list of recorded observations is presented in Table XIII.;2 and the locations of these observations are mapped in Figures XIII.2-4. Photographs referenced in Table XIII.2 are presented in Figures XIII.8-31.

Description of Fishery

A full shellfish stock survey was beyond the scope of the shoreline survey, and this report only presents observations made during the survey. Wild stocks of Pacific oysters, cockles, mussels and various clam species are present along this stretch of coast.

Pacific oysters were observed settled on any suitable hard substrate such as chalk reefs, rocks and sea defences towards the low water mark, in some places at a relatively high density (e.g. circa 10 animals per m^2 on the chalk reef in Epple Bay). The harvester indicated that these stocks are also present on patches of gravel substrates suitable for dredging lower down this shoreline, and in the sub-littoral. He has identified a market for these oysters where they would be sent to France for long term relaying, which would make the fishery viable even under a C classification. The area of interest for exploitation in this manner was initially described as from Reculver to Ledge Point, but an annotated chart received from the harvester post survey (13th Jan 2011) indicated that the exploitable area should extend a further 2km east, to the Nayland Rock. Specific areas of high densities identified by the harvester were off from the Minnis Bay outfall and just off Epple Bay, but there are likely to be further exploitable patches of this species along the entire North Kent Coast. Subsequent checks by Thanet Council revealed an absence of intertidal stock to the east of Nayland Rock. Pacific oysters are also exploited by casual gatherers along the entire North Kent coast. Identifying suitable Pacific oyster monitoring points for this stretch may be problematic as intertidal stocks are limited and patchy, generally confined to suitable hard substrates so any individual point may be rapidly depleted with repeated sampling. Given the amount of human activity along this shore, bagged shellfish are unlikely to be left unmolested in the intertidal zone, so their use at monitoring points is probably not practical.

There is a shellfish hatchery at Reculver (Seasalter Shellfish) which produces significant amounts of Pacific oyster seed, as well as native oysters, various species of clams and other bivalve species to order. This company also owns the Pollard Ground off Whitstable, and another area off the Isle of Sheppey known as the Ham Ground, which lies outside the area considered in this survey. At the Pollard Ground there are two large areas of trestles which are used for growing seed from the hatchery to a larger size before they are sold on as larger seed for ongrowing. At present this trestle site is not in production due to an outbreak of Oyster Herpes Virus (OHV). There is another, much smaller Pacific oyster trestle site at Whitstable (Whitstable Oyster Company) on another stretch of privately owned foreshore. Here Pacific oysters are ongrown to market size to supply a few local restaurants. The Whitstable Oyster Company also have a shellfish purification and despatch centre at Whitstable Harbour.

There are also some limited stocks of native oysters in the area but no confirmed sightings of this species were made during the shoreline survey. These are mainly present in deeper water and are dredged in season.

Most mussel stocks observed were undersize stocks on small beds on isolated patches. They are sometimes dredged and relaid for ongrowing. Some larger animals were observed on rocks. A large quantity seed mussels have been relaid at Lower Pollard Spit (part of the Seasalter Shellfish private grounds) by Cardium shellfish where they are currently being ongrown.

Extensive cockle beds are present throughout the survey area within sandy substrates. These are mainly exploited by dredging.

Various species of wild clams are present in places throughout the survey area, and although there is not currently a commercial fishery for these species they are subject to some casual gathering. Attempts to culture Manila clams by ongrowing them under netting within the Pollard Ground met with high mortalities, and although efforts continue, the culture of this species here is yet to be fully established here on a commercial scale.

Sources of contamination

Sewage discharges

Two major sewage treatment works were observed during the survey. The first was located at Swalecliffe (Swalecliffe STW), incorporates UV treatment, and discharges offshore (observation 62). The second was at Sweech Bridge (Herne Bay STW, observation 63). It is believed that this works discharges in part to the marshes behind Reculver, and so any contamination from here would be carried to coastal waters through the Hogwell Sewer to the surface water outfall by the church at Reculver (observation 7), and possibly via other freshwater outfalls draining these marshes between Reculver and Birchington. Both these works will also have emergency / overflow discharges.

In addition to any intermittent discharges direct from the two sewage works, other intermittent sewage discharges were noted as follows (from east to west):

- Seaview Terrace, Margate (observation 1), where a semi-buried pipe was seen running across the beach. Cefas records indicate that there are a further two intermittent overflow discharges from the western end of Margate, one at St Mildreds Bay circa 1.6km to the west of Seaview Terrace, and one at The Bay, about 800m to the east. The location of these was not confirmed during the shoreline survey as at the time it was thought that classification was only required as far east as Ledge Point.
- Kings Hall Pumping Station (Herne Bay, observation 79), where inspection covers on the promenade suggested there was an outfall to sea.
- Hampton pier, where inspection covers were seen in the sea defences and a red marker buoy was observed offshore (observation 85). Running water was heard under these covers, and rainfall in the hours preceding this observation had been significant.
- At the west end of Tankerton Beach, two inspection hatches were seen next to the promenade possibly indicating a pipeline to sea, but no other obvious signs of an outfall were seen either further back or offshore (observations 56 and 57).
- The Gorral Tank Overflow (observation 55), with a red marker buoy a few hundred meters offshore.
- Within Whitstable Harbour there is an outfall from the Whitstable Oyster Company depuration plant, but only discharges waste seawater from the depuration tanks (not seen).
- A Southern Water pumping station at Seasalter (observation 46), although no evidence of a sea outfall was seen.

Sanitary related debris was present in varying amounts within the high water strand line all along the North Kent coast. In some areas it was in the form of old cotton buds which may have been of distant origin, whereas in other places (Reculver, Whitstable, Herne Bay Harbour) it appeared to be of more recent origin and was also observed lower down the shore. The location of this debris will be dependent on circulation and settlement patterns as well as the location of discharges, but it nevertheless suggests that spills of untreated sewage had occurred relatively recently somewhere along this stretch of coast.

Freshwater inputs

The majority of North Kent aside from the immediate coastal strip and the Marshes between Reculver and Minnis Bay falls within the Stour catchment, which discharges to the east Kent coast. A number of relatively small streams and surface water outfalls were observed during the survey, and where possible these were sampled and measured to obtain estimates of their bacterial loading. The results of these are shown in Figure 5 and Table 4. These identified that the most significant freshwater inputs were in the vicinity of Reculver and at Hampton, and possibly at Minnis Bay, although no samples and measurements were obtained from the two outfalls here. Weather conditions varied during the course of this survey, with heavy rain on the 6th January, when the stretch from Reculver to Swalecliffe was surveyed, so measured loadings from inputs here are likely to be higher than those experienced in dry weather.

Boats and Shipping

11 fishing boats were recorded in Whitstable Harbour, and 6 small pleasure craft were recorded in Herne Bay Harbour. There is a large sailing club at Whitstable. Little was seen in the way of boat traffic, but in the summer a large number of small leisure craft use the area (small sailing dinghys, jetskis etc) although they would not be expected to make any overboard discharges in the main.

