EC Regulation 854/2004

CLASSIFICATION OF BIVALVE MOLLUSC PRODUCTION AREAS IN ENGLAND AND WALES

SANITARY SURVEY REPORT

Langstone Harbour

2013

Cover photo: Langstone Harbour.

CONTACTS:

For enquires relating to this report or further information on the implementation of sanitary surveys in England and Wales:

Simon Kershaw/Alastair Cook
Food Safety Group
Cefas Weymouth Laboratory
Barrack Road,
The Nothe
WEYMOUTH
Dorset
DT43 8UB

☎ +44 (0) 1305 206600
✉ fsq@cefas.co.uk

For enquires relating to policy matters on the implementation of sanitary surveys in England:

Beverley Küster
Hygiene Delivery Branch
Enforcement and Delivery Division
Food Standards Agency
Aviation House
125 Kingsway
London
WC2B 6NH

☎ +44 (0) 20 7276 8000
shellfish_hygiene@foodstandards.gsi.gov

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

CONSULTATION:

Consultee	Date of consultation	Date of response
Environment Agency	24/01/2013	14/02/2013
Local Enforcement Authority	24/01/2013	14/02/2013
IFCA	24/01/2013	-
Southern Water	24/01/2013	15/02/2013

DISSEMINATION: Food Standards Agency, Portsmouth Port Health Authority, Southern IFCA, Environment Agency.

RECOMMENDED BIBLIOGRAPHIC REFERENCE: Cefas, 2013. Sanitary survey of Langstone Harbour. 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 native oysters (*Ostrea edulis*), hard clams (*Mercenaria mercenaria*) and mussels (*Mytilus* spp.) within Langstone Harbour. The area was prioritised for survey in 2012-13 by a shellfish hygiene risk ranking exercise.

1.2 AREA DESCRIPTION

Langstone Harbour is situated on the south coast of England between Portsea Island and Hayling Island; its location is shown in Figure 1.1. It covers a total area of 19 km², the majority of which is intertidal (Soulsby *et. al*, 1985). A narrow mouth in the south connects it to the Solent, and two smaller channels in the northern corners connect Langstone Harbour with Portsmouth Harbour and Chichester Harbour.

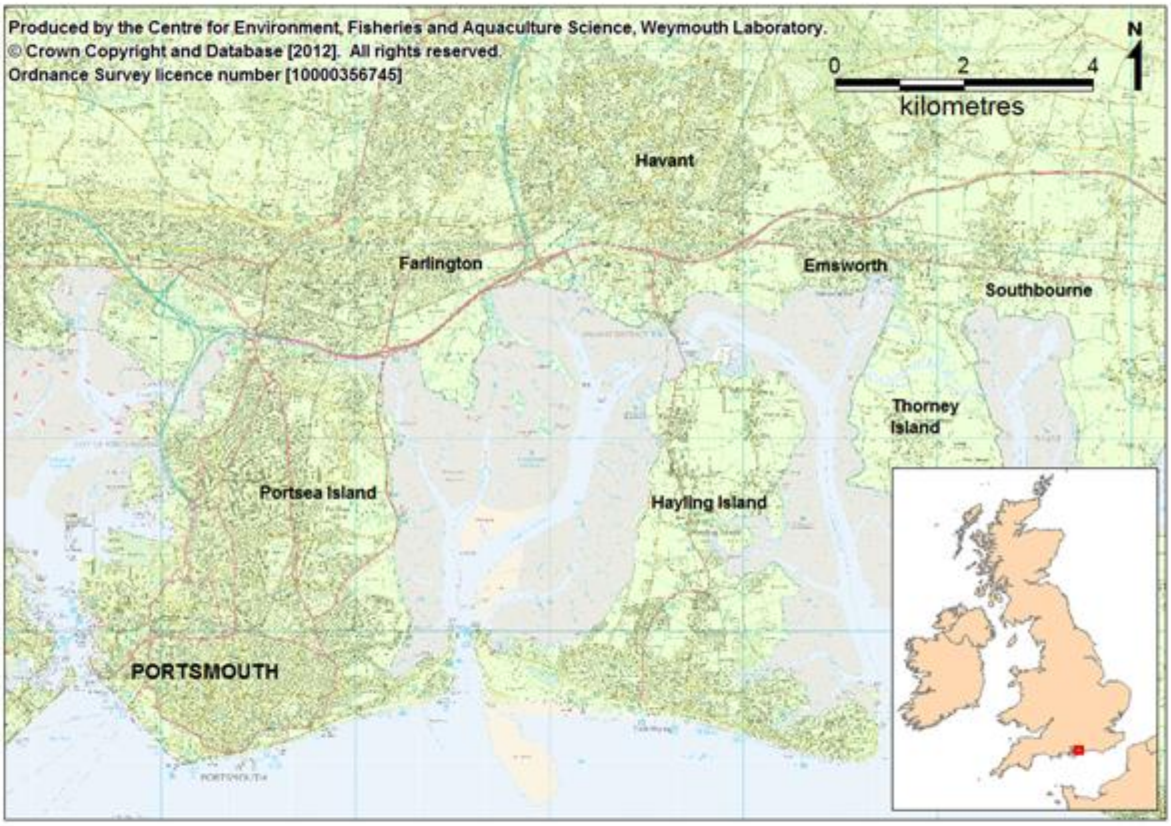


Figure 1.1. Location of Langstone Harbour

Langstone Harbour has been recognised as an important area for its habitats and wildlife. It encompasses a large area of intertidal mudflats and tidal channels. Smaller areas of *Spartina* salt marsh and grazing marsh exist in the upper tidal limits. Four rocky islands also exist in the north east, which are not inundated by the high tide. The majority of the perimeter is protected by sea wall, except for most of Hayling Island coastline which is unprotected. Langstone Harbour falls under several national and international conservation designations: SPA, SSSI, SAC, Ramsar site and SEMS as it supports large numbers of internationally and nationally important flocks of wading and migratory birds. The intertidal mudflats also sustain a large variety of bivalves and marine invertebrates; a source of food for the birds that frequent the mudflats and supporting a bivalve fishery. The harvesting of oysters from Langstone harbour has taken place since Roman times (Havant Borough Council, 2010).

Boating within Langstone Harbour is an important pastime, with many recreational activities taking place such as yachting, dinghy sailing, windsurfing and canoeing. A considerable number of commercial fishermen and charter fishing boats operate out of this sheltered harbour. The harbour is also used for commercial shipping associated with the aggregate trade.

CATCHMENT

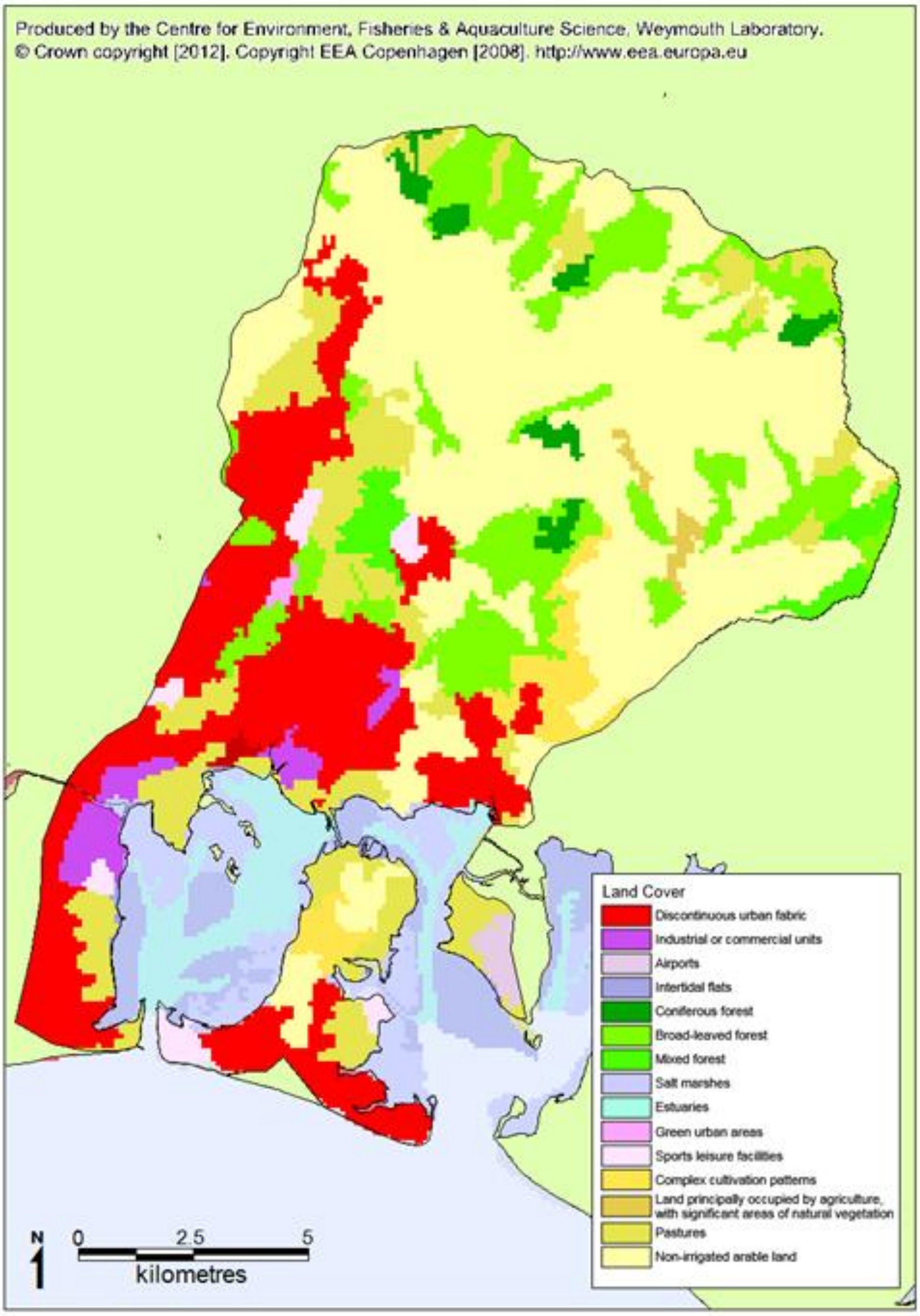


Figure 1.2 Land cover in the Langstone Harbour catchment area

Figure 1.2 illustrates land cover within the Langstone Harbour catchment area which covers an area of approximately 190km². This includes the hydrological catchment for Emsworth Channel which is likely to have some influence on Langstone Harbour due to the connection between the two water bodies. The eastern edge of the catchment includes the outskirts of the major conurbation of Portsmouth. A band of urbanised land stretches north on the eastern edge of the catchment to the towns of

Horndean and Clanfield. There is a marked division of land use between the upper and lower reaches of the catchment. The upper catchment lies within the South Downs, and is mainly arable land, with areas of woodland: coniferous, broadleaved and mixed, agricultural and cultivated land. The lower catchment is more significantly urbanised and there are a few industrial or commercial areas. The urban areas are interspersed with some pasture, arable land, woodland and sports and leisure facilities within the lower catchment. The northern division of Hayling Island is predominantly cultivated land, pasture and arable land, with the most urbanised areas being located in the south.

Different land cover types will generate differing levels of contamination in surface runoff. Highest faecal coliform contribution arises from developed areas, with intermediate contributions from the improved pastures and lower contributions from the other land 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 geology also changes markedly between the north and the south of the catchment, and this is likely to result in differing hydrological regimes. The upper reaches are underlain with chalk so there will be significant flows of groundwater here, whereas the lower reaches are underlain with bands of Reading and London clay which is much less permeable (Hampshire County Council, 2010).

2. RECOMMENDATIONS

2.1 NATIVE OYSTERS

2.1.1 Native oysters are widely distributed throughout the harbour but confined to the subtidal channels. Therefore the whole harbour requires continuing classification, although the fishery and RMP locations will be limited to within the subtidal channels.

2.1.2 It is proposed that the following five native oyster classification zones are established.

- Budds Farm. This zone is subject to several of the most significant sources of contamination including the Budds Farm overflows and three watercourses (Hermitage, Lavant and Brockhampton stream). It is also likely to be influenced by sources discharging to the northern reaches of the Emsworth Channel, such as the River Ems. In recent years the Budds Farm storm tanks have discharged storm sewage for about 16% of the time, and so represents the most significant (albeit intermittent) source in this zone and will cause acute episodes of contamination on a fairly regular basis. It is therefore recommended that the RMP is located at SU 7037 0457, where the drainage channel to which this outfall discharges meets the subtidal channel from which oysters are dredged. This location should also be reasonably effective at capturing contamination from the Hermitage and the Brockhampton streams.
- Langstone Channel. This zone is likely to be primarily influenced by the up-estuary sources influencing the Budds Farm zone. Contamination from the Fort Cumberland intermittent outfall in the harbour mouth may be an influence at times, but it has only discharged about 5% of the time in recent years and the tides and bathymetry offer scope for significant dilution and mixing. The oyster beds are in deeper water here, so given the distance from the main sources and increased dilution potential improved water quality and perhaps a better classification may arise here relative to the Budds Farm zone. An RMP located at SU 7062 0320 would best capture contamination from upstream sources.
- Sinah Lake. This is a shallower channel, distinct from the main channel, which drains the south eastern part of the harbour, to which there is little in the way of major sources of contamination aside from a few minor surface water outfalls. The most significant of these, according to shoreline survey measurements, discharges at Newtown and flows across the intertidal and joins the Sinah Lake at its Head, where it is shallower and the dilution potential lower. Therefore an RMP located at SU 7070 0094 should be best representative of this zone.
- Broom Channel. This includes the upper part of the Broom Channel and the smaller Russells Lake channel. Sources of contamination include three intermittent discharges to the upper reaches of the Broom Channel/Portsea Creek of which two are monitored and spilled only for 4% and 0.5% of the time in recent years. There are also a few surface water outfalls, drainage from the Farlington Marshes on which cattle are grazed, and a large number of moorings in the channel to the north of where most oyster stocks are

located. An RMP located in the Broom channel off Kendalls Wharf (SU 6769 0322) which is about the northern limit from where stocks are dredged would capture contamination from sources to the north as well as the surface water outfalls here.

- Salterns. In the south western corner of this zone lies an area of decreased water quality subject to contamination from surface water outfalls possibly carrying some sewage content, Southsea Marina and a large number of boat moorings. However, the pattern of tidal circulation suggests that water from this area would tend to be carried out the harbour mouth without coming into contact with the areas of the main channel from where oysters are dredged. Contamination from the Fort Cumberland intermittent outfall in the harbour mouth may be an influence at times, but it has only discharged about 5% of the time in recent years and the tides and bathymetry offer scope for significant dilution and mixing. Up estuary sources as described for the Broom Channel zone may be of significance, as may the Salterns Lake outfall. It is therefore recommended that the RMP for this zone is located at the upstream end of this zone where the Salterns Lake channel meets the Broom channel (SU 6833 0197).

2.1.3 The following sampling criteria should apply:

- The species sampled should be market size native oysters.
- The sampling method should be dredge.
- A tolerance of 100m applies to allow repeated sampling via dredge.
- A minimum of 10 samples per year are required to maintain classification.
- For seasonal classifications sampling should commence two months prior to the open season. If the open season is likely to alter year on year then sampling across the period which includes all months in which production may take place, including the two month lead in period, is required. The frequency of sampling should be not less than monthly.

2.2 MUSSELS

2.2.1 The area requiring continuing classification is a zone of 0.74 km^2 bounded by the Salterns Lake, the Milton Lake, and the Broom/Main channels, extending to mean high water springs.

2.2.2 The main source of contamination discharging directly to this zone is the Salterns Lake outfall. Salterns lake is a small still water which receives surface runoff from Portsea Island as well as an unmonitored intermittent sewage discharge (Burrfields Road CSO). It discharges intermittently via a pumping station. To the south lies an area of decreased water quality subject to contamination from surface water outfalls possibly carrying some sewage content, Southsea Marina and a large number of boat moorings. However, the pattern of tidal circulation suggests that water from this area would tend to be carried out the harbour mouth without coming into contact with this site. An RMP located at the end of Salterns Quay (SU 6778 0180) would best capture contamination from the Salterns Lake outfall.

2.2.3 The following sampling criteria should apply:

- The species sampled should be mussels of a market size.

- The use of bagged mussels here may be a convenient option, in which case they should be deployed on the substrate and allowed to equilibrate *in situ* for at least 2 weeks before sampling.
- If this is not possible, then samples should be hand gathered as close to the upstream end of the Salterns Lake channel as possible, and the location sampled taken by GPS and recorded on the sample submission form.

2.2.4 As harvesting is year round, sampling should also be year round on a monthly basis.

2.3 Clams

2.3.1 Although the main focus of fishing effort for clams is the north eastern part of the harbour a sampling plan will be provided to cover the entire area. This sampling plan will apply to American hard clams and *Tapes* spp. It is up to the LEA to decide which zones will require classification for which species. As clams occur in the intertidal areas, the zoning and sampling plan is slightly different to that outlined above for native oysters.

2.3.2 It is proposed that the following four classification zones are established for all clam species.

- <u>Budds Farm.</u> This zone is subject to several of the most significant sources of contamination including the Budds Farm overflows and three watercourses (Hermitage, Lavant and Brockhampton stream). It is also likely to be influenced by sources discharging to the northern reaches of the Emsworth Channel, such as the River Ems. In recent years the Budds Farm storm tanks have discharged storm sewage for about 16% of the time, and so represents the most significant (albeit intermittent) source in this zone and will cause acute episodes of contamination on a fairly regular basis. It is therefore recommended that the RMP is located at the end of this outfall (SU 7050 0506).
- <u>South East Langstone Harbour.</u> This zone is likely to be primarily influenced by the up estuary sources influencing the Budds Farm zone. Contamination from the Fort Cumberland intermittent outfall in the harbour mouth may be an influence at times, but it has only discharged about 5% of the time in recent years and the tides and bathymetry offer scope for significant dilution and mixing. There are also a few surface water outfalls to the adjacent shore, and an area of moorings by the harbour mouth. On balance, it is recommended that the RMP is located at Stoke Common Lake (SU 7094 0291). This should capture contamination from the up estuary sources in the Budds Farm zone as well as being indicative of increased levels of contamination associated with increased land runoff (a surface water outfall discharges here)
- <u>Broom.</u> Sources of contamination include three intermittent discharges to the upper reaches of the Broom Channel/Portsea Creek of which two are monitored and spilled only for 4% and 0.5% of the time in recent years. There are also a few surface water outfalls, drainage from the Farlington Marshes on which cattle are grazed, and a large number of moorings in the upper reaches of the Broom channel. The Salterns Lake outfall may also be an influence.

- Milton. The area to the south and west of the Milton Lake has been identified as an area of decreased water quality. It is subject to contamination from two surface water outfalls possibly carrying some sewage content, Southsea Marina and a large number of boat moorings. An RMP located at the Eastney Lake channel (SZ 6774 9523) should be best located to capture contamination from these sources.

2.3.3 The following sampling criteria should apply:

- The species sampled should be market size American hard clams to classify this species, and market size Manila or native clams (Palourdes) to classify both these two species (*Tapes* spp.).
- Sampling via hand digging or dredge are both acceptable methods.
- A tolerance of 100m applies to allow repeated sampling.
- The sampling frequency should be monthly and on a year round basis.
- Should employing a local gatherer prove the best practical option, the LEA should consult with the FSA to ensure that sample collection method meets all the appropriate requirements.[1]

[1] Should such a strategy be pursued, the LEA should contact the FSA to agree alternative options. Proposals must comply with the appropriate sampling protocols, ensure adequate training and supervision is provided and is to be documented accordingly.

3. SAMPLING PLAN

General Information

Location Reference

Production Area	Langstone Harbour
Cefas Main Site Reference	M019
Ordnance survey 1:25,000 map	Explorer 120
Admiralty Chart	3418

Shellfishery

Species/culture	Native oysters (*Ostrea edulis*) Hard clams (*Mercenaria mercenaria*) Manila & native clams (*Tapes* spp.) Mussels (*Mytilus* spp.)	Wild Wild Wild Cultured
Seasonality of harvest	Closed season for native oysters (March-October inclusive)	

Local Enforcement Authority

Name	Portsmouth Port Health Authority Public Protection Services Civic Offices Guildhall Square Portsmouth PO1 2PQ
Environmental Health Officer	Steve Lucking
Telephone number ☎	02392 688362
Fax number 🖷	02392 841256
E-mail	steve.lucking@portsmouthcc.gov.uk
Name	Environmental Health Department Havant Borough Council Civic Offices Centre Road Havant PO9 2AX
Environmental Health Officer	Sylvia Crabtree
Telephone number ☎	02392 474174
Fax number 🖷	02392 446659
E-mail	sylvia.crabtree@havant.gov.uk

Requirement for Review

The Guide to Good Practice for the Microbiological Monitoring of Bivalve Mollusc Harvesting Areas (EU Working Group on the Microbiological Monitoring of Bivalve Mollusc Harvesting Areas, 2010) indicates that sanitary assessments should be fully reviewed every 6 years, so this assessment is due a formal review in 2019. The assessment may require review in the interim should any significant changes in sources of contamination come to light, such as the upgrading or relocation of any major discharges. Species sampling requirements may also require interim review in the light of changes in landing size for a particular species.

Table 3.1 Number and location of representative monitoring points (RMPs) and frequency of sampling for classification zones within Burry Inlet

Classification zone	RMP	RMP name	NGR	Latitude & Longitude (WGS84)	Species	Growing method	Harvesting technique	Sampling method	Tolerance	Frequency	Comments
Budds Farm		Budds Farm	SU 7037 0457	50° 50.183N 1° 0.123W	Native oysters	Wild	Dredge	Dredge	100m	Monthly	For seasonal classifications sampling should commence two months prior to the open season. If the open season is likely to alter year on year then sampling across the period which includes all months in which production may take place, including the two month lead in period, is required.
Langstone Channel		Langstone Channel	SU 7062 0320	50° 49.443N 0° 59.926W		Wild	Dredge	Dredge	100m	Monthly	
Sinah Lake		Sinah Lake	SU 7070 0094	50° 48.223N 0 °59.883W		Wild	Dredge	Dredge	100m	Monthly	
Broom Channel		Broom Channel	SU 6769 0322	50 °49.474N 1° 2.421W		Wild	Dredge	Dredge	100m	Monthly	
Salterns		Salterns	SU 6833 0197	50° 48.796N 1° 1.889W		Wild	Dredge	Dredge	100m	Monthly	
Salterns		Salterns Quay	SU 6778 0180	50° 48.708N 1° 2.360W	Mussels	Wild	Hand	Hand (bagged mussels)	10m	Monthly	Deploying bagged mussels may be the best strategy here.
Budds Farm		Budds Farm Outfall	SU 7050 0506	50° 50.447N 1° 0.006W	Hard clams and *Tapes* spp.	Wild	Hand/Dredge	Hand/Dredge	100m	Monthly	Hard clams results can be used to classify hard clams, Manila or native clams can be used interchangeably to classify one another (*Tapes* spp.). The LEA is to decide which areas need classifying for which species.
South East Langstone Harbour		Stoke Common Lake	SU 7094 0291	50° 49.284N 0° 59.656W		Wild	Hand/Dredge	Hand/Dredge	100m	Monthly	
Broom		A 2030 Bridge	SU 6752 0384	50° 49.810N 1° 2.559W		Wild	Hand/Dredge	Hand/Dredge	100m	Monthly	
Milton		Eastney Lake	SZ 6774 9523	50° 45.164N 1° 2.466W		Wild	Hand/Dredge	Hand/Dredge	100m	Monthly	

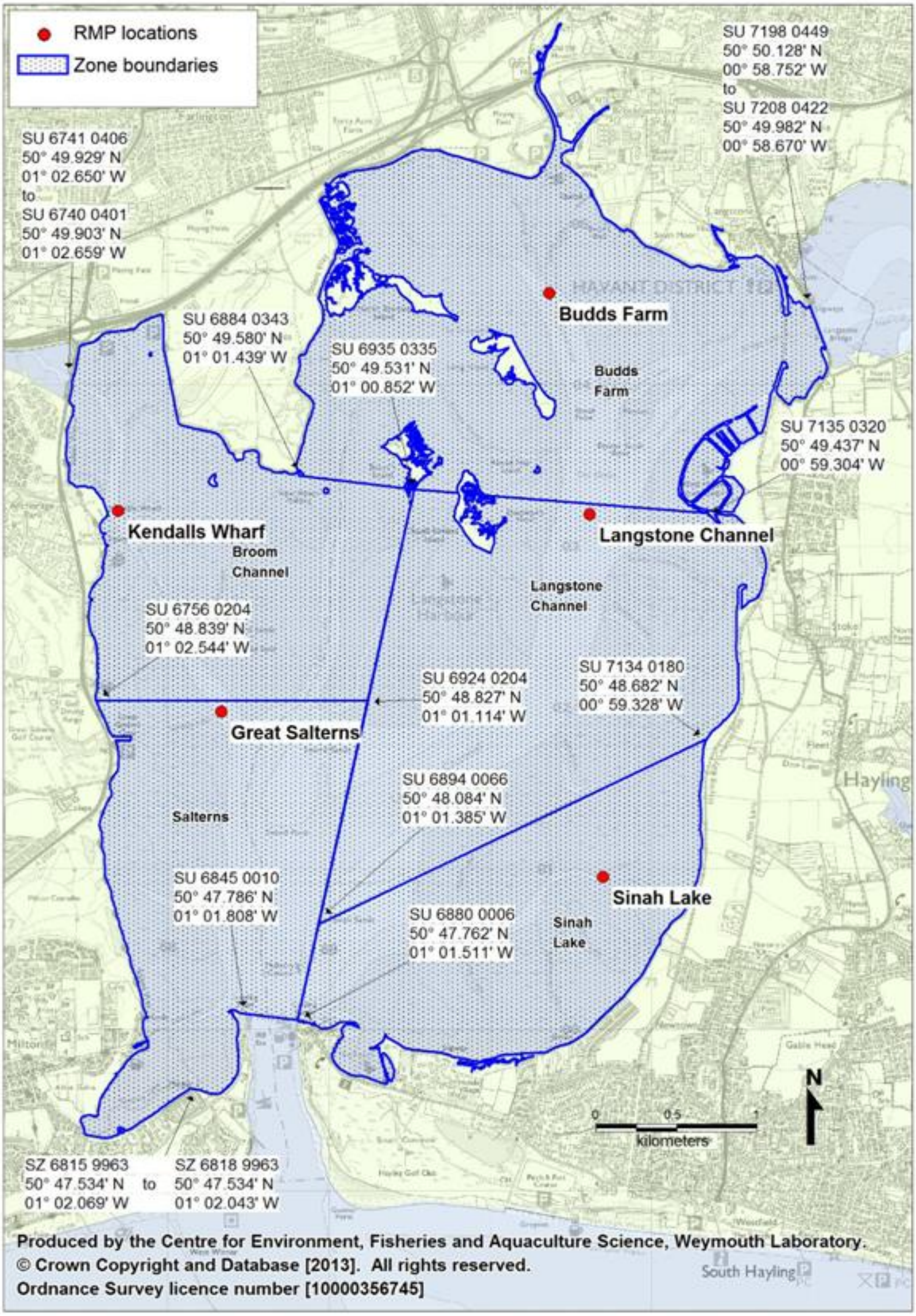


Figure 3.1 Recommended classification zone boundaries and RMP locations for native oysters

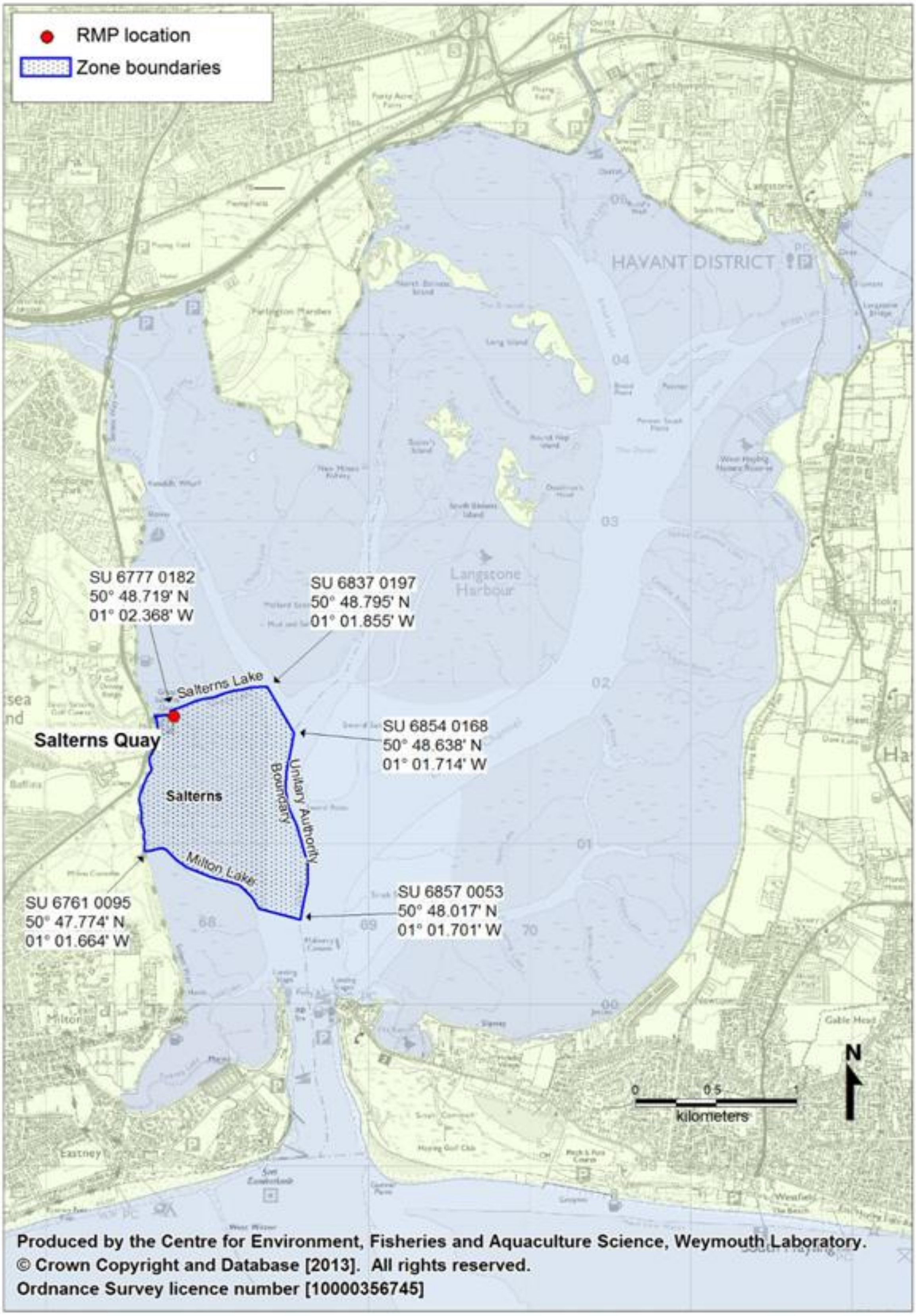


Figure 3.2 Recommended classification zone boundaries and RMP locations for mussels

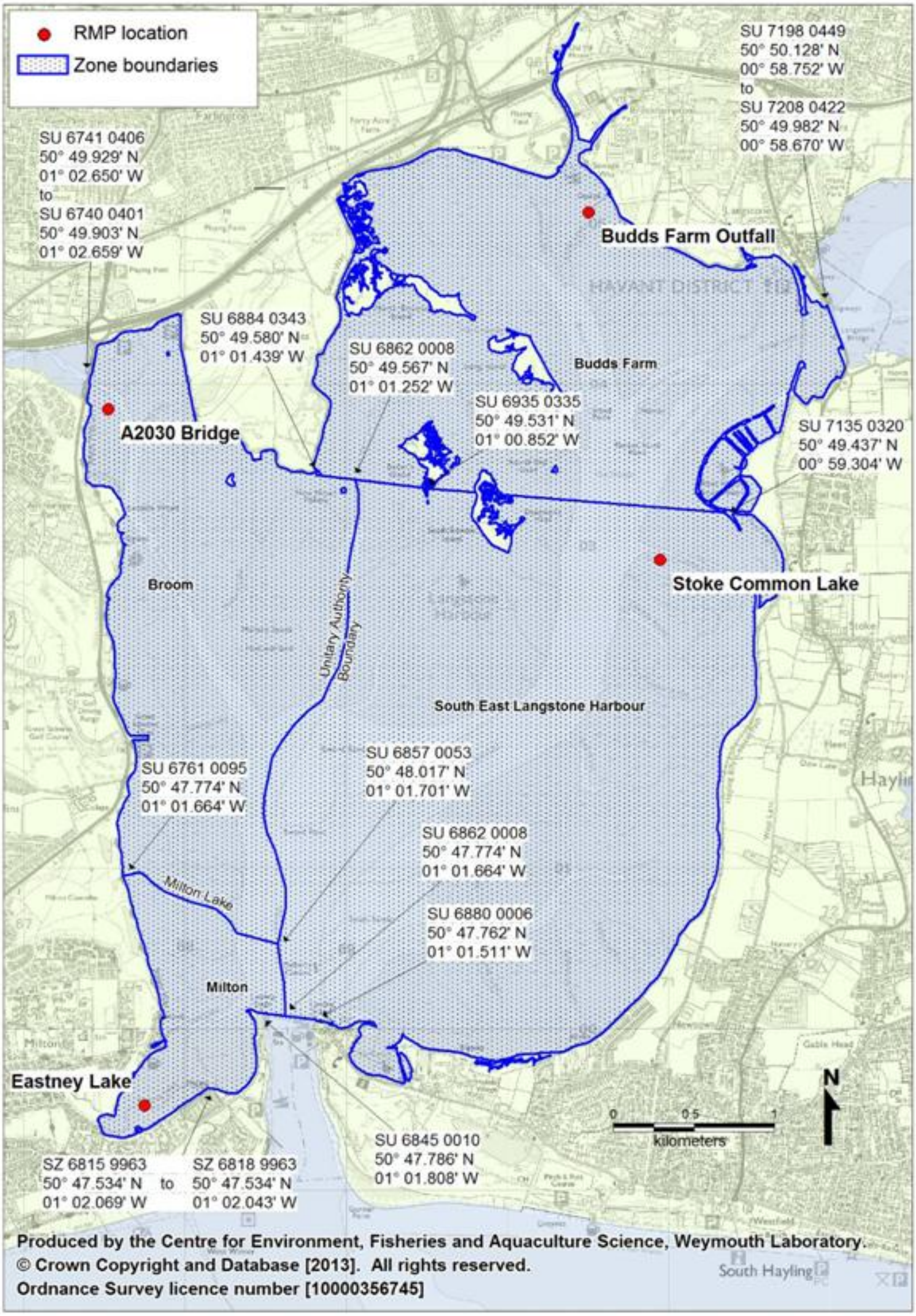


Figure 3.3 Recommended classification zone boundaries and RMP location for clams (Tapes spp. and American Hard clams)

4. SHELLFISHERIES

4.1 SPECIES, LOCATION AND EXTENT

Mussels (*Mytilus* spp.), native oysters (*Ostrea edulis*) and American hard clams (*Mercenaria mercenaria*) are currently classified for commercial harvest. Figure 4.1 shows the approximate locations of the main concentrations of shellfish resources as well as areas of seagrass where a voluntary dredging ban applies.

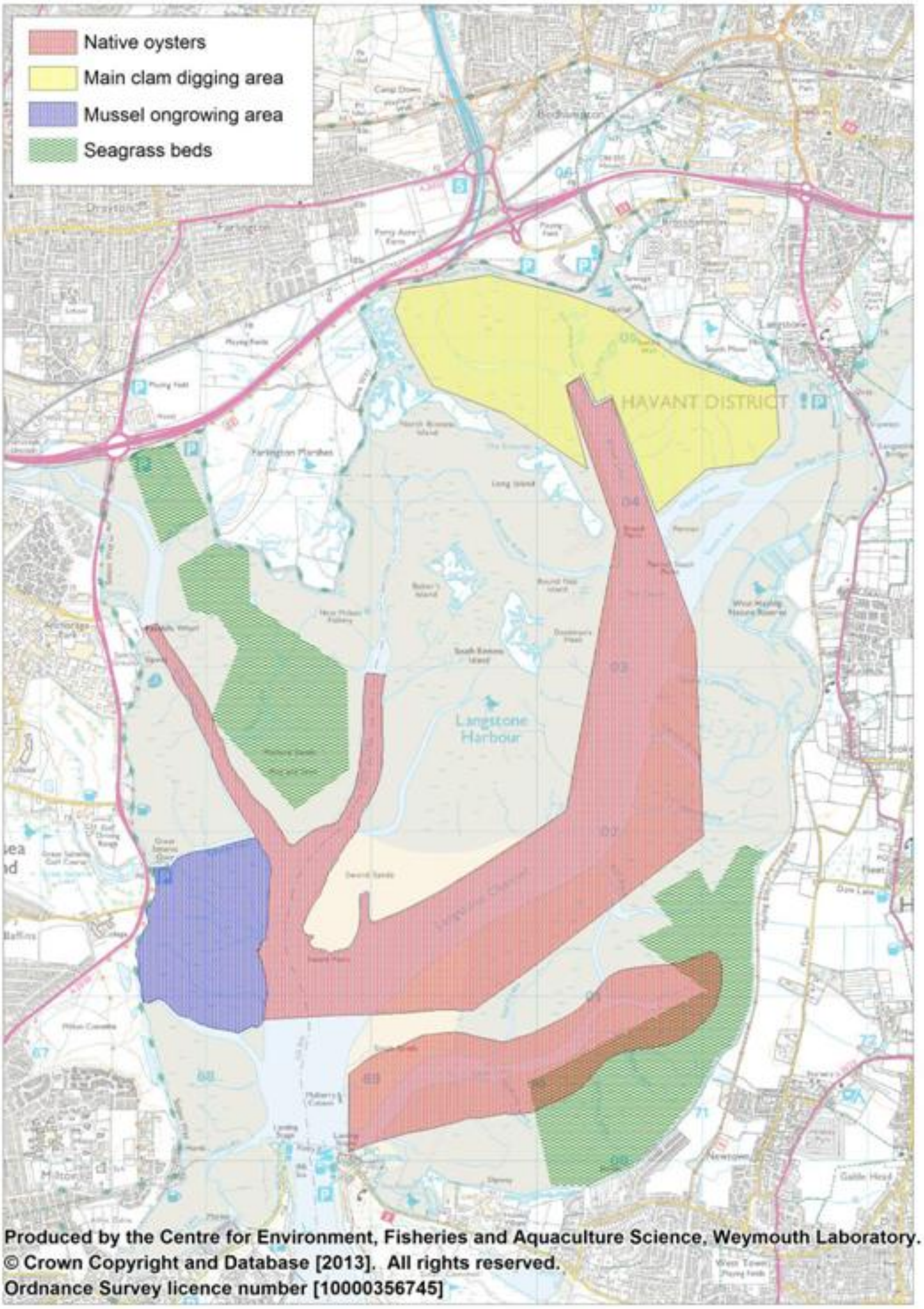


Figure 4.1. Overview of shellfish distribution within Langstone Harbour

The oyster dredge fishery is supported by a self sustaining natural population of this species which are taken from the main channels, particularly the Langstone Channel and Sinah Lake using dredges. Populations of this species in Langstone Harbour and the wider Solent area have declined significantly in recent years, perhaps due to recruitment failures (Vause, 2010). Formerly, 86 boats would dredge for oysters in Langstone Harbour at the beginning of the season, but currently only 22 boats are involved (Portsmouth Council, pers comm.). During the first week of the season each boat may catch from 1 to 1.5 tonnes per day, but catch rates (and fishing effort) drop rapidly as the season progresses.