Livestock

About 85 sheep were recorded on the Graveney Marshes, just to the west of Seasalter, so these would be expected to contribute to levels of contamination in watercourses draining this area. No livestock were recorded on the marshes at Reculver at the time of survey, where the fields were in use for arable farming. Dog walkers were commonly observed along the promenade, concentrated in the more urban areas, and on the beach at Minnis Bay.

Wildlife

Small aggregations of seagulls and waders were seen in various places throughout the survey so some diffuse inputs from these direct to the intertidal zone may be expected. An aggregation of about 2-300 geese was recorded on arable land in the marshes just to the east of Reculver, so some contamination from wildfowl may be expected in runoff from this area.

Water circulation patterns

Tidal diamonds on the North Kent Coast (Admiralty Totaltide) indicate that in general, tidal flows are parallel to the shore, moving in an easterly direction on the flood tide, and a westerly direction on the ebb tide. This implies that contamination originating from shoreline sources will create a region of influence either side of them on the east-west plane, with greatest impacts closest to the source, and that the north-south movement of contamination will be much more limited.

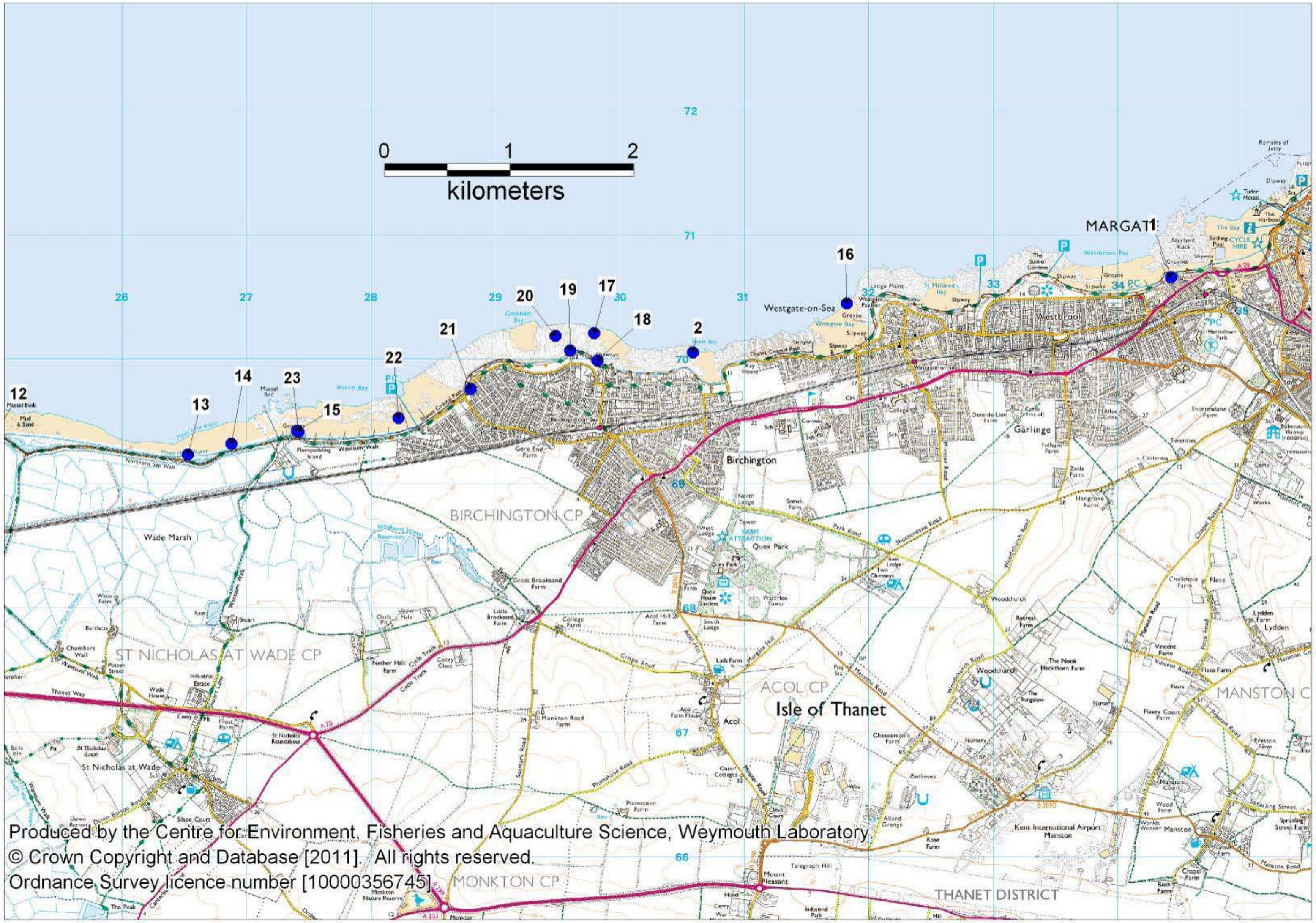

Figure XIII.2. Locations of shoreline observations for the eastern end of the North Kent coast (see Table 2 for details)