Manila clams (*Tapes philippinarum*), American hard clams and native clams (*Tapes decussatus*) are all present within the Harbour. They are exploited commercially both via dredge and hand digging. The main clam species here are actually Manila clams rather than hard clams (Southern IFCA, pers comm.) which form the bulk of clam landings from the harbour. Hand digging effort is mainly concentrated around the north east part of the harbour off Broadmarsh where up to a dozen individuals may be working at low water on spring tides. Some hand digging is also undertaken on the east shore but the softer substrate makes access more difficult. Catches are about 90% Manila clams and 10% native clams (neither of which are currently classified). Each gatherer may collect 50kg of clams per tide, although the average is around 20kg. The dredge fishery is limited to about 6 boats, and dredging may occur anywhere in the harbour with suitable habitats. Annual landings are about 5 tonnes of Manila clams and 2 tonnes of American hard clams from this fishery.

There is a site at Salterns where seed mussels are ongrown by Viviers (UK) Ltd of Portsmouth. Around 700 tonnes of seed mussels were laid here four years ago (Southern IFCA, pers. comm.). The area used is bounded by the Milton Lake, Salterns Lake and the main Langstone Channel. The growers advise that approximately 20 tonnes are harvested annually from this site. The site is not on private grounds nor covered by a Several, Regulating or Hybrid order.

Some cockles are present within Eastney Lake in the south west of the harbour and within the clam beds in the north east of the harbour. Whilst these are subject to casual gathering for personal consumption, they are not of commercial interest (Portsmouth Council, pers comm.).

4.2 GROWING METHODS AND HARVESTING TECHNIQUES

All stocks of clams and oysters are wild. The commercial harvesting technique for both is via dredge although some limited hand digging of clams also occurs. As the clams burrow up to 15 cm into the substrate, toothed dredges are required to extract them, whereas oyster dredges only have a scraper bar.

Mussels are ongrown from seed laid on the substrate at the Salterns site, and harvested, depurated and marketed as required.

4.3 SEASONALITY OF HARVEST, CONSERVATION CONTROLS AND DEVELOPMENT POTENTIAL

For native oysters there is a closed season from March to October inclusive. Effort is highest in the first week of November when the season opens, when larger numbers of boats (formerly 86, now 22) enter the fishery. After the initial rush, catch rates of sizeable oysters drop significantly and the level of effort drops. Native oysters are subject to a minimum landing size of 70 mm. The maximum dredge opening is 1.5 m and only two dredges can be towed. Stocks of this species have declined significantly within Langstone Harbour and the wider Solent area in recent years and although the fishery continues, as a consequence catches have fallen. . Should the decline continue it is possible that the fishery may become unviable or be stopped for conservation reasons in the future. An initiative to encourage recovery of the native oyster population is underway in neighbouring Chichester Harbour (Vause, 2010) and should this prove successful there may be interest in employing similar tactics within Langstone Harbour.

For hard clams, Manila clams and native clams there is no closed season, but minimum sizes of 63 mm, 35 mm and 40 mm respectively apply. There is a voluntary ban on dredging within areas of seagrass, although it is uncertain to what extent this is adhered to. There is little solid information on the status of clam stocks, so biomass, stock structure, recruitment dynamics and hence the levels of fishing effort they can withstand are unknown.

Mussels may be harvested at any time of the year. No conservation controls apply to the culture site.

All gathering of wild stocks is currently limited to the hours from 08:00 to 16:00 (The byelaw requiring this is currently under review.) The IFCA may close any wild fishery at any time for reasons of stock preservation.

A Southern IFCA byelaw made under Marine and Coastal Access Act 2009 affords protection of eelgrass (Zostera spp.) in the Portsmouth Harbour Special Protection Area. The northern end of this area connects with Langstone Harbour. This bans dredging to protect the Eel Grass. At present there is a voluntary ban on dredging in Eel grass areas in Langstone Harbour. If a ban on dredging in Eel grass areas becomes mandatory in Langstone Harbour then the recommended Classification Zones will need to be reviewed.

4.5 Hygiene Classification

Table 4.1 lists all classifications within Langstone Harbour from 2003 onwards.

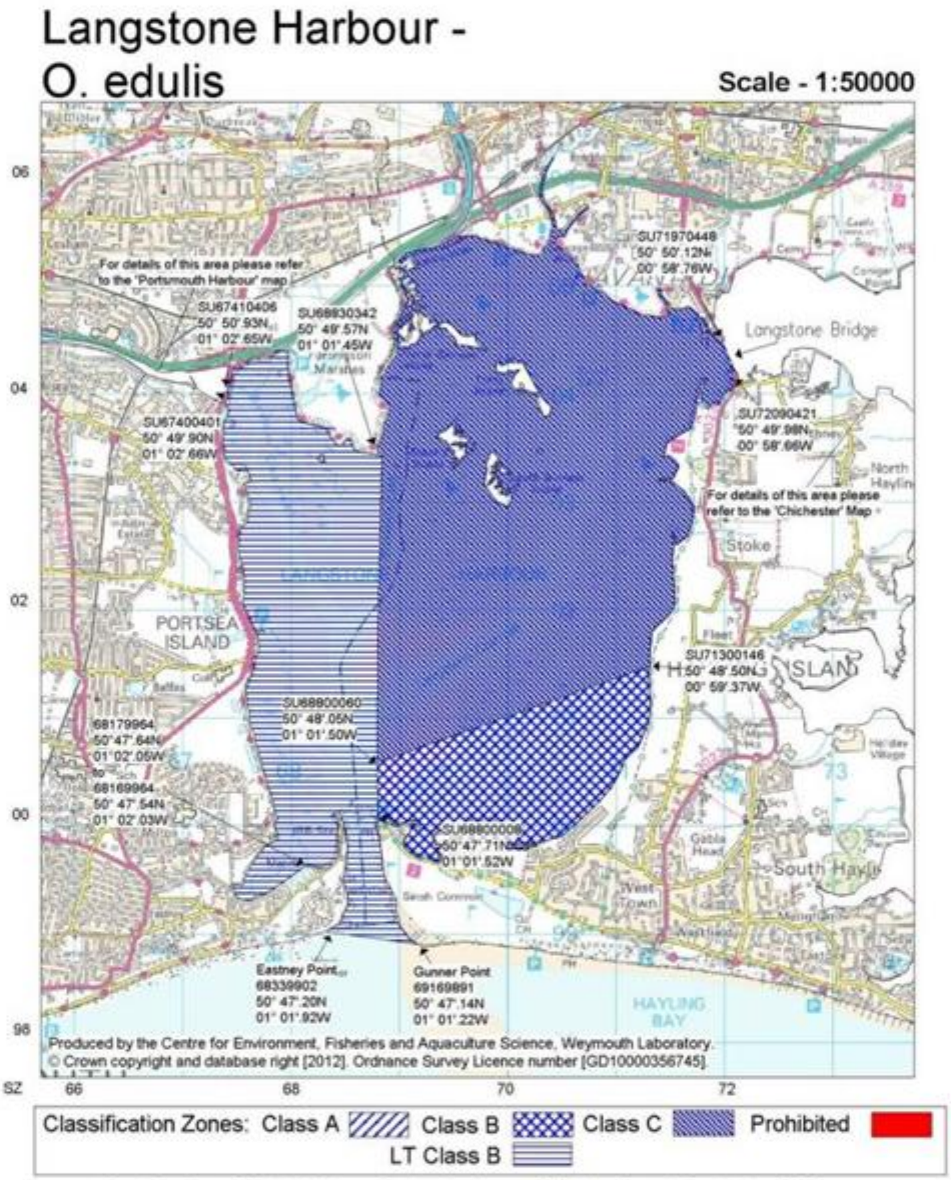
Table 4.1 Classification history for Langstone Harbour, 2003 onwards

Area	Species	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Main Channel	Native oyster	B	B	B	B	B	B	C	C	C	C
Broom Channel	Native oyster	B	B	B	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT	B-LT
Salterns S. Quay	Mussels	n/c	n/c	n/c	n/c	B	B	B	B-LT	B-LT	B-LT
Sinah Lake	Native oyster	B	B	B	B	B	B	C	C	B	B
Main Channel	Hard clams	B	B	B	B	B	B	C	C	C	C
Milton Lake	Mussels	-	-	-	-	B	B	B	B-LT	B-LT	B-LT

LT denotes long term classification

From 2003-2008 all parts of Langstone Harbour held B classifications. From 2009 to present, the north eastern part of the harbour (Main Channel) has held a C classification for both native oysters and hard clams. In 2009, native oysters at Sinah Lake (south east part of the harbour) declined to a C classification, but subsequently returned to a B classification in 2011. Native oysters at the Broom Channel and mussels at Milton Lake, both in the western half of the harbour have maintained a consistent B classification throughout this period. This indicates that there are higher peak levels of faecal contamination in the north eastern part of the harbour. Bivalves harvested from class C areas require either heat treatment, or relaying in an approved relay area for two months. There are no approved relay areas for hard clams in England and Wales, and only one for native oysters (Poole Harbour). Both hard clams and mussels are currently classified based on native oyster monitoring results. There was some initial monitoring of mussels but hard clams have never been sampled.

There is no classification for Manila clams or native clams, although they are taken from the harbour and presumably marketed somewhere on a regular basis. Manila clams are known to accumulate faecal indicator bacteria to higher levels than native oysters and hard clams (Younger and Reese, 2011) so issuing a preliminary classification based on the monitoring results for other species sampled here would not be acceptable. For classification purposes, both Manila clams and native clams are treated as the same species (referred to as *Tapes* spp.). Manila clams and/or native clams will therefore require sampling and classification so they can be marketed in compliance with the hygiene legislations. It is also concluded that the classified area for all species of clams will need to cover the entire harbour to accommodate the dredge fishery, so the area classified currently for hard clams will require extending.



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

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

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

N.B. Lat/Longs quoted are WGS84
Separate maps available for M. mercenaria and Mytilus spp. at Langstone Harbour

Food Authority: Portsmouth Port Health Authority

Figure 4.2 Current native oyster classifications

Langstone Harbour - M. mercenaria

Scale - 1:50000

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

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

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

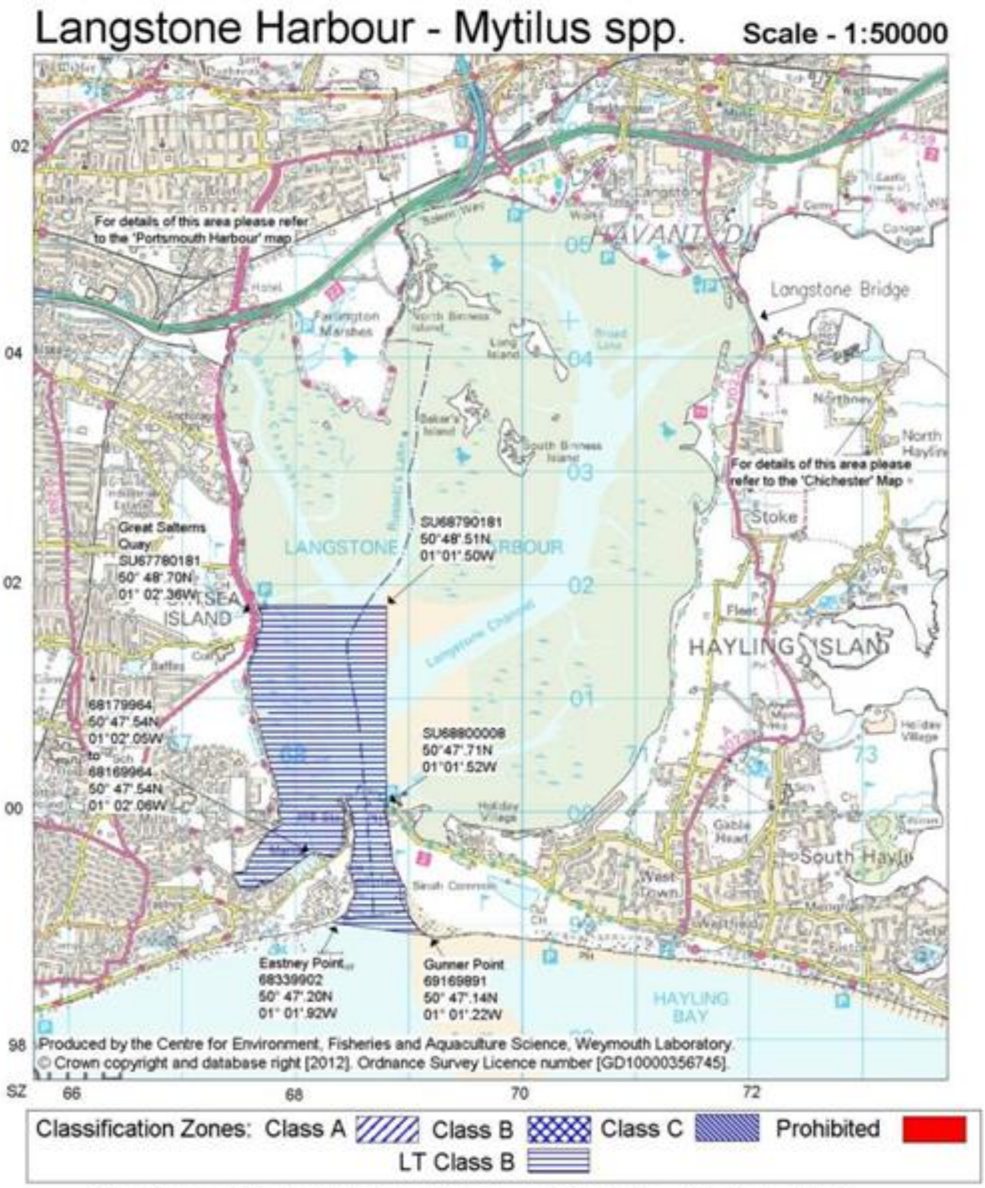
Further details on the classified species and the areas may be obtained from the responsible Food Authority. Enquiries regarding the maps should be directed to: Shellfish Microbiology, CEFAS Weymouth Laboratory, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB. (Tel: 01305 206600 Fax: 01305 206601)

N.B. Lat/Longs quoted are WGS84

Separate maps available for O. edulis and Mytilus spp. at Langstone Harbour

Food Authority: Portsmouth Port Health Authority

Figure 4.3 Current hard clam classifications



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

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N.B. Lat/Longs quoted are WGS84
Separate maps available for O. edulis and M. mercenaria at Langstone Harbour

Food Authority: Portsmouth Port Health Authority

Figure 4.4 Current mussel classifications

Table 4.2 Criteria for classification of bivalve mollusc production areas.

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

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

5. OVERALL ASSESSMENT

AIM

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

SHELLFISHERIES

Native oysters are present throughout the harbour within the main channels and are the subject of a dredge fishery. Oyster stocks have declined markedly in recent years, but the fishery still remains viable for a reduced number of boats. Continuing classification is therefore required for the whole harbour, or the subtidal areas at least. Samples will require collection via dredge from the subtidal channels, which should be suitably representative of the fishery. The oyster season runs from 1st November to the end of February, so a classification is only needed during this time. Fishing effort is highest during the first week of the season, after which it declines rapidly. A minimum of 10 samples per year are required to maintain a classification, so sampling of this fishery should be at least monthly. If the season is fixed year on year, sampling would not be required for the months of March and April assuming all other months are sampled. Alternatively ten samples could be taken not less than one month apart within the period September to February inclusive (i.e. covering the season and two months prior to the season).

Manila clams (*Tapes philippinarum*), American hard clams and native clams (*Tapes decussatus*) are all present within the harbour, and are exploited both by hand-digging and dredging. The majority of clam stocks are Manila clams, which are currently unclassified. Hand digging mainly occurs in the north east corner, whereas dredging occurs throughout the harbour where there are suitable habitats, so the entire harbour will require classification for these three species. For classification purposes, both Manila clams and native clams are treated as the same species (referred to as *Tapes* spp.). The hard clam classification is currently based on native oyster monitoring results, and clams have never been sampled. Hard clams accumulate *E. coli* to broadly similar levels as oysters, so this may be acceptable in some instances. However, the clams are found in the intertidal area, whereas the oysters are found in the subtidal channels. There may be marked differences in the exposure to indicator bacteria between these two habitats so results from oyster sampling may not be properly representative of levels of contamination within the clams. Manila clams accumulate *E. coli* to higher levels than native oysters so oyster monitoring would not be an acceptable surrogate for *Tapes* spp. even if they co-occurred in the same habitat type. All clam species require a year round classification. The IFCA indicate that hand digging of clam samples should be possible in most areas, but suggested that employing a local shellfish gatherer to collect samples may represent the best practical option. Should such a strategy be pursued, the LEA should contact the FSA to ensure that it complies with the appropriate protocols,[2]

There is an intertidal mussel ongrowing area bounded by the Milton Lake, Salterns Lake and the main Langstone Channel. This fishery is active and requires continued classification on a year round basis. Classifications are currently based on a nearby (subtidal) native oyster RMP. Again, there may be differences in the exposure to indicator bacteria between these two habitats and so results from oyster sampling may not be properly representative of levels of contamination within the mussels. A comparison of seven sets of paired (same day) samples showed that results were higher on average in the oysters, but at one of the mussel sites sampled the results did not appear to align with the oyster results.

Cockles are also present in some areas, but are not subject to a commercial fishery and so do not require a sampling plan.

POLLUTION SOURCES

FRESHWATER INPUTS

The catchment area draining Langstone harbour and the Emsworth Channel covers approximately 190km^2. The upper catchment is underlain by chalk of the South Downs where water moves slowly through chalk aquifers rather than via watercourses on the surface. The length of travel times through the aquifers suggest little or no microbial contamination from the upper catchment will survive passage. The geology changes in the lower catchment where springs emerge and minor watercourses receive surface runoff. These watercourse will carry contamination from sources such as urban and agricultural runoff into Langstone Harbour.

Two principle watercourses flow into Langstone Harbour from the north; both of which drain mainly urban areas. The Hermitage discharges next to Budds Farm sewerage works at Brockhampton, and the Lavant discharges at Langstone. There is another similar watercourse (the Ems) discharging to the north shore of the Emsworth Channel, which is also a potential source of contamination. Additionally, there are also some minor natural watercourses and engineered surface water outfalls which discharge at various locations around the harbour.

The volumes of runoff which the harbour receives are small, with mean discharge recorded at gauging stations on the Hermitage and Lavant of 0.184 and 0.089 m^3/sec respectively. A flood relief culvert diverts some flow from the Lavant to the Hermitage at times of higher discharge. The gauging station on the Ems recorded a higher average discharge of 0.450 m^3/s. There was some seasonality in discharge rates at all three of these gauging stations, with higher flows generally occurring in the colder months of the year. The seasonal pattern observed differed somewhat

[2] Should such a strategy be pursued, the LEA should contact the FSA to agree alternative options. Proposals must comply with the appropriate sampling protocols, ensure adequate training and supervision is provided and is to be documented accordingly.

between the three watercourses, particularly for the Ems, where discharge rates remained high on average throughout spring.