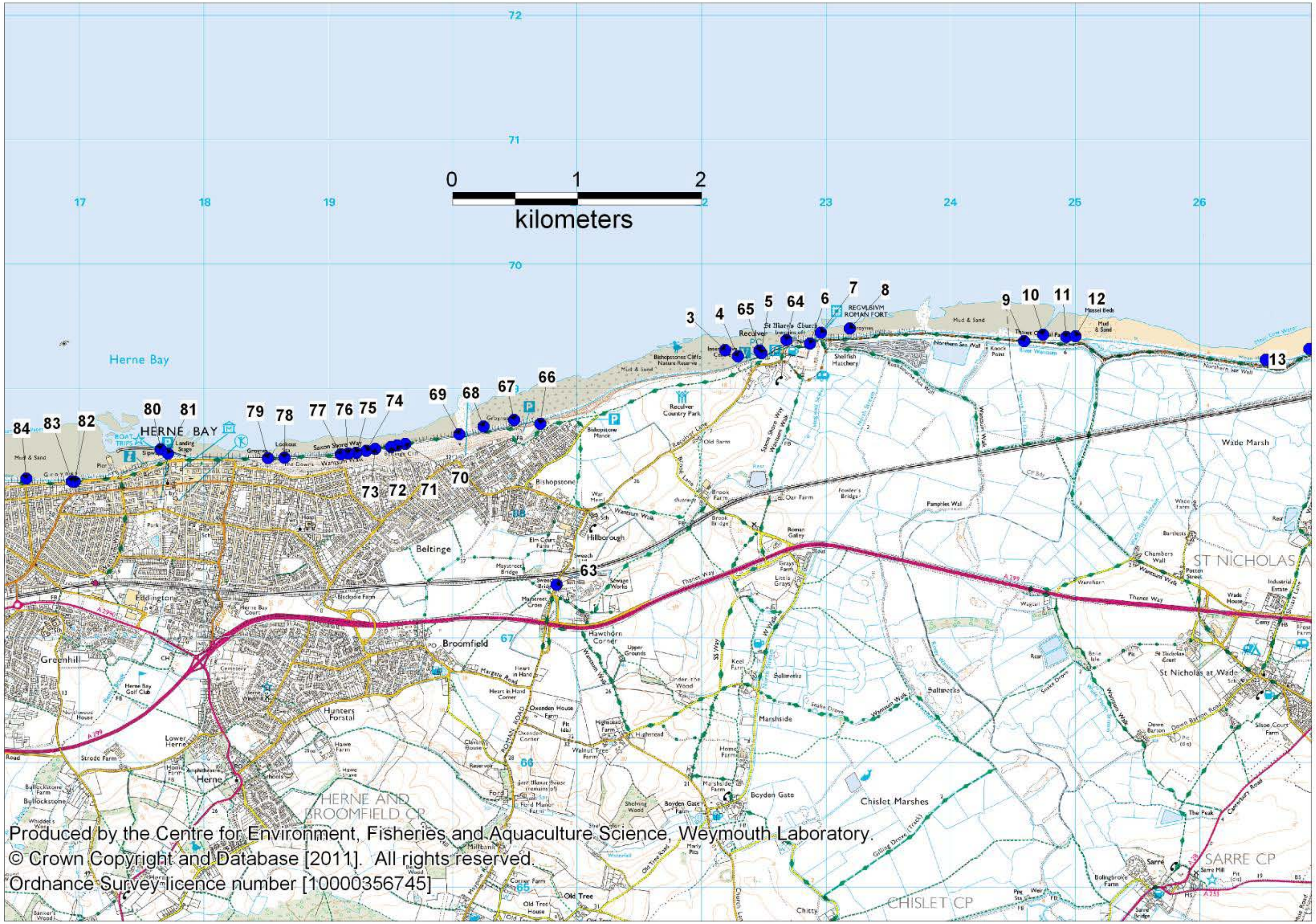

Figure XIII.3. Locations of shoreline observations for the central part of the North Kent coast (see Table 2 for details)

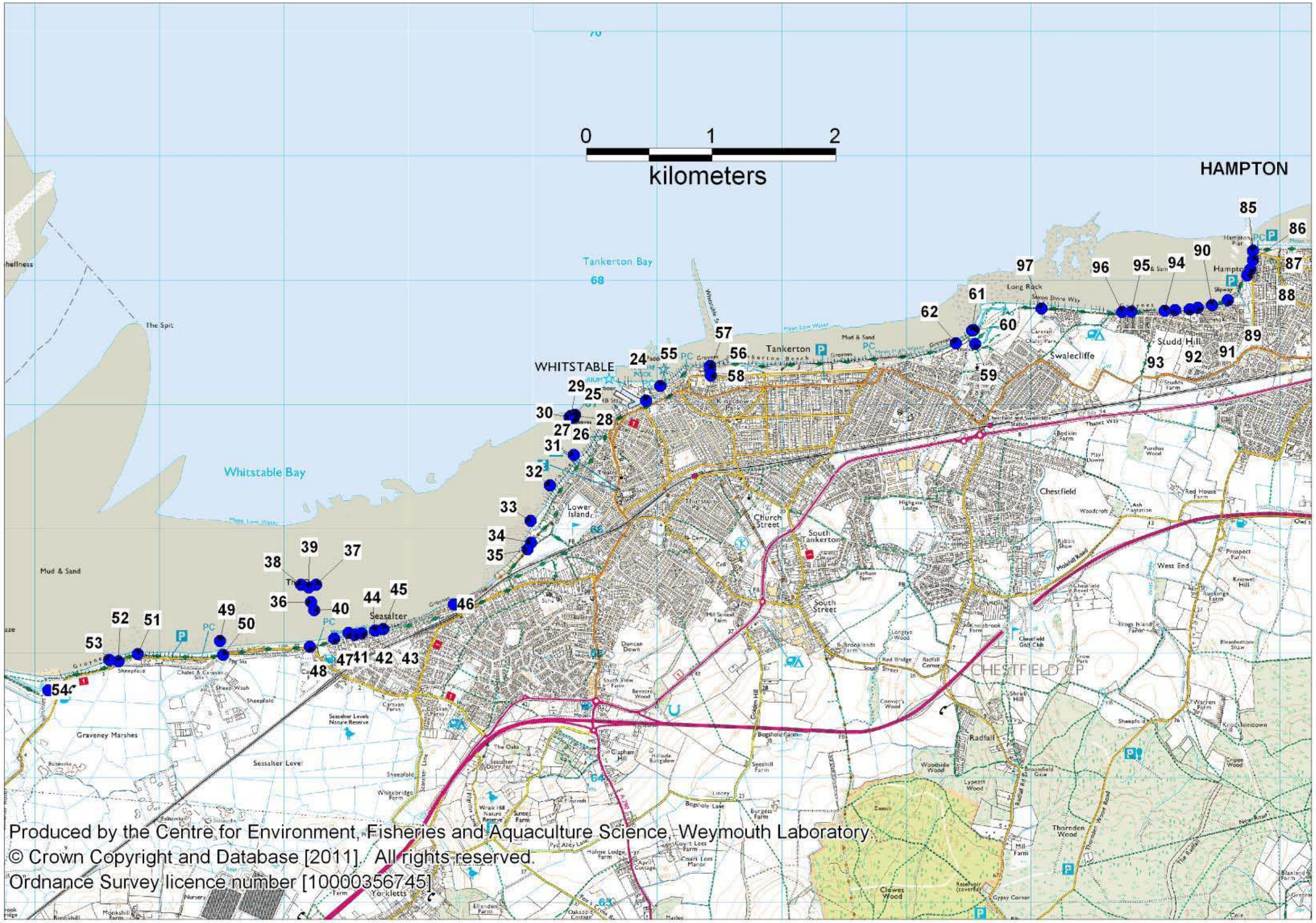

Figure XIII.4. Locations of shoreline observations for the western end of the North Kent coast (see Table 2 for details)

Table XIII.2. Details of shoreline observations

No.	Date and time	Position	Photograph	Details
1	08-DEC-10 16:28	TR 34425 70660		Southern Water enclosure, pipe running into beach (Seaview Terrace CSO)
2	09-DEC-10 07:10	TR 30586 70057	Figure XIII.8	Pacific oysters present at ~10 animals per m^2. Intended fishing area is about 300m offshore from here. Pacific oyster sample 1.
3	09-DEC-10 08:33	TR 22187 69311		Seawater sample 1 31.8ppt.
4	09-DEC-10 08:37	TR 22289 69262		Sanitary debris
5	09-DEC-10 08:41	TR 22478 69288		Sanitary debris, about 50 seagulls
6	09-DEC-10 08:50	TR 22869 69365		Caravan Park next to hatchery
7	09-DEC-10 08:53	TR 22954 69450	Figure XIII.9	Surface water outfall 380cmx5cmx1.135m/s. Freshwater sample 2.
8	09-DEC-10 09:05	TR 23188 69484		Pacific oyster sample 2
9	09-DEC-10 09:27	TR 24587 69384	Figure XIII.10	200-300 Brent geese on arable fields behind sea defences
10	09-DEC-10 09:31	TR 24738 69434	Figure XIII.11	Surface Water outfall 550cmx25cmx0.512m/s. Freshwater sample 3. 50 seagulls.
11	09-DEC-10 09:36	TR 24925 69417		Seawater sample 4 22.2ppt.
12	09-DEC-10 09:48	TR 25001 69423		Pacific oyster sample 3.
13	09-DEC-10 10:12	TR 26528 69235		30 oystercatchers
14	09-DEC-10 10:17	TR 26877 69321	Figure XIII.12	Surface water outfall, covered by tide so not possible to measure. Seawater sample 5 24.6ppt. Cotton buds
15	09-DEC-10 10:37	TR 27406 69428		Pacific oyster sample 4.
16	09-DEC-10 07:50	TR 31820 70450		Pacific oyster sample 5. Seawater sample 6.
17	09-DEC-10 08:50	TR 29790 70210		Pacific oyster sample 6. Seawater sample 7. Sewage related debris.
18	09-DEC-10 09:05	TR 29820 69990		Blocked off outfall.
19	09-DEC-10 09:21	TR 29600 70070		Mussels on rocks. No outfalls evident within this bay.
20	09-DEC-10 09:35	TR 29480 70190		Few mussels and Pacific oysters present here.
21	09-DEC-10 09:47	TR 28800 69760		Area of formerly high mussel densities now denuded. No Pacific oysters at this point in east Minnis Bay
22	09-DEC-10 10:24	TR 28220 69530		Seawater sample 8
23	09-DEC-10 10:43	TR 27417 69416	Figure XIII.13	Minnis Bay outfall buoy visible to the west. 6 dogs on beach.
24	05-JAN-11 07:42	TR 10906 67034		Whitstable Harbour. 11 fishing boats. Gorral outfall, depuration plant outfall, and another surface water outfall discharge to this harbour but none was seen.
25	05-JAN-11 07:52	TR 10337 66917	Figure XIII.14	Corner of Whitstable Oyster Company trestles. Pacific oyster sample 7.
26	05-JAN-11 07:52	TR 10323 66892		Corner of trestles
27	05-JAN-11 07:52	TR 10319 66893		Corner of trestles
28	05-JAN-11 07:53	TR 10328 66912		Corner of trestles
29	05-JAN-11 07:59	TR 10300 66909		Corner of trestles
30	05-JAN-11 07:59	TR 10293 66900		Corner of trestles

No.	Date and time	Position	Photograph	Details
31	05-JAN-11 08:03	TR 10326 66597	Figure XIII.15	Neptune outfall. Canterbury Council drainage engineers indicate that this may be opened if required.
32	05-JAN-11 08:09	TR 10135 66352	Figure XIII.16	Surface water outfall 135x1cmx0.076m/s. Freshwater sample 9. Canterbury Council drainage engineers indicate that this may be opened if required, although a small amount was flowing at the time of survey. Pacific oyster sample 8 from spillway.
33	05-JAN-11 08:24	TR 09978 66066	Figure XIII.17	Surface water outfall (West Beach Caravan Park) 20x1cmx0.357m/s. Freshwater sample 10
34	05-JAN-11 08:32	TR 09983 65888		Caravan park
35	05-JAN-11 08:34	TR 09953 65837		Public toilets
36	05-JAN-11 09:15	TR 08216 65411		Sanitary debris
37	05-JAN-11 09:17	TR 08257 65552	Figure XIII.18	Inner corner of Seasalter trestles
38	05-JAN-11 09:22	TR 08134 65550		Inner corner of trestles
39	05-JAN-11 09:25	TR 08197 65531		Pacific oyster sample 9
40	05-JAN-11 09:29	TR 08242 65347		Sanitary debris
41	05-JAN-11 09:39	TR 08518 65163	Figure XIII.19	20cm cast iron surface water drain, dripping, no smell
42	05-JAN-11 09:41	TR 08567 65149		20cm cast iron surface water drain, not flowing
43	05-JAN-11 09:43	TR 08622 65162		20cm cast iron surface water drain, not flowing
44	05-JAN-11 09:45	TR 08729 65182		20cm cast iron surface water drain, not flowing
45	05-JAN-11 09:46	TR 08794 65196		20cm cast iron surface water drain, not flowing
46	05-JAN-11 09:55	TR 09361 65393	Figure XIII.20	Southern Water pumping station, no outfall visible.
47	05-JAN-11 10:12	TR 08403 65117		Aggregation of about 100 small waders and 30 seagulls
48	05-JAN-11 10:15	TR 08206 65052		caravan park
49	05-JAN-11 10:21	TR 07486 65100	Figure XIII.21	2 surface water outfalls alongside each other. Larges one blocked but flowing, smaller one not blocked with minimal flow. 50cmx2cmx0.502m/s and 30cmx4cmx0.138m/s. Freshwater sample 11
50	05-JAN-11 10:32	TR 07510 64989		Seasalter pumping station
51	05-JAN-11 10:37	TR 06826 64994		85 sheep in fields
52	05-JAN-11 10:40	TR 06671 64935		Old cess pit
53	05-JAN-11 10:43	TR 06594 64948	Figure XIII.22	Old surface outfall (blocked)
54	05-JAN-11 11:10	TR 06107 64702	Figure XIII.23	Possible septic tank, presumed to soakaway
55	05-JAN-11 11:34	TR 11021 67150	Figure XIII.24	Concrete installation (Gorral tank), red marker buoy offshore
56	05-JAN-11 11:43	TR 11420 67312	Figure XIII.25	Inspection cover
57	05-JAN-11 11:46	TR 11420 67287		Inspection cover
58	05-JAN-11 11:48	TR 11426 67235		Small enclosure, likely to be electricity
59	05-JAN-11 12:03	TR 13549 67487		200 gulls
60	05-JAN-11 12:06	TR 13535 67600	Figure XIII.26	Stream 105x12cmx0.393m/s. Water sample 12. Cotton buds on beach
61	05-JAN-11 12:11	TR 13523 67598		Oyster sample 10