During the shoreline survey, watercourses and surface water outfalls which could be safely accessed were sampled for *E. coli* and measurements of discharge rates were made. These included the Lavant, the Brockhampton Stream (a small watercourse discharging to the north shore just west of the Langstone Bridge) and three small natural watercourses draining from Hayling Island. Of these, the Brockhampton Stream carried the highest bacterial loading (1.83×10^{11} *E. coli*/day), which was almost an order of magnitude higher than that from the Lavant (2.2×10^{10} *E. coli*/day). The Hermitage could not be safely accessed so was not sampled or measured but it likely to be of greater significance than the Lavant on the basis of volumes discharged. Land runoff to the western shore of the harbour and some other areas is via a series of engineered outfalls and pipes. Two of these located on the southern half of the western shoreline carried very high levels of *E. coli* at the time of shoreline survey suggesting some sanitary input. Also of significance, an engineered outfall at Newton on Hayling Island was found to carry 1.70×10^{11} *E. coli*/day) (see Appendix XII for further details). A further outfall of potential importance is a pumped outfall from Salterns Lake, through which a significant proportion of Portsea Island drains, although this was not operating at the time of shoreline survey.

Human Population

Total resident population within the Langstone Harbour and Emsworth Channel catchment area was 247,780 at the time of the last census for which data were available at the time of writing (2001). Population densities were highest on the western side of the catchment closest to Portsmouth City. Approximately two thirds of the catchment is covered by the South Downs National Park, which is more rural in character and supports much lower population densities than the coastal areas. Therefore, the western shores of the harbour are potentially most susceptible to impacts from urban runoff and sewage discharges, although the latter will depend on the local sewerage infrastructure.

The area receives significant influxes of visitors, attracted by the beaches of Hayling Island, the city of Portsmouth and the South Downs. Therefore, total population will be highest in summer and lowest in winter, and the volumes of sewage received by treatment works serving the area will fluctuate accordingly.

Sewage Discharges

There is only one continuous water company owned sewage discharge directly to the Langstone Harbour hydrological catchment (West Marden STW). This is also a small works providing secondary treatment for a population of around 200. It discharges to groundwaters within the upper catchment so no impacts within Langstone Harbour are anticipated from this STW. There is a major sewage works serving Portsmouth and Havant at Budds Farm on the north shore of Langstone Harbour which used to discharge to the harbour but the treated effluent from here now discharges via the Eastney Long Sea Outfall in the Solent over 5km south of the mouth of Langstone Harbour. The sewerage network serving the towns surrounding does however include a number of intermittent overflow discharges which have the potential to deliver significant volumes of storm sewage to Langstone Harbour. Such spills are more likely to occur when sewerage systems are overloaded with large amounts of surface runoff, although they may occur at any time through mechanical failures or blockages for example.

There are two intermittent outfalls from the Budds Farm STW. Treated effluent (normally discharged via the Eastney LSO) may be discharged from time to time from outlet 1 and the storm tanks discharge via outlet 2. There is a cluster of four intermittent discharges to the Broom Channel/Ports Creek. There is another intermittent outfall direct to the mouth of the harbour (Fort Cumberland) and several others not discharging directly to Langstone Harbour which may nevertheless be of significance. Spill records from the monitored outfalls (Budds Farm outlet 2, Fort Cumberland, Cosham (Court Lane) and Mainland Drayton) indicate that the Budds Farm outlet 2 spilled the most, and for the period mid 2005 to March 2011 was active for 16% of the time. The others were much less active, operating for 5%, 4% and 0.5% of this period respectively. Alternative pumping arrangements have been installed at Budds Farm in recent years in the PS3 pumping station to avoid un-permitted and premature discharges. A long term solution is being sought for problems that were identified in 2009 (P. Linwood Southern Water *pers. comm.*) Although the volumes discharged per unit time are uncertain, and probably vary significantly from outlet to outlet and possibly from event to event, it is likely that the Budds Farm outfall still has the most significant impact on shellfish hygiene. However this should reduce if further improvements are implemented in the future.

There are also some small private sewage discharges, mainly located within the more rural upper catchment areas. They are typically septic tanks or small package treatment plants each serving a small number of properties. Seventy seven (77) of these discharge to groundwaters and maximum permitted flows from these range from 0.3 to 40 m^3/day, but only three exceed 5 m^3/day. However, discharges to groundwaters are unlikely to have an influence on water quality within Langstone Harbour. A further 26 small private discharges are to various watercourses draining mainly to the Emsworth Channel but also to Langstone Harbour, with maximum permitted flows ranging from 0.1 to 8m^3/day. There are also three further private discharges direct to seawater from Hayling Island, which have maximum flows ranging from 2.6 to 3.6 m^3/day. Of all these private discharges, there are two by the east shore of Hayling Island which may potentially have some localised influence. Both are domestic discharges located at Fleet, one of which discharges to a watercourse with a maximum flow of 1 m^3/day, and the other discharges to Langstone Harbour and has a maximum permitted flow of 3.6 m^3/day. The watercourse to which one discharges was sampled and measured during the shoreline survey and did not carry a particularly high *E. coli* loading at the time. The one discharging direct to the harbour was not positively identified during the shoreline survey, the location recorded on the permit database is about 300 m inland.

During the shoreline survey two surface water pipes discharging at the south west corner of the harbour were found to contain very high concentrations of *E. coli*, suggesting they contain some sanitary content. None of the records on the discharge permit database could account for this however, perhaps suggesting a sewage misconnection may be responsible.

Sewage related plastics were seen in the strand line in several locations within the harbour during the shoreline survey, indicating discharges of untreated sewage occurring from outfalls, boats or both.

In summary, there are no major continuous sewage discharges to Langstone Harbour, or the Emsworth Channel. The vast majority of sewage inputs are likely to result from intermittent overflow discharges. Of these, Budds Farm has spilled the most in recent years, and so is likely to represent the most significant source of sewage contamination to the harbour. RMPs should therefore be set where they are most exposed to effluent from this discharge. There is an intermittent outfall within the mouth of the harbour (Fort Cumberland) which also spills regularly but less so than Budds Farm. There is a cluster of four intermittent discharges to Ports Creek, and the two of these where spills have been recorded are active less frequently. There is also an un-monitored overflow to Salterns Lake (Burrfields Road) which may be of some significance, and two surface water outfalls in the south west corner of the harbour which carried *E. coli* levels suggestive of some sanitary content at the time of shoreline survey.

Agriculture

The majority of agricultural land within the hydrological catchment of Langstone Harbour is used for arable farming, but there are also some small pockets of pasture where livestock are grazed. The upper catchment is almost all arable, and pastures are mainly within the lower catchment. Some areas of pasture are immediately adjacent to Langstone Harbour, mainly around the northern parts of the harbour. Organic fertilisers (manures and sewage sludge) may be applied periodically to arable land, whereas animals grazing on pastures will continually deposit faeces *in situ*. Such contamination will be carried into coastal waters via land runoff, and so the magnitude of fluxes will be highly rainfall dependent, with peak concentrations of faecal indicator bacteria in watercourses arising when heavy rain follows a significant dry period. Agricultural contamination in the upper catchment area is unlikely to be of any significance to the harbour as water movements here are via chalk aquifers.

Totals of only 2857 cattle, 1398 sheep and 2295 poultry were recorded within the Langstone Harbour and Emsworth Channel catchments in the 2010 agricultural census so impacts associated with livestock farming are likely to be relatively minor overall. The larger watercourses draining to the north shore of the harbour are likely to carry some limited contamination of agricultural origin at times. Smaller watercourses draining areas of pasture adjacent to the harbour such as the Farlington Marshes and north eastern parts of Hayling Island may carry higher concentrations of agricultural contamination into the harbour. During the shoreline survey, 80 cattle were recorded on the Farlington Marshes, 20 were recorded in a field on the north shore just west of Langstone Bridge, and six cattle were recorded on the north west corner of Hayling Island.

There is likely to be seasonality in levels of contamination originating from livestock. Numbers of sheep and cattle will increase significantly in the spring, with the birth of lambs and calves, and decrease in the autumn when animals are sent to market. Cattle are grazed on the Farlington Marshes from early spring to late summer. During the winter cattle may be transferred from pastures to indoor sheds, and at these times slurry will be collected and stored for later application to fields. Timing of these applications is uncertain, although farms without large storage capacities are likely to spread during the winter and spring. Poultry manure and sewage sludge may be spread at any time of the year, depending on crop cycles. Peak levels of contamination from sheep and cattle may arise following high rainfall events in the summer, or on a more localised basis if wet weather follows a slurry application which may be more likely in winter or spring.

Boats

There is significant boat traffic within Langstone Harbour, which hosts two small commercial ports used by the marine aggregate trade, as well as a large numbers of recreational craft, a few houseboats, and a small fishing fleet. The harbour is used by smaller recreational craft such as small sailing dinghies and kayaks. Merchant shipping is prohibited from making overboard discharges to inshore waters so traffic associated with the aggregates trade should be of no significance. Smaller pleasure craft will not have onboard toilets and so will not generally make overboard discharges. The more sizeable private vessels such as yachts, cabin cruisers and fishing vessels with onboard toilets are likely to discharge to the harbour. Houseboats in occupation may make regular sewage discharges.

Southsea Marina has 320 pontoon berths just to the west of the harbour entrance, and there are several hundred deep water and drying moorings in various locations around the harbour. Most of these are located around the harbour entrance, and in the northern reaches of the Broom Channel. Eight houseboats were observed during the shoreline survey within a small embayment just to the east of the harbour mouth. There are sewage holding tank pump out facilities available in Southsea Marina, and both Portsmouth Harbour to the west, and Chichester Harbour to the east.

Vessels in overnight occupation on moorings or at anchor may be most likely to make overboard discharges, so higher impacts may be anticipated within moorings or anchorages. Occupied yachts on pontoon berths may be less likely to discharge as this is somewhat antisocial in the crowded marina setting, and facilities on land are easier to access. Boats may also make overboard discharges whilst underway, so the main navigation channels may also be more susceptible to impacts from boat traffic. Peak pleasure craft activity is anticipated during the summer, so the magnitude of boat related impacts are likely to follow this seasonal pattern.

Wildlife

Langstone Harbour contains intertidal mudflats, seagrass beds, saltmarsh and four small rocky islands. These habitats attract significant colonies of overwintering waterbirds (waders and wildfowl) as well as seabirds (gulls, terns etc.), seals and other wild animals. Their presence may be a significant source of contamination at certain times and places. The largest wildlife populations are those of waterbirds, which are present throughout the colder months of the year with an average peak count of 27,344 for the five winters up to 2010/11. Grazers such as geese will primarily use saltmarsh habitats so their impacts will be via runoff from areas such as the Farlington Marshes. RMPs within or near to the drainage channels from saltmarsh areas will be best located to capture contamination from these birds. Other species such as waders will forage for invertebrates on intertidal habitats so their impacts will be widely spread throughout the intertidal area. As the majority of waterbirds migrate elsewhere to breed, their impacts will be principally felt during the winter months.

Some other species such as gulls are present year-round or migrate to the harbour in the summer to breed. A survey in 2000/01 recorded 3,570 breeding pairs of gulls and terns within Langstone Harbour, mainly on the islands and at the West Hayling Nature Reserve. These birds are likely to forage widely throughout the area so inputs are considered diffuse, but may be more concentrated in the immediate vicinity of the nest sites.

Seals are a regular presence within Langstone Harbour, with a colony of about 24 animals in the wider Solent area. Bottlenose dolphins and harbour porpoises have also been sighted occasionally within Langstone Harbour. Whilst these species may represent a minor source of contamination, their presence will be unpredictable both spatially and temporally and so will not influence the sampling plan. No other wildlife species which have a potentially significant influence on levels of contamination within shellfish have been identified in the survey area.

Otters, water voles, roe deer, foxes and other small mammals are all present around Langstone Harbour, but they are widely distributed and present only in small numbers. As such they will have no bearing on the sampling plan.

DOMESTIC ANIMALS

Dog walking takes place along coastal path that runs adjacent to the shoreline of the Harbour this could represent a potential source of diffuse contamination to the near shore zone. As a diffuse source, this will have no influence on the location of RMPs.

SUMMARY OF POLLUTION SOURCES

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

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

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

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

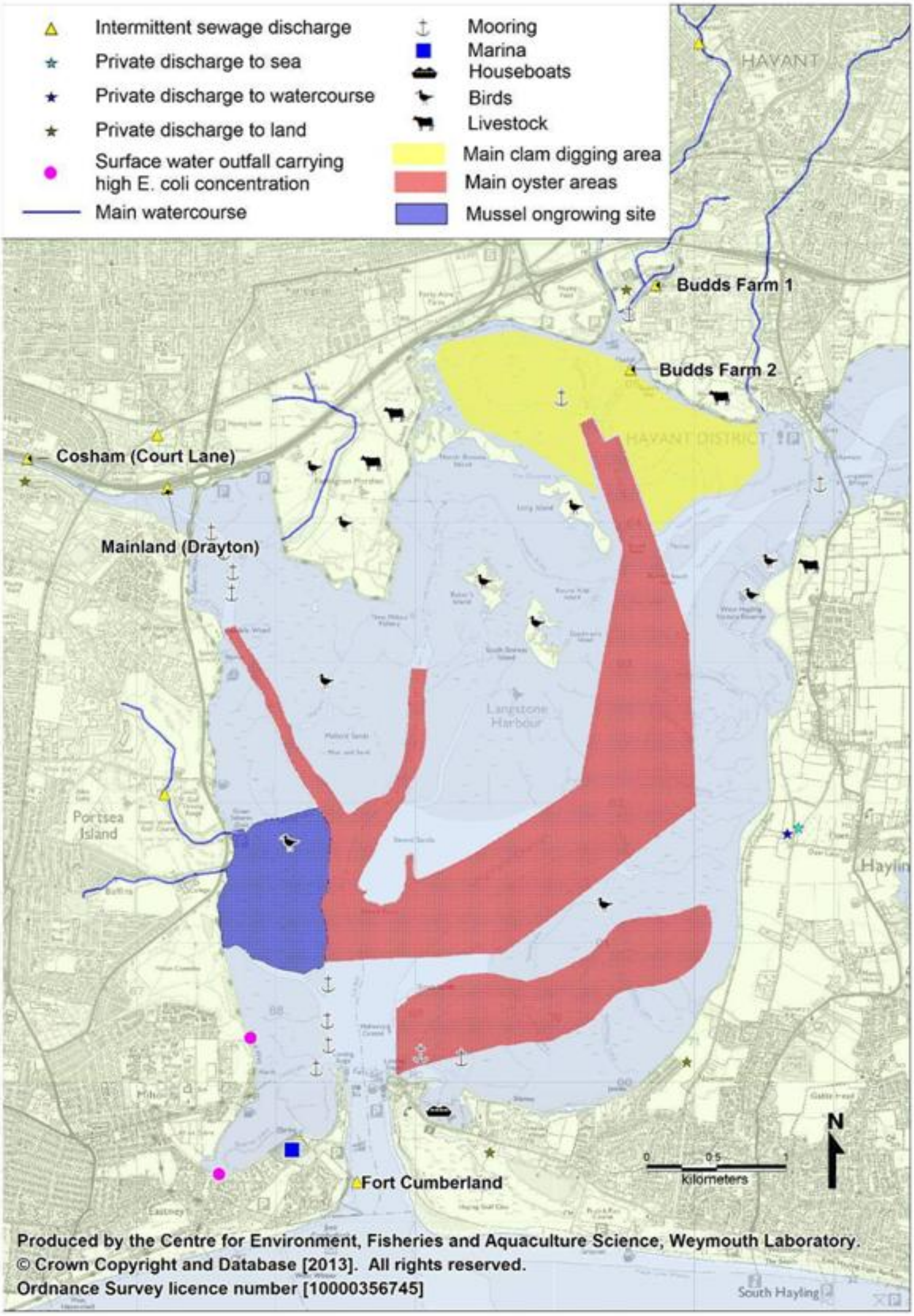

Figure 5.1 Significant sources of microbiological pollution to Langstone Harbour.

HYDROGRAPHY

Langstone Harbour covers an area of about 19 km^2, most of which is intertidal. It has a relatively deep and narrow mouth flanked by sand/gravel spits on either side. Inside the mouth, there are several smaller channels emanating from the main channel, which become progressively narrower and shallower. A series of intertidal creeks of varying sizes drain into the deeper channels. A narrow, shallow passage on the north western corner connects Langstone Harbour to Portsmouth Harbour at high water and on the north eastern side a wider, deeper passage connects it to Chichester Harbour. The intertidal areas are mainly mudflats, with saltmarsh at higher elevations. Sediments are progressively finer away from the mouth suggesting current speeds are lower in the inner reaches. A dilution factor from the Budds Farm outfall of only 50 is reported for most of the north east part of the harbour due to its shallow intertidal nature, whereas a minimum dilution factor of 500 is reported from the Fort Cumberland outfall at the mouth.

Tidal amplitude is 4.4 m on spring tides and 2.1 m on neap tides, and tides are the principle driver of water circulation within the harbour. Tidal streams move into the harbour and up the channels on the flood, then spread over the intertidal areas, with the reverse occurring on the ebb. Contamination from shoreline sources will tend to be carried down these creeks and into the main channels during the ebb tide. Shellfish in the intertidal areas are likely to be more influenced by local sources, whereas the oysters in the deeper channels will be subject to contamination from a larger range of sources. Currents are strongest at the harbour entrance (up to 2 m/s), diminishing up the main channels (generally less than 1.2 m/s), and are slowest over the intertidal areas (<0.4 m/s) particularly in the north-eastern part of the harbour (0.2 m/s). This suggests that sources of contamination in the intertidal areas, particularly the north-eastern part of the harbour will have more acute but localised effects than those discharging to the deeper channels and the harbour mouth.

On spring tides the volume of water in the harbour increases from 8.76 million m^3 at low tide to 66.57 million m^3 at high tide and on neap tides it increases from 15.53 million m^3 to 45.81 million m^3. Therefore, most of the water in the harbour is exchanged during the course of a tide so contaminants will generally be flushed rapidly from the harbour, particularly from sources nearer its mouth.

Although the vast majority of water exchange occurs via the mouth, some exchange of water through the secondary connections to Portsmouth and Chichester Harbour has been documented. These exchanges are in a overall westerly direction, and have been estimated respectively at 1.5% and 7% of tidal prism for Langstone Harbour on spring tides. Therefore, contamination from sources within Portsmouth Harbour is unlikely to be of significance to Langstone Harbour, whereas contamination from the Emsworth Channel in Chichester Harbour is of potential significance, particularly to any fisheries in the north east corner of Langstone Harbour.

In addition to tidally driven currents there are effects of freshwater inputs and wind. Given the large volumes of tidal exchange relative to the volumes of freshwater input the harbour is considered well mixed so density driven circulation is unlikely to modify tidal circulation patterns. Salinity measurements taken at a number of points within the harbour indicate average salinities approaching that of undiluted seawater throughout. The prevailing south westerly winds will tend to push surface water in a north easterly direction, creating return currents either at depth or along sheltered margins. Exact effects are dependent on the wind speed and direction as well as the state of the tide and other environmental variables, so a great range of scenarios may arise. Where strong winds blow across a sufficient distance of water they may create wave action and where these waves break, contamination held in intertidal sediments may be re-suspended. The north eastern part of the harbour may be most regularly affected, although given the enclosed nature of the harbour strong wave action is not anticipated.

SUMMARY OF EXISTING MICROBIOLOGICAL DATA

Langstone Harbour has microbiological monitoring data for both shellfish flesh and seawater, derived from the hygiene classification monitoring programme, Portsmouth Port Health Authority investigations, and the shellfish waters monitoring programme. Figure 5.2 shows the locations sampled referred to in this assessment.