No.	Date and time	Position	Photograph	Details
62	05-JAN-11 12:17	TR 13393 67495		Large STW (has UV treatment, and LEA notified in event of UV failure)
63	05-JAN-11 13:17	TR 20831 67427		Sweech Bridge STW. Some effluent returned to Stour, some goes into drain then out via the outfall at Reculver, at the caravan park by the church
64	06-JAN-11 08:01	TR 22679 69391		Sanitary debris
65	06-JAN-11 08:04	TR 22463 69307		Sanitary debris
66	06-JAN-11 08:34	TR 20702 68721	Figure XIII.27	Stream 55cmx24cmx0.381m/s. Freshwater sample 13. Many cotton buds trapped here.
67	06-JAN-11 08:52	TR 20491 68749		Pacific oyster sample 11 taken between WP 45 and 46 (very few oysters present here)
68	06-JAN-11 09:07	TR 20245 68698		Pacific oyster sample 11 taken between WP 45 and 46 (very few oysters present here)
69	06-JAN-11 09:14	TR 20051 68635		Sanitary debris. 2 x 15cm diameter cast iron surface water pipes (not flowing)
70	06-JAN-11 09:22	TR 19617 68558		15 cm diameter cast iron surface water pipe, not flowing.
71	06-JAN-11 09:23	TR 19552 68547		15cm cast iron surface water pipe, flowing ~250ml/sec. Freshwater sample 14.
72	06-JAN-11 09:28	TR 19503 68532		2 inspection covers behind wall
73	06-JAN-11 09:35	TR 19376 68518		15 cm diameter cast iron surface water pipe, not flowing.
74	06-JAN-11 09:37	TR 19304 68503		15 cm diameter cast iron surface water pipe, not flowing.
75	06-JAN-11 09:38	TR 19224 68486		15 cm diameter cast iron surface water pipe, not flowing.
76	06-JAN-11 09:39	TR 19158 68482		15 cm diameter cast iron surface water pipe, not flowing.
77	06-JAN-11 09:40	TR 19099 68476		15 cm diameter cast iron surface water pipe, not flowing.
78	06-JAN-11 09:47	TR 18647 68447		Sound of running water under inspection cover
79	06-JAN-11 09:50	TR 18514 68445	Figure XIII.28	Southern Water pumping station. Large vents on to with sewage smell. Inspection covers on seawall. Probably a discharge pipe runs out to sea from here.
80	06-JAN-11 10:12	TR 17654 68515		Harbour. 6 small boats. Sewage smell and fresh sanitary debris. Seawater sample 15.
81	06-JAN-11 10:17	TR 17711 68481		Unlabelled enclosure. Possible pumping station.
82	06-JAN-11 10:33	TR 16961 68256		Inspection covers on beach
83	06-JAN-11 10:34	TR 16941 68257		15 cm diameter cast iron surface water pipe, not flowing.
84	06-JAN-11 10:41	TR 16573 68278	Figure XIII.29	Surface water outfall (2 pipes side by side). 25cmx3cmx0.858m/s and 20cmx2cmx0.721m/s. Freshwater sample 16 (mixture of the two flows).

No.	Date and time	Position	Photograph	Details
85	06-JAN-11 11:01	TR 15779 68238	Figure XIII.30	Inspection hatch in sea defences. Sound of running water. Red buoy offshore from here.
86	06-JAN-11 11:03	TR 15779 68163		Aggregation of ~100 waders on sea defences
87	06-JAN-11 11:06	TR 15733 68041	Figure XIII.31	Surface water outfall 210cmx15cmx0.806m/s. Freshwater sample 17
88	06-JAN-11 11:14	TR 15758 68090		Pacific oyster sample 12
89	06-JAN-11 11:22	TR 15577 67843		15 cm diameter cast iron surface water pipe, not flowing.
90	06-JAN-11 11:24	TR 15451 67801		15 cm diameter cast iron surface water pipe, not flowing.
91	06-JAN-11 11:25	TR 15338 67779		15 cm diameter cast iron surface water pipe, not flowing.
92	06-JAN-11 11:26	TR 15273 67768		15 cm diameter cast iron surface water pipe, not flowing.
93	06-JAN-11 11:28	TR 15155 67761		15 cm diameter cast iron surface water pipe, not flowing.
94	06-JAN-11 11:29	TR 15069 67755		15 cm diameter cast iron surface water pipe, not flowing.
95	06-JAN-11 11:32	TR 14805 67747		15 cm diameter cast iron surface water pipe, not flowing.
96	06-JAN-11 11:33	TR 14728 67746		15 cm diameter cast iron surface water pipe, not flowing.
97	06-JAN-11 11:42	TR 14081 67774		Small stream running through caravan park. Outfall covered by tide and not possible to access the stream to take samples and measurements.

Sample results

A total of 12 Pacific oyster samples were taken during the survey (Table XIII.3 and Figure XIII.5). None of the results exceeded 4600 *E. coli* MPN/100g, and all but one contained <1000 *E. coli* MPN/100g, indicating that in general levels of contamination in shellfish within the intertidal zone of this coastline are fairly low. One sample contained 3500 *E. coli* MPN/100g, and was taken in close proximity to a significant freshwater input at Hampton suggesting there was a 'hotspot' of contamination within this small bay at the time of survey.

Table XIII.3 Pacific oyster sample **E. coli** *results*

No.	Date & time	Position	*E. coli* (MPN/100g)
1	09-DEC-10 07:10	TR 30586 70057	490
2	09-DEC-10 09:05	TR 23188 69484	230
3	09-DEC-10 09:48	TR 25001 69423	490
4	09-DEC-10 10:37	TR 27406 69428	790
5	09-DEC-10 07:50	TR 31820 70450	110
6	09-DEC-10 08:50	TR 29790 70210	220
7	05-JAN-11 07:52	TR 10337 66917	80
8	05-JAN-11 08:09	TR 10135 66352	70
9	05-JAN-11 09:25	TR 08197 65531	330
10	05-JAN-11 12:11	TR 13523 67598	130
11	06-JAN-11 08:52	TR 20491 68749	80
12	06-JAN-11 11:14	TR 15758 68090	3500