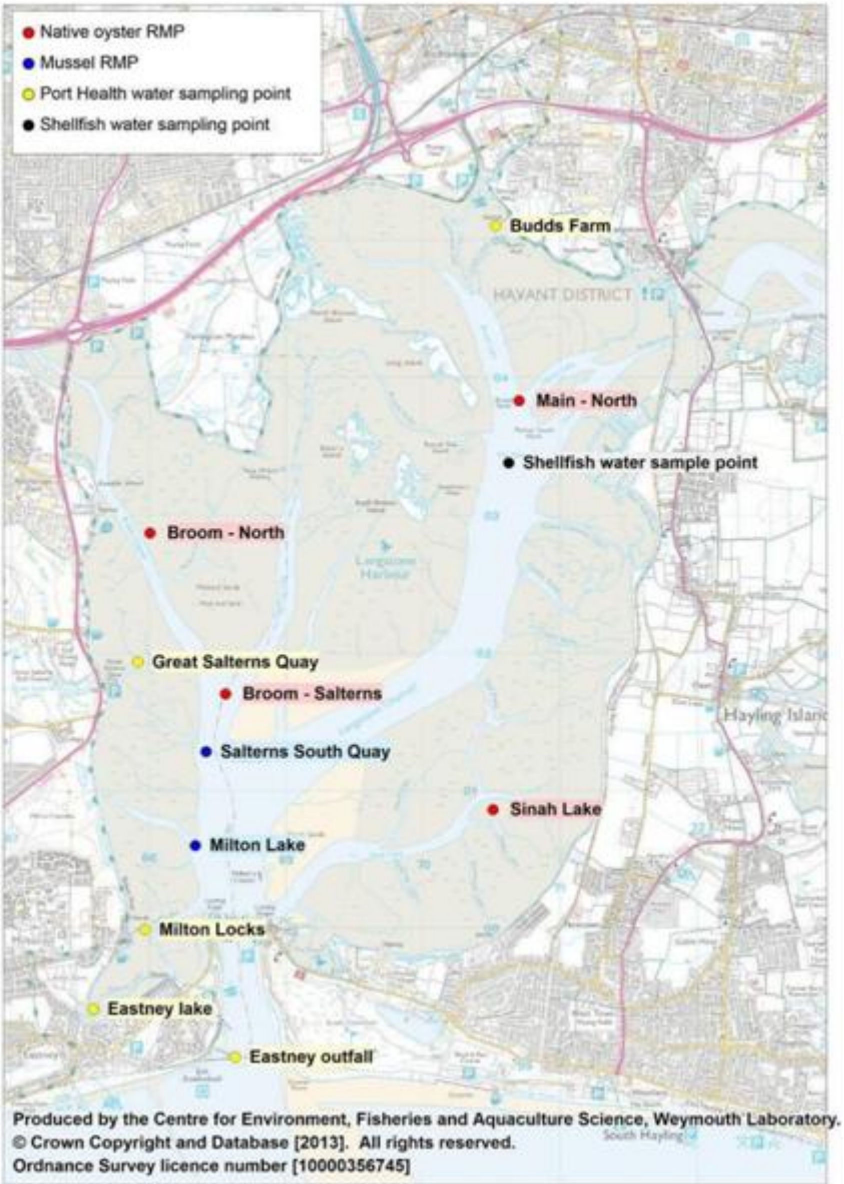

Figure 5.2. Location of shellfish and seawater sampling locations

The four main native oyster RMPs were all sampled just over 100 times from 2003 to present. There was no significant differences between RMPs in average *E. coli* levels or in the proportions of results exceeding the class B threshold (4,600 *E. coli* MPN/100 g). The range of results was large at all four of these RMPs indicating variable levels of contamination in the water column. Significant correlations were found for all site pairings when *E. coli* results from paired (same day) samples were compared, suggesting water quality within the main channels is under broadly similar influences. The two RMPs in the eastern part of the channel (Main – North and Sinah Lake) both returned prohibited levels results (>46,000 *E. coli* MPN/100 g) whereas the two on the western side of the harbour (Broom-North and Broom - Salterns) did not. This suggests that occasionally contamination events arise which are more acute in the eastern part of the harbour. The two mussel RMPs were only sampled on nine occasions, and yielded very similar results to one another.

There was significant seasonal variation at the two sites nearer the southern end of the harbour (Broom - Salterns and Sinah Lake) but not for the two sites towards the northern end of the harbour (Broom - North and Main - North). At both Broom - Salterns and Sinah Lake, results were significantly higher in the autumn compared to the summer. This suggests that there is some difference in the profile of sources impacting on the harbour across the north-south plane.

Significant influences of tide across both the spring/neap and high/low cycles were detected at Broom - Salterns and Sinah Lake but not at the other two native oyster RMPs. At both the sites where an influence was found, results were higher whilst the tide was ebbing, suggesting sources of contamination further up the tidal channels are a major contaminating influence. No similar effect was found for the sites further to the north, which may possibly be explained by their greater distance from the harbour entrance limiting the influence of cleaner water carried in on the flood tide. Across the spring/neap cycle, results at Broom - Salterns and Sinah Lake were higher on average during neap tides. This may be related to either the smaller amount of flushing or the slower current speeds which occur during such tides.

No influence of rainfall was found at any of the oyster RMPs. Although only nine samples were taken from the mussel RMPs, a significant influence of rainfall was found at one of them (Milton Lake). This may in part be due to the different habitats in which the species occur, as oysters in the deeper channels are likely to be less exposed to low salinity waters than mussels in the intertidal areas.

The use of oysters as a surrogate for mussels may be suitably protective of public health based on compliance with classification thresholds for the seven occasions when both mussel RMPs and the nearby Salterns - Broom Channel oyster RMP were all sampled on the same day. However, the highest individual result was recorded at Milton Lake, and whilst the results from Salterns Quay mussels appear to increase as they increase in native oysters in the Broom Channel, results from Milton Lake mussels did not. This suggests that the mussel site should be monitored separately from the oysters, at least until such time that a more robust assessment of their comparability can be made.

Around 40 samples were taken from each of the Portsmouth Port Health water sampling points. Levels of contamination were significantly higher on average at Budds Farm and Eastney Lake compared to the other sites, indicating that these are areas of lower water quality. The highest average result, peak result (by almost an order of magnitude) and highest proportion of results exceeding 1000 *E. coli* cfu/100 ml were all recorded at Budds Farm. A significant influence of spring/neap tidal cycle was detected at Eastney Lake, Milton Locks and Great Salterns Quay. At all these three sites there was a clear tendency for higher results during neap tides and tides of increasing size, perhaps due to the reduced tidal exchange. The pattern of results against the high/low tidal cycle was not investigated as exact times of sample collection were not recorded. A significant influence of rainfall was only detected at Eastney Outfall, Eastney Lake and Milton Locks. This was strongest at Eastney outfall, in the mouth of the harbour. Significant effects of rainfall only occurred at Eastney Lake 6-7 days after rainfall, and the reason for this delay is unclear.

One location towards the head of the main channel was sampled on a quarterly basis for faecal coliforms as part of the shellfish waters monitoring programme. The average result here was relatively low (6 cfu/100 ml). Strong seasonality was found here, with results for the winter significantly higher than spring and summer, and results for the autumn significantly higher than for the summer. A strong correlation was found between faecal coliforms results and the high/low tidal cycle. High results tended to arise whilst the tide was ebbing or at the lower states of tide. No influence of the spring/neap tidal cycle was detected. Levels of faecal coliforms at this site were strongly affected by rainfall for up to 6 days after a rainfall event.

APPENDICES

APPENDIX I
HUMAN POPULATION

Figure I.1 shows population densities in census output areas within or partially within the Langstone Harbour catchment area, derived from data collected from the 2001 census. Equivalent data from 2011 census were unpublished at the time of writing.

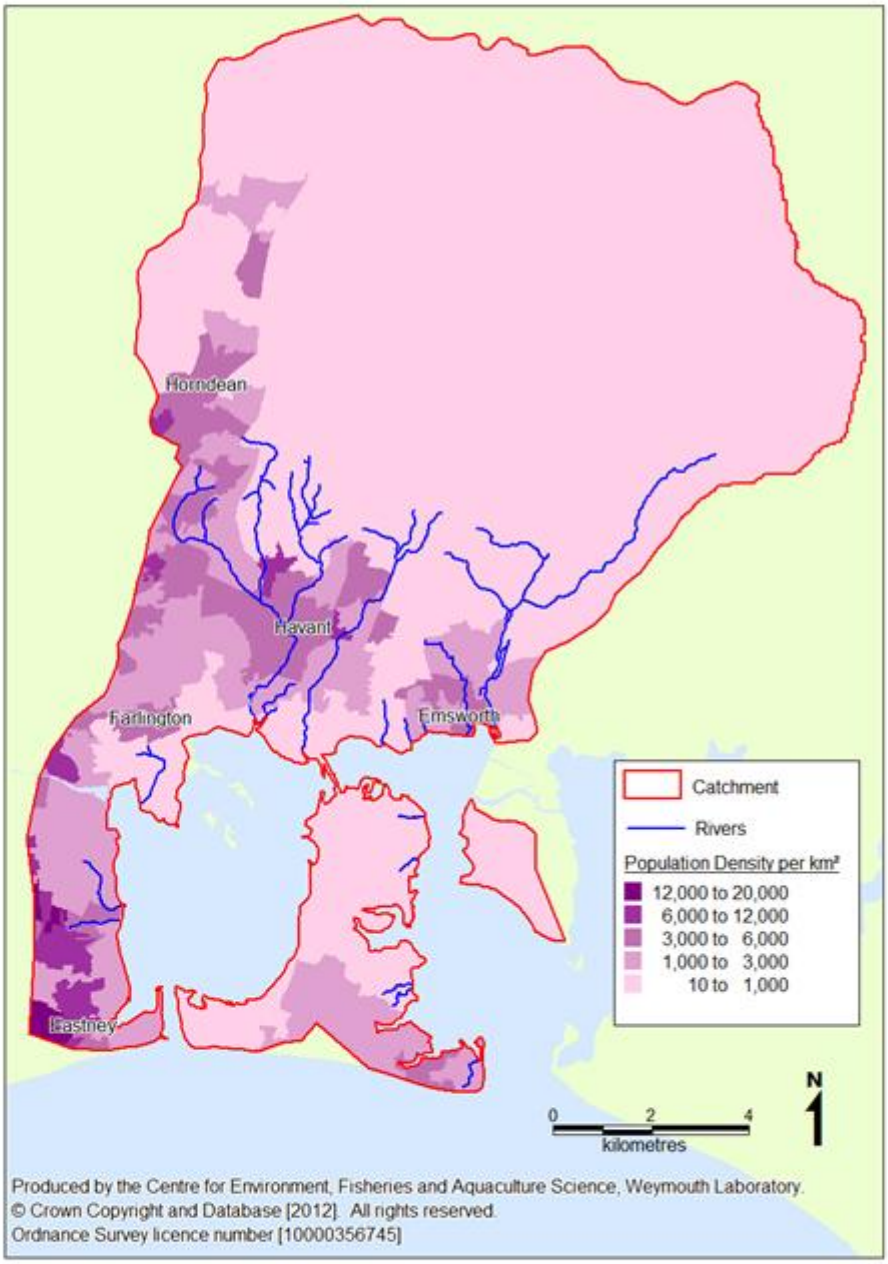

Figure I.1 Human population density in Census Areas in the Langstone Harbour Catchment.

The total resident population within the Langstone Harbour catchment area was 247,780 at the time of the last census. Figure I.1 indicates that population densities were highest on the western side of the catchment closest to Portsmouth city with densities of up to 20,000 persons per km^2 in Eastney. Havant and the village of Horndean had areas with population densities ranging from 1,000 to 12,000 persons per km^2. Therefore the south west region of the catchment was most heavily populated and at the most risk from contaminated urban runoff. Impacts from sewage will depend on the nature and locations of discharges serving these settlements and are discussed in detail in Appendix VII. Approximately two thirds of the catchment is covered by the South Downs National Park, which is more rural in character and supports much lower population densities than the coastal areas.

The area receives significant influxes of visitors, attracted by the beaches of Hayling Island, the city of Portsmouth and the South Downs. In 1995 Havant attracted 1.89m day visitors and 304,000 overnight visitors (Havant Borough Council, 2012a) and 7.1% of residents are employed in the tourist industry. A study of tourism in Portsmouth and Southsea in 2010 revealed that 17% of visitors interviewed were staying in accommodation on Hayling Island, 4% in Havant and 3% in Emsworth (Tourism South East, 2010). Therefore it can be assumed that there will be significant seasonal variation of population levels in the catchment of Langstone Harbour with an increase of tourists in the summer months. Consequently total population will be highest in summer and lowest in winter, and bacterial loadings from sewage treatment works serving the area will fluctuate accordingly.

APPENDIX II
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: SEWAGE DISCHARGES

Details of all consented discharges within the Langstone Harbour hydrological catchment (Appendix VIII for details) were taken from the Environment Agency's national discharge database (July 2012). Their locations are shown in Figure II.1, together with two surface water outfalls sampled on the shoreline survey which contained very high concentrations of *E. coli*.

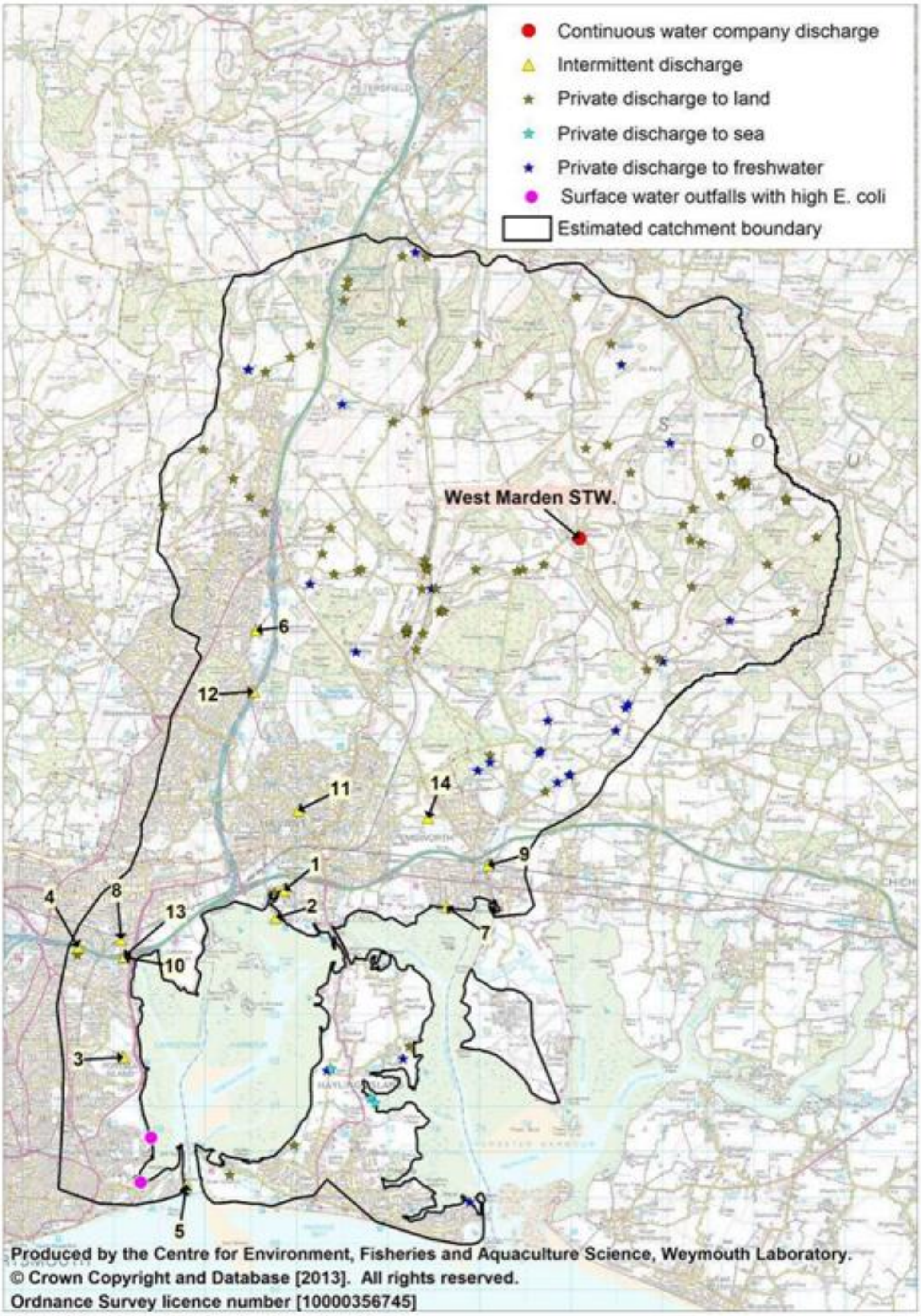

Figure II.1 Sewage discharges to Langstone Harbour and catchment

There is only one continuous water company owned sewage discharge to the Langstone Harbour catchment. Details of this are presented in Table II.1.

Table II.1 Details of the continuous water company sewage discharge to the area

Name	Location	DWF (m^3/day)	Treatment Level	Estimated bacterial loading (faecal coliforms/day)*	Receiving Water
West Marden STW	SU7719013360	40	Secondary (Biological filtration)	$1.3x10^{11}$	Groundwater via infiltration system

*Based on geometric base flow averages from a range of UK STWs (Table II.1). Such estimates are intended for comparative purposes only, and bacterial loadings generated by STWs are likely to fluctuate significantly

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

Treatment Level	Flow			
	Base-flow		High-flow	
	n	Geometric mean	n	Geometric mean
Storm overflow (53)	-	-	200	$7.2x10^6$
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.

West Marden STW is a small works which provides secondary treatment for a population of around 200. The effluent goes to groundwaters via an infiltration system, so no impacts within Langstone Harbour are anticipated from this STW. There is a major sewage works serving Portsmouth and Havant at Budds Farm on the north shore of Langstone Harbour, which used to discharge to the harbour. The treated effluent from here was re-routed to the Eastney Long Sea Outfall in 2001, which is located in the Solent over 5km south of the mouth of Langstone Harbour. The sewerage network serving the towns surrounding does however include a number of intermittent overflow discharges which have the potential to deliver significant volumes of storm sewage to Langstone Harbour. Storm sewage can carry high concentrations of faecal indicator bacteria (Table II.2). Those discharging either direct to Langstone Harbour or to its hydrological catchment are listed in Table II.3.

Table II.3 Details of intermittent discharges to Langstone Harbour and catchment.

ID	Name	Location	Receiving water
1	Budds Farm WWTW outlet 1	SU7072005700	Brockhampton Creek
2	Budds Farm WWTW outlet 2	SU7054005100	Langstone Harbour
3	Burrfields Road CSO	SU6720002060	Great Salterns Lake
4	Cosham (Court Lane) PS	SU6622004460	Ports Creek
5	Fort Cumberland Storm Tanks	SZ6858099290	Langstone Harbour
6	Greenfield Crescent Cowplain EMO	SU7011011360	Wallington tributary
7	Kings Road Emsworth CSO	SU7427105341	Emsworth Channel
8	Kirtley Close Drayton CSO	SU6715004630	Ditch tributary of Broom Channel
9	Lumley Road PS	SU7518006240	River Ems
10	Mainland (Drayton) PS	SU6722004240	Broom Channel
11	Priorsdean Crescent CSO	SU7103007430	Hermitage Stream
12	Ramblers Way Waterlooville CEO	SU7006010030	Wallington tributary
13	St Andrews Road CSO	SU6722004250	Broom Channel
14	Woodbine Cottage	SU7387007270	Unnamed drain

Discharges highlighted in yellow have spill information presented in Figure II.2

There are two intermittent outfalls from the Budds Farm STW. Treated effluent (normally discharged via the Eastney LSO) may be discharged from time to time from outlet 1 and the storm tanks discharge via outlet 2. There is a cluster of four intermittent discharges to the Broom Channel/Ports Creek, a narrow tidal creek connecting the north of Langstone Harbour to Portsmouth Harbour. There is another intermittent outfall direct to the mouth of the harbour (Fort Cumberland) and several others not discharging directly to Langstone Harbour which may nevertheless be of significance.

Spill records were available for four of these intermittent discharges from mid 2005 to March 2011. Figure II.2 presents a bubble plot of spills by outlet throughout this period, where each bubble represents a recorded spill, and the size of the bubble represents the duration of the spill.

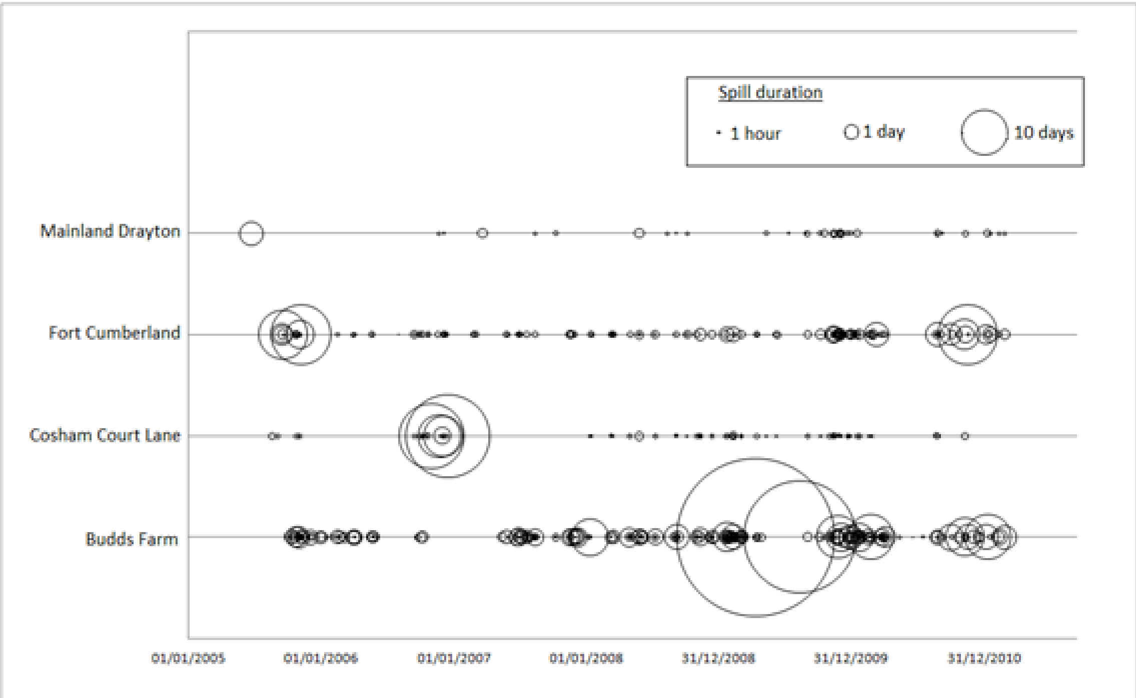

Figure II.2 Bubbleplot showing occurrence of spills from four intermittent outfalls monitored since 2005.

Of the four sites, Budds Farm STW discharges the most, with 345 individual events totalling 350 days recorded during this period. Budds Farm therefore spilled for about 16% of this period and so its impacts on shellfish hygiene are likely to have been captured during routine monitoring. At Cosham (Court Lane) PS 128 individual events were recorded lasting about 4% of this period. Aside from a series of relatively lengthy spills which occurred in November and December 2006 all were of short duration (<12 hours). Fort Cumberland storm tanks recorded 95 events lasting about 5% of the period. Mainland Drayton PS recorded only 36 events lasting <0.5% of the period and so is of much less significance on this basis. It must be noted that the volumes discharged per unit time are uncertain, and probably vary significantly from outlet to outlet, and possibly from event to event.

Although most properties within the survey area are connected to the water company sewerage networks there are a number of private sewage discharges serving those which are not. The vast majority of these are located in the more rural areas of the upper catchment area. Of the private discharges listed in the Environment Agency's national discharge database 77 discharge to soakaway and typically serve one or a small number of properties. The maximum permitted flows from these range from 0.3 to 40 m^3/day, of which only three exceed 5m^3/day. A further 26 small private discharges are to various watercourses draining mainly to the Emsworth Channel but also to Langstone Harbour, with maximum permitted flows ranging from 0.1 to 8 m^3/day. There are also three further private discharges direct to seawater from Hayling Island, which have maximum flows ranging from 2.6 to 3.6 m^3/day. The private discharges are typically septic tanks or small package treatment plants and although may they make a contribution to levels of *E. coli* in some watercourses, overall impacts from these are anticipated to be minor. It is not anticipated that those draining to soakaway will have a significant contaminating effect on coastal waters.

Of all these private discharges, there are two by the east shore of Hayling Island which may potentially have some localised influence. Both are domestic discharges located at Fleet, one of which discharges to a watercourse with a maximum flow of 1m^3/day, and the other discharges to Langstone Harbour and has a maximum permitted flow of 3.6 m^3/day. The watercourse to which one discharges was sampled and measured during the shoreline survey and did not carry a particularly high *E. coli* loading at the time (Table XI.2, line 35, 6.1×10^9 cfu/day). The one discharging direct to the harbour was not positively identified during the shoreline survey, the location recorded on the permit database is about 300 m inland.

During the shoreline survey two flowing pipes were sampled and found to contain 450,000 and 600,000 *E. coli* cfu/100 ml (Table XI.2, lines 5 and 9). No permits are listed on the database which could account for these pipes carrying sewage. The high concentrations of indicator bacteria suggest that they were receiving some sanitary input at the time of survey. Both are to the south west corner of the harbour.

Sewage related plastics were seen in the strand line in several locations within the harbour during the shoreline survey. This suggests that there are discharges of untreated sewage in the area, but as the debris was non-degradable plastics it is not necessarily indicative of recent spill events. None of the more readily degradable sewage related debris was seen, although access to the intertidal areas was heavily constrained by the thick mud.

In summary, there are no major continuous sewage discharges to Langstone Harbour, or the Emsworth Channel. The vast majority of sewage inputs are likely to result from intermittent overflow discharges. Of these, Budds Farm has spilled the most in recent years, and so is likely to represent the most significant source of sewage contamination to the harbour. RMPs should therefore be set where they are most exposed to effluent from this discharge. The regularity and duration of spills here suggest that the influence of this discharge may be captured perhaps once or twice a year under a monthly sampling regime. There is a single intermittent outfall within the mouth of the harbour (Fort Cumberland) which also spills regularly but less so than Budds Farm. There is a cluster of four intermittent discharges to Ports Creek, and the two of these where spills have been recorded are active less frequently. There is also an un-monitored overflow to Salterns Lake (Burrfields Road) which may be of some significance, and two surface water outfalls in the south west corner of the harbour which carried *E. coli* levels suggestive of a sanitary content at the time of shoreline survey.

APPENDIX III
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: AGRICULTURE

The majority of agricultural land within the hydrological catchment of Langstone Harbour is used for arable farming, but there are some small pockets of pasture. Some of these areas of pasture are immediately adjacent to Langstone Harbour, mainly around the northern parts of the harbour (Figure 1.2). Figure III.1 and Table III.1 presents livestock numbers and densities for the catchment. These data were provided by Defra and are derived from the June 2010 census. Geographic assignment of animal counts in this dataset is based on the allocation of a single point to each farm, whereas in reality an individual farm may span the catchment boundary. Nevertheless, Table III.1 should give a reasonable indication of the numbers and types of livestock within the catchment.

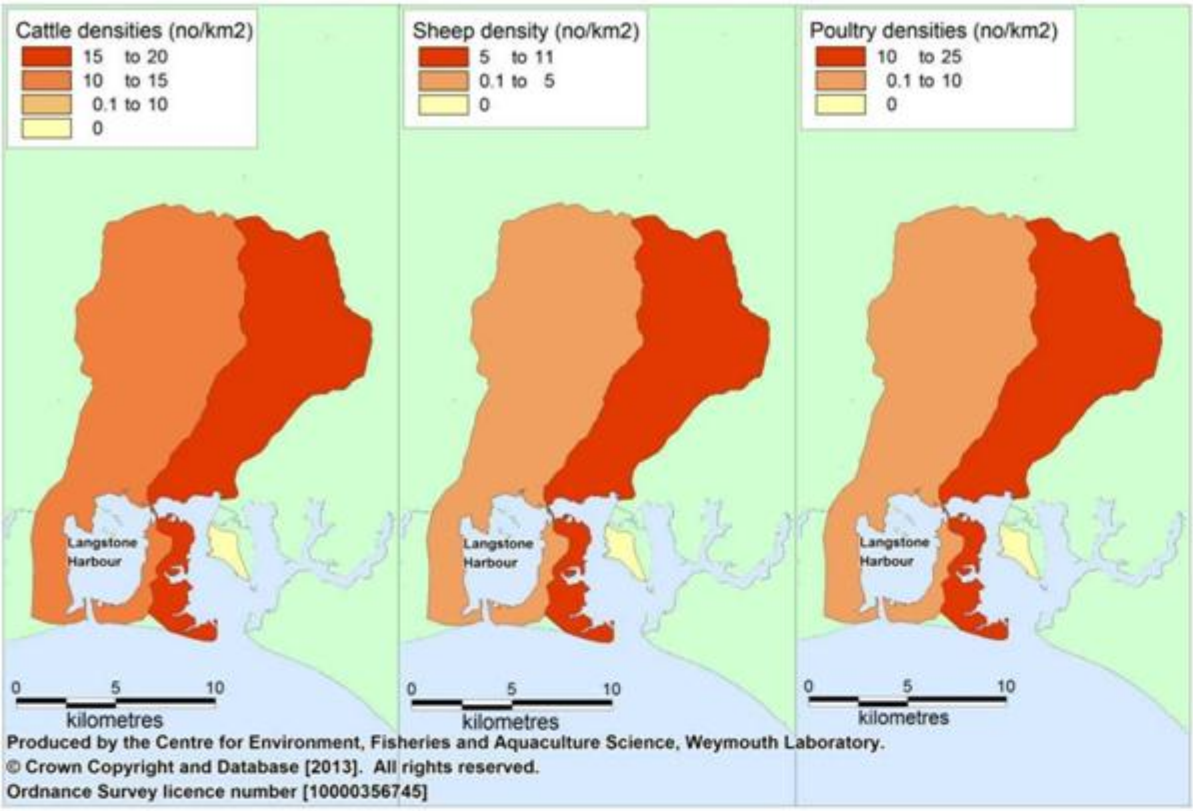

Figure III.1 Livestock densities within the Langstone Harbour and Emsworth Channel catchment areas

Table III.1 Summary statistics from 2010 livestock census for the areas draining to Langstone Harbour and the Emsworth Channel

Subcatchment		Langstone Harbour	Emsworth Channel (main catchment)	Emsworth Channel (Thorney Island)
Area (km^2)		115	79	3
Cattle	No.	1,469	1,388	0
	Density (no/km^2)	12.8	17.6	0
Sheep	No.	571	827	0
	Density (no/km^2)	5.0	10.5	0
Poultry	No.	430	1,865	0
	Density (no/km^2)	3.7	23.7	0

The concentration of faecal coliforms excreted in the faeces of animal and human and corresponding loads per day are summarised in Table III.2.

Table III.2 Levels of faecal coliforms and corresponding loads excreted in the faeces of warm-blooded animals.

Farm Animal	Faecal coliforms (No./g wet weight)	Excretion rate (g/day wet weight)	Faecal coliform load (No./day)
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).*

Contamination of livestock origin will either be deposited directly on pastures by grazing animals, or collected from operations such as cattle sheds and poultry houses and spread on both arable land and pasture. This in turn will enter watercourses which will carry it to coastal waters. As primary mechanism for mobilisation of faecal matter deposited on pastures into watercourses is via land runoff, fluxes of agricultural contamination into coastal waters will be highly rainfall dependent. Peak concentrations of faecal indicator bacteria in watercourses are likely to arise when heavy rain follows a significant dry period (the 'first flush'). Flows of water through the upper catchment are via chalk aquifers, and only re-emerge as surface streams in the lower catchment where the geology changes. The flow of groundwater through aquifers is typically very slow, from 1 m/year to 1 m/day (Environment Agency, 2011) and such lengthy travel times suggest little microbial contamination would survive passage. 50 days are deemed sufficient to remove microbial contamination from groundwater flows.

There are small numbers of grazing animals (both sheep and cattle) within the catchment, as well as small numbers of poultry. Given the small numbers the overall impact of livestock farming is likely to be relatively small. Densities are slightly higher within the main Emsworth Channel catchment than within the Langstone Harbour catchment. The larger watercourses are likely to carry some limited contamination of agricultural origin at times. Smaller watercourses draining areas of pasture adjacent to the harbour such as the Farlington Marshes and north eastern parts of Hayling Island may carry higher concentrations of agricultural contamination into the harbour. During the shoreline survey, 80 cattle were recorded on the Farlington Marshes, 20 were recorded in a field on the north shore just west of Langstone Bridge, and six cattle were seen on the north west corner of Hayling Island. The spatial pattern of application of organic fertilisers (manures, slurries and sewage sludge) to arable crops is uncertain, but arable land is widespread throughout the upper catchment areas. Contamination of chalk aquifers through the use of organic fertilisers in the South Downs is reported to be only of limited local importance compared to inorganic fertilisers (Jones and Robins, 1999).

There is likely to be seasonality in levels of contamination originating from livestock. Numbers of sheep and cattle will increase significantly in the spring, with the birth of lambs and calves, and decrease in the autumn when animals are sent to market. Cattle are grazed on the Farlington Marshes from early spring to late summer (Hampshire Wildlife Trust, 2012), although they were still present at the time of shoreline survey (late October). During winter cattle may be transferred from pastures to indoor sheds, and at these times slurry will be collected and stored for later application to fields. Timing of these applications is uncertain, although farms without large storage capacities are likely to spread during the winter and spring. Poultry manure and sewage sludge may be spread at any time of the year. Therefore peak levels of contamination from sheep and cattle may arise following high rainfall events in the summer, particularly if these have been preceded by a dry period which would allow a build up of faecal material on pastures, or on a more localised basis if wet weather follows a slurry application which is more likely in winter or spring.

APPENDIX IV
SOURCES AND VARIATION AND MICROBIOLOGICAL POLLUTION: BOATS

The discharge of sewage from boats is potentially a significant source of bacterial contamination of shellfisheries. There is significant boat traffic within Langstone Harbour, which hosts two small commercial ports used in the marine aggregate trade and is a popular place for commercial fishing and small pleasure craft. Figure IV.1 presents an overview of boating activity derived from the shoreline survey, satellite images and various internet sources.

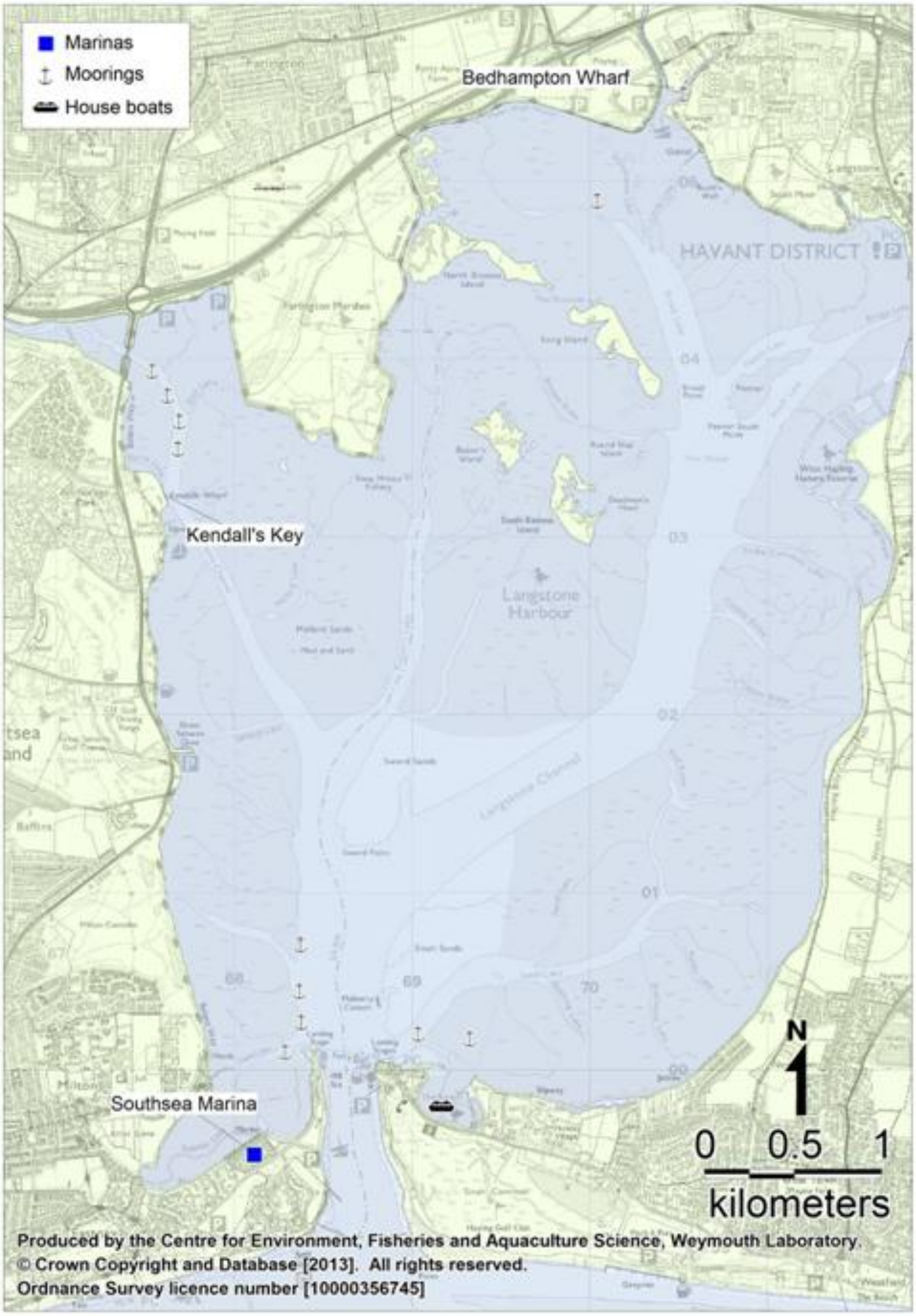

Figure IV.1 Locations of moorings, marinas and commercial ports in Langstone Harbour.

Sea–dredged aggregates are an important commercial trade within Langstone Harbour, 250 ships up to 80 metres in length docked at Kendall's Wharf and Bedhampton Wharf in 2009 (Langstone Harbour Board, 2012a). Merchant shipping vessels are not permitted to make overboard discharges within 3 nautical miles of land[3] so vessels associated with the commercial port should produce little or no impact.

A small fleet of around 25 commercial fishing boats and 13 charter fishing boats operate from Langstone Harbour (www.charterboats-uk.co.uk) catching a variety of fish and shellfish, including sea bass, cockles, oysters and winkles.

Southsea Marina located on the west side in Loch Lake contains 320 pontoon berths for yachts and cabin cruisers. Two pontoons hold a small number of berths one outside the marina and the other close to Hayling Island Ferry Terminal. In addition to this there are several hundred deep water and dry moorings located around the harbour with the majority positioned north of the Southsea Marina, Hayling Island and north of Kendall's Wharf.

Eight houseboats were seen during the shoreline survey in The Kench, a small embayment just to the east of the harbour mouth. These are likely to make regular discharges when in occupation.

Several sailing clubs and watersports centres operate from Langstone Harbour offering a variety of dinghy sailing, powerboat courses, water skiing and canoeing courses. However, these recreational boats are not large enough to contain onboard toilet facilities and therefore are therefore unlikely to make overboard discharges. This is also true of the small Hayling Island ferry which connects Hayling Island and Eastney in approximately five minutes.