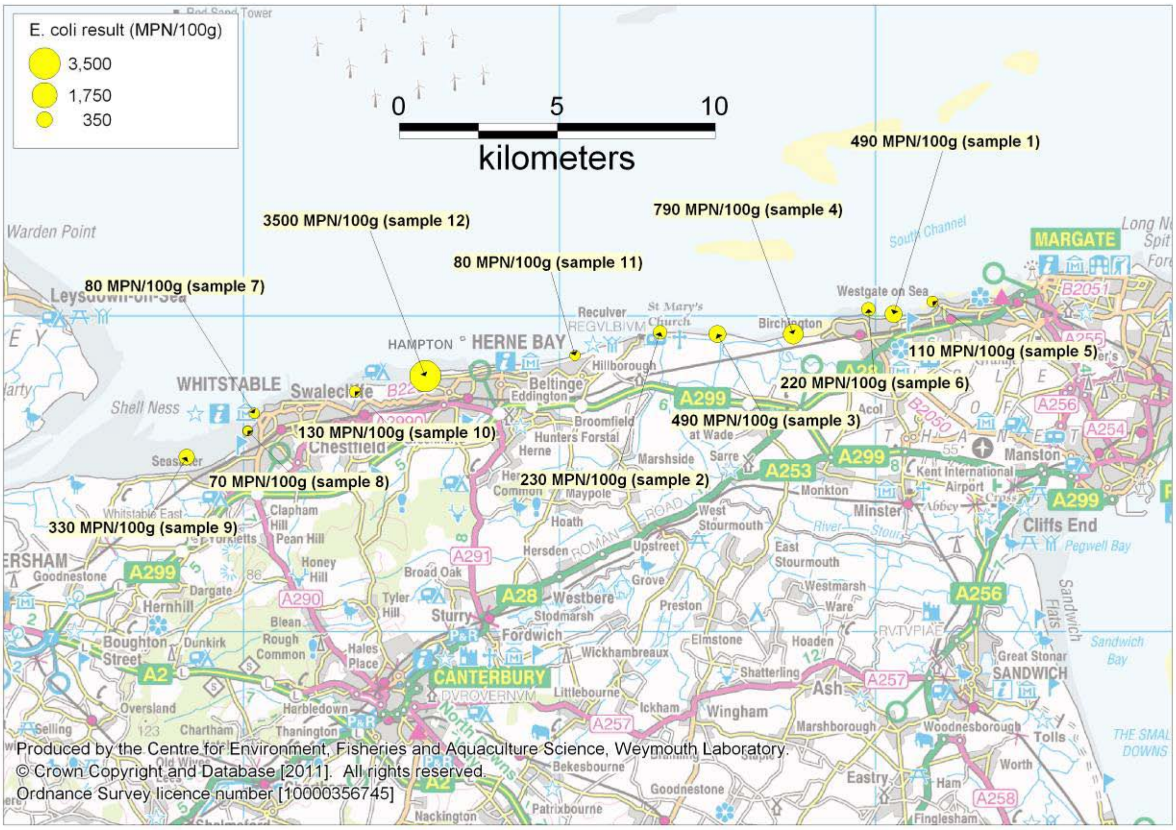

Figure XIII.5 Pacific oyster sample results

Some seawater samples were taken, and where possible any freshwater inputs were sampled and spot discharge measurements taken, to give spot estimates of their *E. coli* loadings (Table XIII.4 and Figure XIII.6).

Table 3. Water sample* E. coli *results

No.	Description	Position	Type	*E. coli* (cfu/100ml)	Salinity (ppt)	*E. coli* (cfu/ day)*
1	09-DEC-10 08:33	TR 22187 69311	Seawater	310	31.8	
2	09-DEC-10 08:53	TR 22954 69450	Surface water outfall (sluice from marshes)	2200		4.1×10^{11}
3	09-DEC-10 09:31	TR 24738 69434	Surface water outfall (sluice from marshes)	410		2.5×10^{11}
4	09-DEC-10 09:36	TR 24925 69417	Seawater	270	22.2	
5	09-DEC-10 10:17	TR 26877 69321	Seawater	210	24.6	
6	09-DEC-10 07:50	TR 31820 40450	Seawater	57		
7	09-DEC-10 08:50	TR 29790 70210	Seawater	150		
8	09-DEC-10 10:24	TR 28220 69530	Seawater	100		
9	05-JAN-11 08:09	TR 10135 66352	Surface water outfall pipe	140		1.2×10^{8}
10	05-JAN-11 08:24	TR 09978 66066	Surface water outfall pipe	5		3.1×10^{6}
11	05-JAN-11 10:21	TR 07486 65100	Surface water outfall (partially blocked off sluice)	37		1.6×10^{8}
12	05-JAN-11 12:06	TR 13535 67600	Engineered stream (via sluice)	330		1.4×10^{10}
13	06-JAN-11 08:34	TR 20702 68721	Stream (Bishopstone Glen)	6700		2.9×10^{11}
14	06-JAN-11 09:23	TR 19552 68547	Cast iron surface drainage pipe	35000		7.6×10^{9}
15	06-JAN-11 10:12	TR 17654 68515	Seawater	110	30.2	
16	06-JAN-11 10:41	TR 16573 68278	Surface water outfall pipes	4400		3.5×10^{10}
17	06-JAN-11 11:06	TR 15733 68041	Engineered stream (via sluice)	7000		1.5×10^{12}

*Number of *E. coli* cfus carried into coastal water per day by each freshwater input, as calculated from a spot gauging of discharge and the *E. coli* result from a sample of the water taken at the same time.

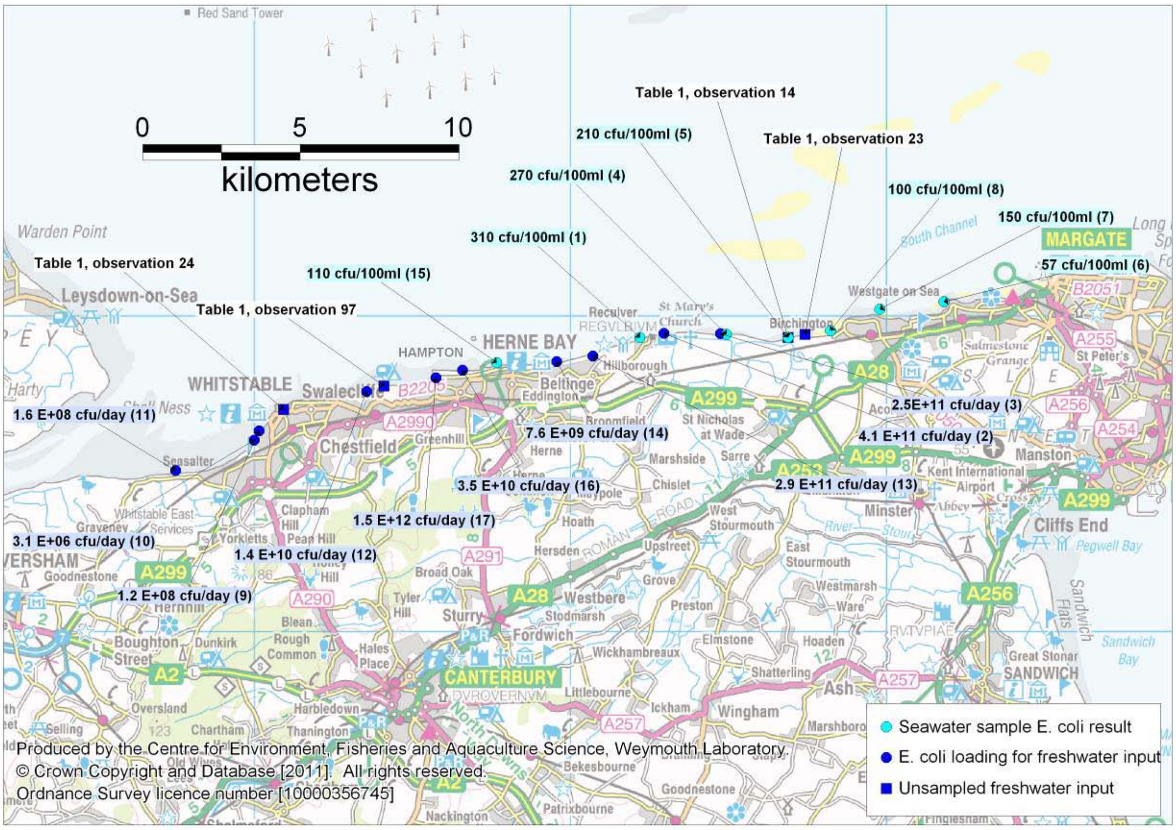

Figure XIII.6. Seawater sample results and calculated loadings of freshwater inputs