The more sizeable private vessels such as yachts, cabin cruisers and fishing vessels are likely to make overboard discharges from time to time. Those in overnight occupation on moorings or at anchor may be more likely to make overboard discharges, so higher impacts may be anticipated within moorings or anchorages. Occupied houseboats are also likely to make regular discharge, and eight houseboats were seen in a small embayment just east of the harbour entrance. Occupied yachts on pontoon berths may be less likely to make overboard discharges as this is somewhat antisocial in the crowded marina setting, and facilities on land are easy to access. Boats may also make overboard discharges whilst underway, so the main navigation channels may also be more susceptible to impacts from boat traffic. Peak pleasure craft activity is anticipated during the summer, so associated impacts are likely to follow this seasonal pattern. It is difficult to be more specific about the potential impacts from boats and how they may affect the sampling plan without any firm information about the locations, timings and volumes of such discharges.

[3] The Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008

APPENDIX V
SOURCES AND VARIATION OF MICROBIOLOGICAL POLLUTION: WILDLIFE

Langstone Harbour contains a diversity of habitats including, intertidal mudflats (covering the largest area), seagrass meadows, Atlantic saltmarsh and shingle ridges. There are also three small rocky islands located in the northern part of the harbour estuary. The rich shoreline and intertidal areas of Langstone Harbour attracts significant numbers of birds and other wildlife. Consequently it has been designated as a conservation area falling under SPA, SSSI, SAC, Ramsar and SEMS protecting Langstone's wildlife and habitats.

Studies in the UK have found significant concentrations of microbiological contaminants (thermophilic *Campylobacter*, salmonellae, faecal coliforms and faecal streptococci) from intertidal sediment samples supporting large communities of birds (Obiri-Danso and Jones, 2000). Langstone Harbour has been ranked 10th in the UK for most important places for birds with some of the largest colonies, within the UK of little terns and Brent geese (Langstone Harbour Board, 2012b). Other species include dunlin, black-tailed godwit, black headed gull, Mediterranean gull and egret.

An average total count of 27,344 waterbirds (wildfowl and waders) was reported over the five winters up to 2010/11 for Langstone Harbour (Holt *et al*, 2011). Brent geese migrate to Langstone Harbour in their thousands (up to 10% of the world's population) from the Arctic in the autumn and remain until early spring. Many congregate on and around the Farlington Marshes; a RSPB reserve located on the northern shore consisting of grasslands. Brent geese and other overwintering geese and ducks will mainly frequent the grassland and saltmarsh, where their faeces will be carried into coastal waters via runoff into tidal creeks or through tidal inundation. Therefore RMPs within or near to the drainage channels from saltmarsh areas will be best located to capture contamination from this source. Waders, such as dunlin and oystercatchers forage upon shellfish and so will forage (and defecate) directly on the shellfish beds throughout the whole intertidal area. They may tend to aggregate in certain areas holding the highest densities of bivalves of their preferred size and species, but this will probably vary from year to year. Contamination via direct deposition may be patchy, with some shellfish containing high levels of *E. coli* while others a short distance away are unaffected. Due to the diffuse and spatially unpredictable nature of contamination from wading birds it is difficult to select specific RMP locations to best capture this, although they may well be a significant influence during the winter months.

Birds such as gulls and terns and relatively small numbers of waders remain in the area to breed in the summer, but the majority migrate elsewhere outside of the winter months. Bird numbers and potential impacts on the hygiene status of the fisheries are therefore much lower during the summer. The JNCC Seabird 2000 census recorded 3,570 breeding pairs of gulls and terns within Langstone Harbour, mainly on the islands and at the West Hayling Nature Reserve (Mitchell *et al*, 2004). These seabirds are likely to forage widely throughout the area so inputs could be considered as diffuse, but are likely to be most concentrated in the immediate vicinity of the nest sites. Nesting sites on the islands are above the high water mark which will result in their faeces being carried into coastal waters via runoff into tidal creeks or through tidal inundation.

A seal tagging study undertaken by the South East Wildlife Trust in 2008 confirms that a small colony of harbour seals exists within the Solent, this has been recorded between 23 and 25. On average there were 14 sightings per month of harbour seals and a couple of grey seals have also been sighted within Langstone Harbour, which has been distinguished as one of two significant haul out sights for Harbour Seals. Whilst one of the 5 tagged seals foraged almost exclusively within Langstone Harbour the other 4 covered much wider distances (Wildlife Trusts' South East Marine Programme, 2010). Bottlenose dolphins and harbour porpoises have also been sighted within Langstone Harbour but their numbers are not known, it is unlikely that their numbers will be significant. Seals, dolphins and porpoises will enter Langstone Harbour from time to time but only in small numbers and their presence will be unpredictable both spatially and temporally. Consequently the presence of seals, dolphins and porpoises will not influence the sampling plan.

Otters, water voles, roe deer and foxes are all present within Langstone Harbour (Langstone Harbour Board, 2012c). No information on numbers was available but the populations are likely to be small. Otters and water voles generally tend to favour the more secluded areas with access to watercourses. However, given their likely wide distribution and small numbers they have no material bearing on the sampling plan. Rats will also be present within the survey area, possibly in quite large numbers, particularly in the urban areas. Potentially they could be a source of microbiological contamination within the shellfish area, but numbers are not known and given their wide distribution it means they may impact on watercourses and all along the nearshore zone.

No other wildlife species which have a potentially significant influence on levels of contamination within shellfish within the survey area have been identified. Dog walking takes place along coastal path that runs adjacent to the shoreline of the Harbour this could represent a potential source of diffuse contamination to the near shore zone.

APPENDIX VI
METEOROLOGICAL DATA: RAINFALL

The Havant weather station, received an average of 677 mm of rainfall per year between 2003 and 2012. Figure VI.1 presents a boxplot of daily rainfall records by month at Havant.

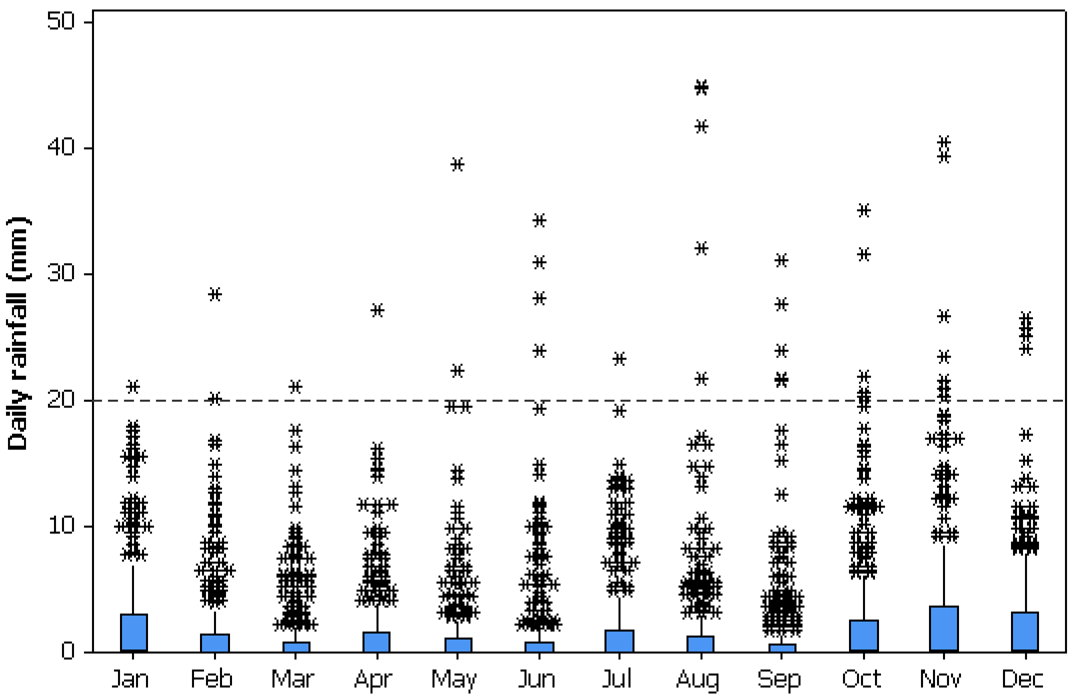

Figure VI.1 Boxplot of daily rainfall totals at Havant, January 2003 to August 2012.
Data from the Environment Agency

Rainfall records from Havant, which is representative of conditions in the vicinity of the shellfish beds, indicate relatively low seasonal variation in average rainfall. Rainfall was lowest on average in March and highest on average in November. Daily totals of over 20 mm were recorded on 1.1% of days and 55% of days were dry. High rainfall events occurred in all months, but were more frequent in the second half of the year.

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

APPENDIX VII
METEOROLOGICAL DATA: WIND

Southern England is one of the more sheltered parts of the UK (Met Office, 2012). The strongest winds are associated with the passage of deep areas of low pressure close to or across the UK. The frequency and strength of these depressions is greatest in the winter from December to February, and this is when mean speeds and gusts are strongest (Met Office, 2012).

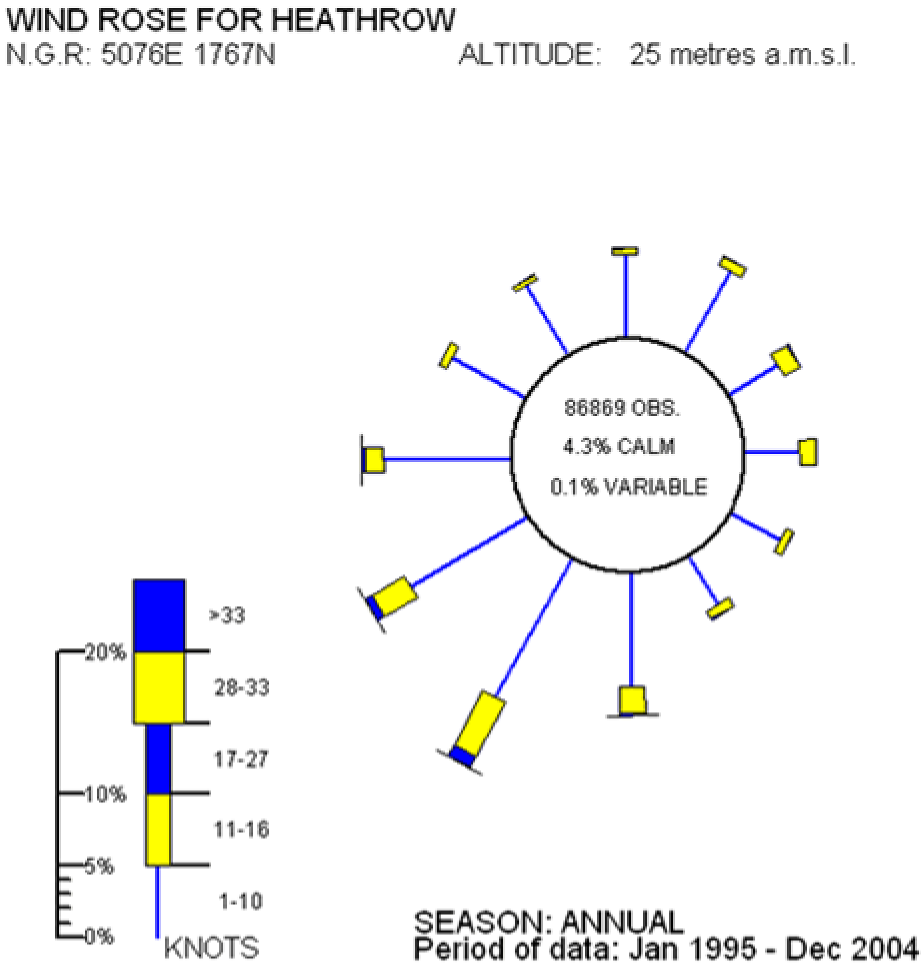

Figure VII.1 Wind rose for Heathrow.
Produced by the Meteorological Office. Contains public sector information licensed under the Open Government Licence v1.0

The wind rose for Heathrow is typical of open, level locations in southern England (Met Office, 2012). The prevailing wind direction is from the south west and the strongest winds usually blow from this direction. A higher frequency of north easterly winds occurs during spring. Coastal locations will receive sea breezes between the late spring and summer months originating from the North Sea and occasionally, the English Channel (Met Office, 2012). Langstone Harbour is a partially enclosed inlet with a narrow mouth that faces south, the land on the south eastern side of the harbour will offer some shelter to areas of the harbour directly adjacent. However, the land surrounding Langstone Harbour is relatively low lying consequently the majority of Langstone Harbour will be exposed to the prevailing winds.

APPENDIX VIII
HYDROMETRIC DATA: FRESHWATER INPUTS

The catchment area draining Langstone harbour covers approximately 190 km^2 as illustrated in Figure VIII.1. The extent of this was estimated from topography shown on Ordnance Survey maps. The northern reaches of the catchment are underlain by chalk of the South Downs and as such, flows of water through the upper catchment are via chalk aquifers, and only re-emerge as surface streams in the lower catchment where the geology changes. It is possible that the topographical catchment does not fully align with the groundwater catchment. The flow of groundwater through aquifers is typically very slow, from 1 m/year to 1 m/day (Environment Agency, 2011) and such lengthy travel times suggest little microbial contamination would survive passage. A retention time of 50 days is deemed sufficient to remove microbial contamination from groundwater flows.

Further South, the catchment is underlain by Reading and London Clay (Jones and Robins 1999) and at this point springs emerge and watercourses carry significant surface flows. Two main watercourses flow into Langstone harbour from the north; both of which flow through the town of Havant. The Hermitage flows beneath the A3(M) and discharges at mean high water next to Budds Farm sewage works at Brockhampton. The Lavant discharges at Langstone. There is another similar watercourse (the Ems) discharging to the north shore of the Emsworth Channel, and its proximity to the entrance of Langstone Harbour makes it a potential source of contamination.

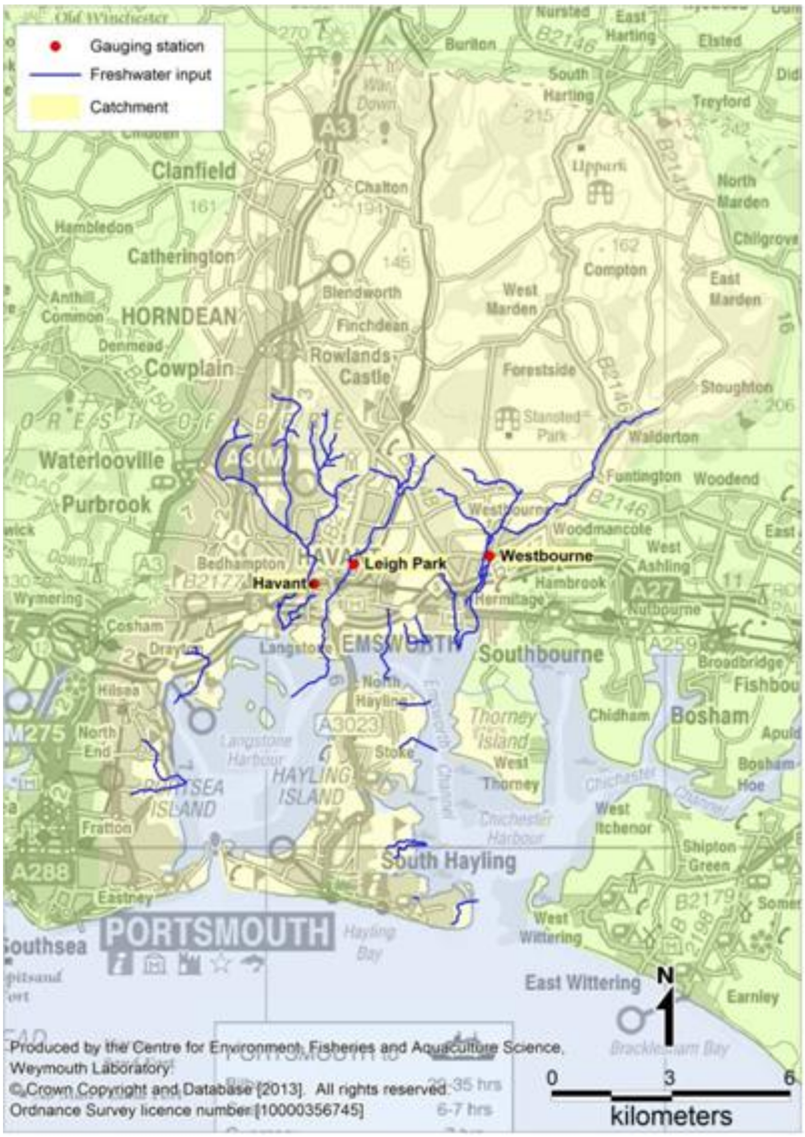

Figure VIII.1 Watercourses within the survey catchment area

These rivers will receive microbiological pollution from point and diffuse sources such as STW discharges and urban and agricultural runoff. They are therefore potentially a significant source of microbiological contamination for the shellfisheries in the harbour. Summary statistics for 3 of the flow gauges on these rivers are presented in Table VIII.1 for the period January 2002 to September 2012 (Hermitage and Ems) and January 2012 to June 2006 (Lavant).

Table VIII.1 Summary flow statistics for flow gauge stations on watercourses draining into the Langstone Harbour, 2003-2012

Watercourse	Station name	Catchment area (km^2)	Mean flow (m^3s^{-1})	Q95[1] (m^3s^{-1})	Q10[2] (m^3s^{-1})
Hermitage	Havant	17.0	0.184	0.022	0.418
Lavant Stream	Leigh Park	54.5	0.089	0.002	0.208
Ems	Westbourne	58.3	0.450	0.015	1.230

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

The Lavant Stream has relatively low flow for its catchment size. This is due to a flood relief culvert which diverts flows to the Hermitage stream to reduce the risk of flooding in Havant town centre (Havant Borough Council, 2012b). Boxplots of mean daily flow record by month at Havant, Leigh Park and Westbourne gauging stations are presented in Figures VIII.2 to VIII.4.