Seawater samples indicated moderate levels of contamination throughout this stretch of coast, but no particular hotspots with high levels of *E. coli* were found. These results gave the tentative impression of higher levels of contamination around Reculver.

The highest *E. coli* loadings from freshwater inputs were recorded at a stream discharging at Hampton (sample 17, in close proximity to the highest oyster sample result), and for the two outfalls draining the western end of the marshes at Reculver (samples 2 and 3) and for the Bishopstone Glen (sample 13). It was not possible to sample the two outfalls draining the eastern end of the marshes at Minnis Bay. Freshwater samples collected on the 6th January during heavy rain generally contained higher levels of *E. coli* than those collected on the two dry survey days.

Conclusions

Classification monitoring arrangements for the entire north Kent coast require rationalisation, and this will be addressed in the full sanitary survey report. In the meantime, a bacteriological survey should be initiated for wild Pacific oysters in the Reculver to Nayland Rock stretch to assess where the RMP(s) should be set so as to be best protective of public health, and to accrue monitoring results towards a preliminary classification.

No specific hotspots or major sources of contamination such as outfalls from major sewage treatment works were identified along the Reculver to Nayland Rock stretch, and the results of shellfish and seawater samples from here did not show much geographic variation. Nevertheless, a number of sources with the potential to cause localised decreases in water quality were found. Therefore, different parts of this stretch are likely to be subject to contamination from different sources, and the impacts of these various sources will require evaluation through a bacteriological survey via repeated sampling at monitoring points set in close proximity to them. Potentially significant sources impacting on this stretch include:

- Surface water outfalls from the marshes at Reculver. There are two of these which drain the western end of the marshes, and they lie about 1.8km apart. The westerly of these will be most impacted by the Sweech Bridge STW, potentially including spills of untreated sewage at times. Therefore of these two outfalls the westerly one has the greatest potential contaminating influence, and it carried higher levels of *E. coli* even though the two are interconnected.
- There are a further two surface water outfalls at Minnis Bay, both draining the eastern half of the marshes. Ordnance Survey maps indicate that connectivity between the eastern and western ends of the marshes is limited by a dyke, so the two outfalls at Minnis Bay may be subject to different contaminating sources to those at the eastern end. These two outfalls lie about 400m apart. It was not possible to sample or measure discharge from either of these outfalls, both of which were covered by the tide, and the more easterly of these two outfalls discharges below MLWS.
- There are intermittent CSO discharges to the west end of Margate, which would be expected to have the greatest impacts in the vicinity of Nayland Rock.

Aside from these, some diffuse inputs from seabirds and possibly dog walkers may contribute to levels of contamination seen in shellfish here. Impact from seabirds would be expected along the entire stretch, whereas impacts from dog walking may be more concentrated along the urbanised eastern end of this stretch.

Recommendations for bacteriological survey

The number and location of final representative monitoring points (RMPs) will be determined by the results of the bacteriological survey and final assessment of the desk study. Where the final RMPs coincide with points monitored for the purposes of bacteriological survey, the results from these sites can be used towards classification providing they are collected and processed in accordance with the standard protocols. Preliminary classifications may be awarded following 10 samplings (from final RMPs) at intervals of at least 1 week apart.

RMPs are set in locations to be best protective of public health – i.e. in places within the area where highest levels of contamination are recorded / expected. In order to determine the location of bacteriological survey points information on the location and nature of the fishery, the locations and magnitudes of sources of contamination, sampling results from the shoreline survey, and the pattern of water circulation were taken into consideration.

Pacific oyster samples should be taken by hand from the intertidal zone from three points along the Reculver to Nayland Rock stretch to evaluate the impacts of the most significant sources. These points are listed in Table XIII.4, and are mapped on Figure XIII.7. Samples should be of stock of a harvestable size. A tolerance of 100m should be applied around these points to ensure there is sufficient stock for repeated sampling. It is believed that there is sufficient stock at all three identified sampling points. A total of 10 samples should be taken from each of these monitoring points not less than 1 week apart.

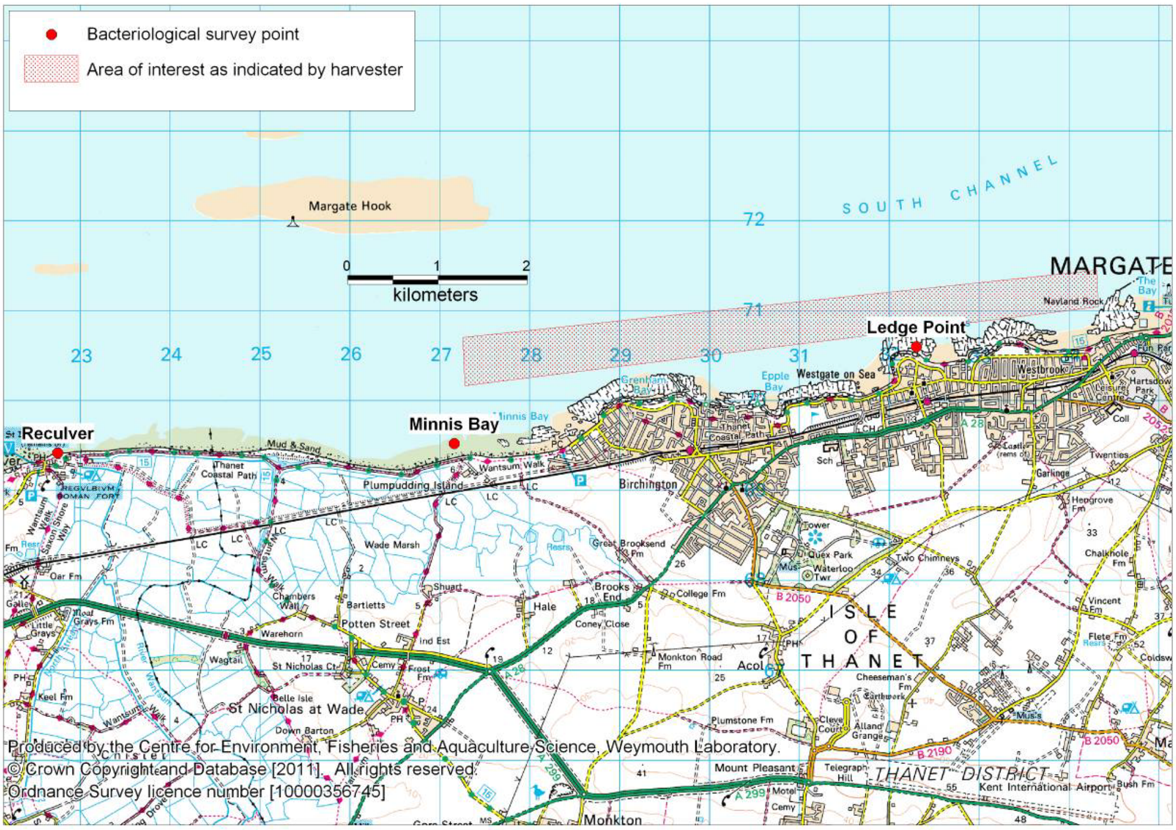

Figure XIII.7 Recommended bacteriological survey points

Table XIII.4. Recommended bacteriological survey points

Name	Grid reference	Comment
Reculver	TR 2275 6942	To capture contamination from surface outfalls draining the western end of the marshes
Minnis Bay	TR 2716 6952	To capture contamination from surface outfalls draining the eastern end of the marshes
Ledge Point	TR 3230 7060	To capture contamination potentially arising from the three CSOs at the western end of Margate. This is the furthest east where there are intertidal stocks.

Figure XIII.8 Shellfish at Epple Bay

Figure XIII.9 Surface water outfall at Reculver

Figure XIII.10 Geese on fields at Reculver Marshes

Figure XIII.11 Surface water outfall near Reculver

Figure XIII.12 Surface water outfall

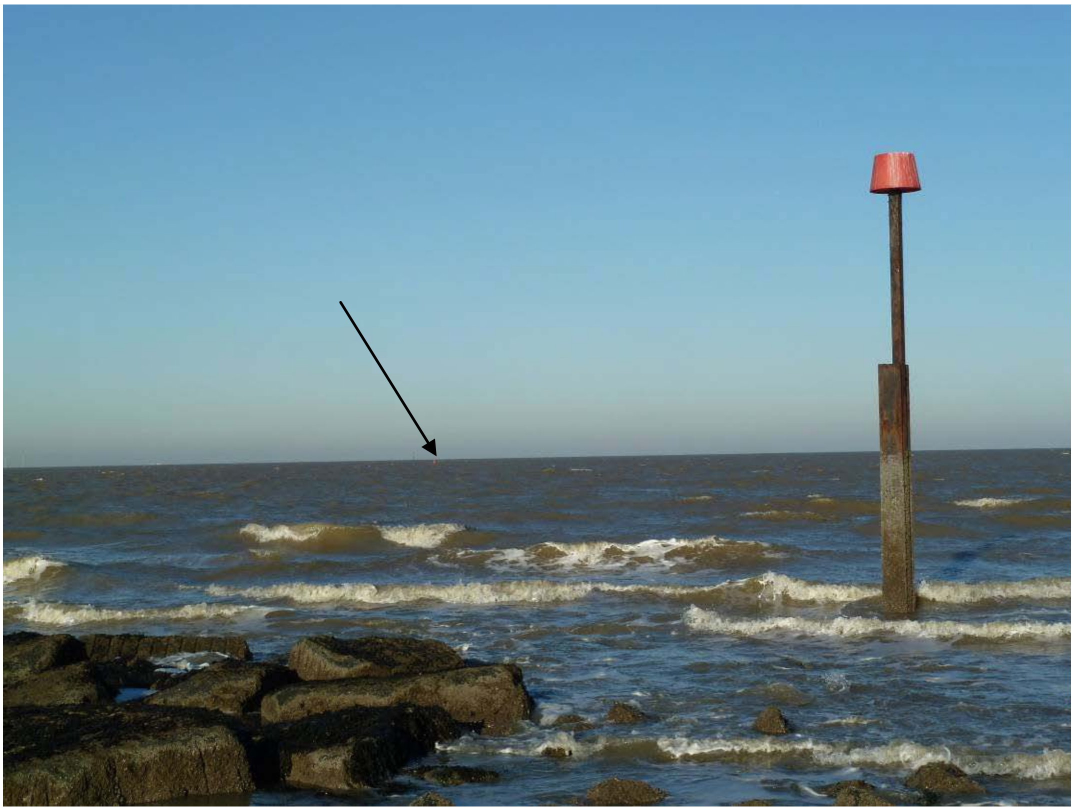

Figure XIII.13 Minnis Bay surface water outfall marker buoy in distance

Figure XIII.14 Trestles at Whitstable

Figure XIII.15 Neptune outfall

Figure XIII.16 Surface water outfall

Figure XIII.17 Surface water outfall

Figure XIII.18 Trestles at Seasalter

Figure XIII.19 Surface water outfall

Figure XIII.20 Pumping station

Figure XIII.21 Blocked surface water outfall

Figure XIII.22 Blocked surface water outfall

Figure XIII.23 Inspection covers possible associated with septic tank in caravan park

Figure XIII.24 Gorral tank

Figure XIII.25 Inspection cover

Figure XIII.26 Stream at Swalecliffe

Figure XIII.27 Bishopstone Glen

Figure XIII.28 Large pumping station

Figure XIII.29 Surface water outfalls

Figure XIII.30 Inspection cover by Hampton Pier

Figure XIII.31 Stream by Hampton pier

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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
ISO	International Organization for Standardization
K&E IFCA	Kent & Essex Inshore Fisheries Conservation Authority
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
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
SSSI	Site of Special Scientific Interest
UV	Ultraviolet
WGS84	World Geodetic System 1984

Glossary

Bathing Water	Element of surface water used for bathing by a large number of people. Bathing waters may be classed as either EC designated or non-designated OR those waters specified in section 104 of the Water Resources Act, 1991.
Bivalve mollusc	Any marine or freshwater mollusc of the class Pelecypoda (formerly Bivalvia or Lamellibranchia), having a laterally compressed body, a shell consisting of two hinged valves, and gills for respiration. The group includes clams, cockles, oysters and mussels.
Classification of bivalve mollusc production or relaying areas	Official monitoring programme to determine the microbiological contamination in classified production and relaying areas according to the requirements of Annex II, Chapter II of EC Regulation 854/2004.
Coliform	Gram negative, facultatively anaerobic rod-shaped bacteria which ferment lactose to produce acid and gas at 37°C. Members of this group normally inhabit the intestine of warm-blooded animals but may also be found in the environment (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 a skewed data such as one 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 Scatterplot Smoothing, more descriptively known as locally weighted polynomial regression. At each point of a given data set, 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 scatterplot.
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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