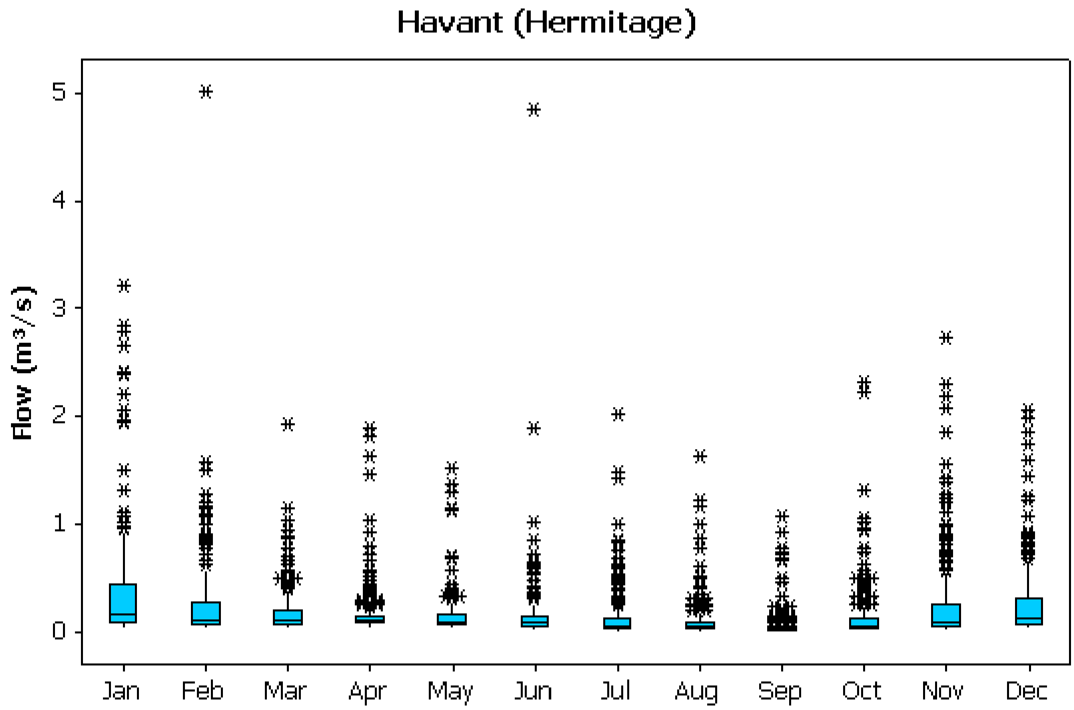

Figure VIII.2 Boxplots of mean daily flow records from the Havant gauging station on Hermitage stream from 2003 - 2012

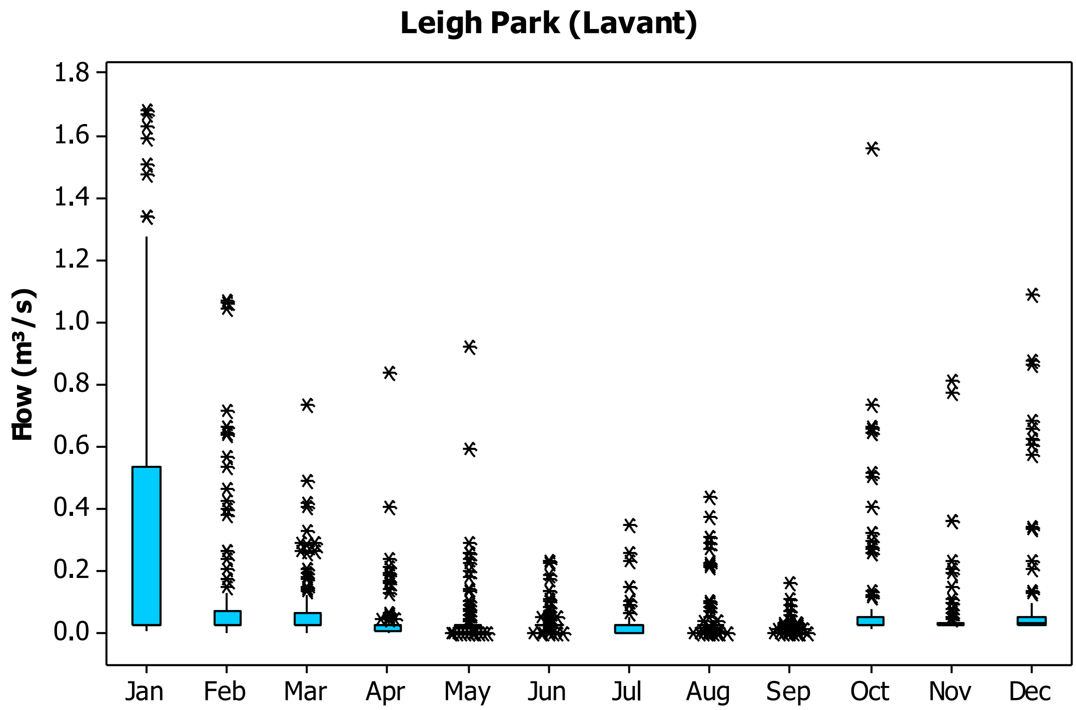

Figure VIII.3 Boxplots of mean daily flow records from the Leigh Park gauging station on Lavant stream from 2003 - 2006

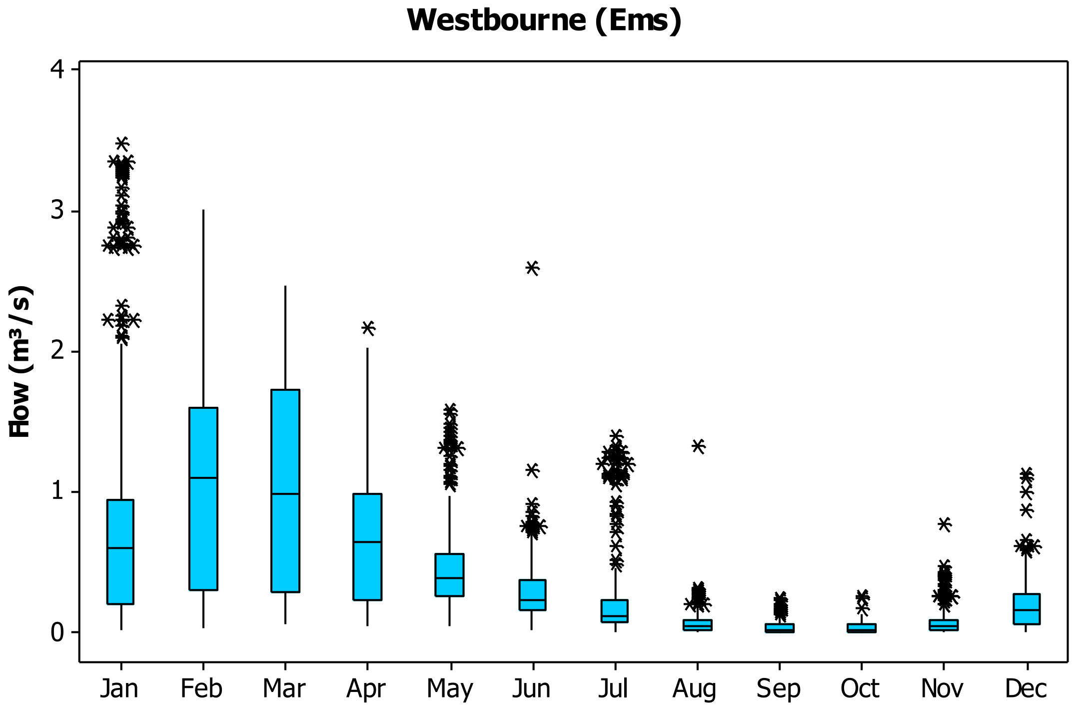

Figure VIII.4 Boxplots of mean daily flow records from the Westbourne gauging station on the River Ems from 2003 - 2012

Flows were highest in the colder months at Havant and Leigh Park. However, at Westbourne, high flows occurred throughout winter and spring, peaking in March. Water is abstracted from aquifers supplied by the River Ems and to a smaller extent from the River Ems itself. Abstractors are required to augment the river with 0.016 m^3/s when flows of less than 0.032 m^3/s are recorded at the Westbourne gauging station. However it has been reported that during periods of low flow the augmented flows do not reach Westbourne (Holmes, 2007).

The seasonal pattern of flows is not entirely dependent on rainfall as during the colder months there is less evaporation and transpiration, leading to a higher water table. This in turn leads to a greater level of runoff immediately after rainfall. Increased levels of runoff are likely to result in an increase in the amount of microorganisms carried into coastal waters. Additionally, higher runoff will decrease residence time in rivers, allowing contamination from more distant sources to have an increased impact during high flow events.

Figure VIII.5 and Table VIII.2 show the *E. coli* loadings measured during the shoreline survey of Langstone harbour. The Brockhampton Stream had the highest *E. coli* loading, which was about an order of magnitude higher than the Lavant Stream. It was not possible to sample and measure the Hermitage as it could not be accessed safely.

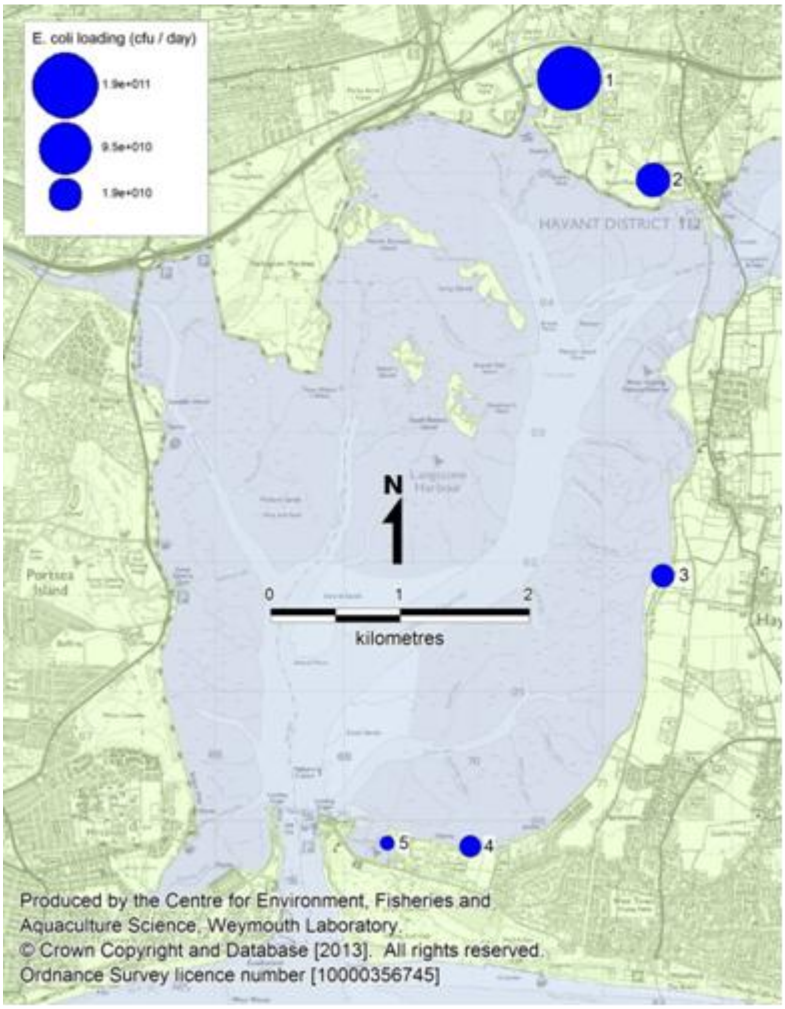

Figure* VIII.5 *Measured stream loadings from shoreline survey

Table VIII.2* E. coli *sample results, measured discharge and calculated* E. coli *loadings

No.	Name	Date & time	*E. coli* (cfu/100 ml)	Measured discharge (m³/day)	*E. coli* (cfu/day)
1	Brockhampton Stream	24/10/2012 11:20	3,200	5,723	1.83×10^{11}
2	Lavant Stream	24/10/2012 13:30	190	11,569	2.20×10^{10}
3	Unnamed watercourse	25/10/2012 10:33	550	1,116	6.14×10^{9}
4	Unnamed watercourse	25/10/2012 12:05	1,300	403	5.24×10^{9}
5	Unnamed watercourse	25/10/2012 12:30	120	1,050	1.26×10^{9}

As well as natural streams, Portsea Island and some parts of Hayling Island and the mainland (Farlington Marshes) are drained by a series of engineered outfalls and pipes. Some of these were flowing and accessible, and so were sampled and measured during the shoreline survey. Those carrying significant loadings or concentrations of *E. coli* were an outfall at Newton on Hayling Island (1.70×10^{11} *E. coli*/day), an outfall at Milton on Portsea Island (5.26×10^{11} *E. coli*/day), and an outfall to Eastney Lake at Eastney carrying 600,000 *E. coli*/100ml that was not possible to measure discharge for (Appendix XII). Also, there is a pumped outfall from Salterns Lake, through which a significant part of Portsea Island drains (Halcrow, 2011) which will operate intermittently, but this was not discharging at the time of shoreline survey.

In conclusion, freshwater inputs into Langstone harbour are relatively minor. Most of the inputs in terms of volumes enter the harbour at its northern shore, although there are smaller inputs at various locations around the harbour. Sources of contamination in the upper catchment are unlikely to have a significant impact on the harbour as most of this water will have been filtered through chalk before it enters the watercourses. However, due to the routes of these watercourses through urban areas in the lower catchment, they may carry high levels of contamination.

APPENDIX IX
HYDROGRAPHY

BATHYMETRY

Source data for part of the admiralty chart presented in Figure IX.1 were mainly gathered in the 1980's therefore the bathymetry may be slightly different now. However important features discussed below are unlikely to have significantly changed.

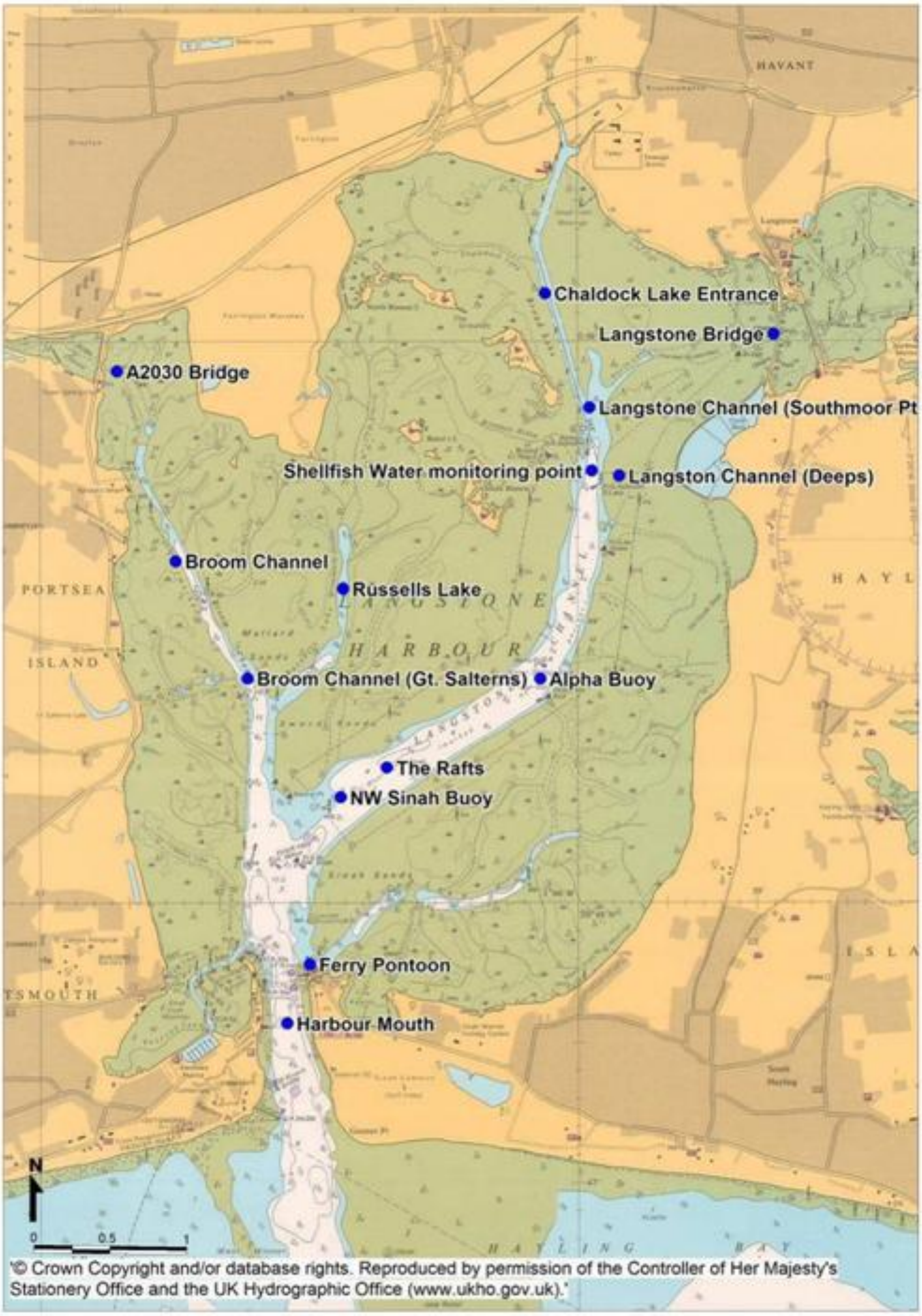

Figure IX.1 Bathymetry chart of Langstone Harbour with salinity sampling sites

Langstone Harbour is a partially enclosed tidal inlet, approximately 4 km from east to west and 5 km from north to south, with a relatively deep (13 m below CD) and narrow mouth flanked by sand/gravel spits on either side. The channel splits and shallows towards the head of the harbour. A series of intertidal muddy creeks of varying sizes drain into the deeper channels. Channels to Kendall's Wharf, Bedhampton Quay and Southsea Marina are maintained by dredging. A narrow, shallow passage on the north western side connects Langstone Harbour to Portsmouth Harbour at high water and on the north eastern side a wider, deeper wider passage connects Langstone and Chichester Harbour. Consequently there is more potential for water exchange with Chichester Harbour than Portsmouth Harbour. Most of the harbour is intertidal, consisting largely of mudflats, with saltmarsh at higher elevations (Futurecoast, 2002) Sediments are progressively finer away from the mouth suggesting current speeds are lower in the inner reaches. Approximately 80% of the total area is exposed at low water on spring tides (Soulsby *et al*., 1985) so a large proportion of water will be exchanged each tide, but dilution potential will be quite low away from the main channels. A dilution factor from the Budds Farm outfall of only 50 is reported for most of the north east part of the harbour, whereas a minimum dilution factor of 500 is reported from the Fort Cumberland outfall at the mouth (Southern Water Services, 1997).

The majority of the perimeter of the harbour is protected by walls, revetments or gabions preventing flooding to the coastal areas, and some parts of Portsea Island are reclaimed land. The saline lagoons at the old oyster beds, now a nature reserve, hold water at all states of the tide. There are three small rocky islands and the Farlington Marshes in the north which are not covered on a spring high water tide.

HYDROGRAPHY

Currents in coastal waters are predominantly driven by a combination of tide, wind and freshwater inputs. Langstone Harbour is meso-tidal with a tidal range on spring tides of 4.4 m at Northney, by Langstone Bridge. There is some tidal asymmetry within Langstone Harbour, with a slight stand during the early flood.

Table IX.1 Tide levels and ranges within Langstone Harbour.

	Height (m) above Chart Datum				Range (m)	
Port	MHWS	MHWN	MLWN	MLWS	Springs	Neaps
Northney	4.9	3.8	1.7	0.5	4.4	2.1

Data from the Proudman Oceanographic Office

There are two tidal diamonds within Langstone Harbour, one of which is at the entrance and the other is in the main Langstone Channel where it splits from the Broom Channel. Tidal stream information from these is presented in Table V.3.

Table IX.2 Tidal stream predictions for Langstone Harbour.

Time before /after high water (hrs)	Station C (entrance)			Station D (Langstone Channel)		
	Direction (°)	Rate (m/s) Spring	Rate (m/s) Neap	Direction (°)	Rate (m/s) Spring	Rate (m/s) Neap
HW-6	5	0.2	0.1	45	0.2	0.1
HW-5	3	0.4	0.2	45	0.3	0.2
HW-4	5	0.8	0.4	45	0.3	0.2
HW-3	354	1.4	0.7	45	0.5	0.3
HW-2	353	1.7	0.9	45	0.7	0.4
HW-1	355	1.0	0.5	45	0.4	0.2
HW	-	0.0	0.0	225	0.2	0.1
HW+1	171	0.8	0.4	225	0.2	0.1
HW+2	167	1.6	0.8	225	0.3	0.2
HW+3	171	1.5	0.7	225	0.8	0.4
HW+4	157	0.9	0.5	225	0.7	0.4
HW+5	171	0.3	0.2	225	0.1	0.1
HW+6	-	0.0	0.0	45	0.2	0.1

Data from the Admiralty Chart 3418 (Langstone and Chichester Harbours)

Table IX.2 indicates that tidal streams move into the harbour and up the channels on the flood, with the reverse occurring on the ebb. Currents are strongest at the harbour entrance, peaking at 1.7 m/s towards the end of the flood on spring tides. In the Langstone channel, peak current velocities (0.8 m/s) arise during the ebb on spring tides. Current velocities are about half this on neap tides. The principal tidal streams follow the main channels, with slower flows where the water spreads over the intertidal areas. Modelling studies indicate that at spring tides the highest speeds occur in the harbour entrance (over 2 m/s) and diminish within the main channels (generally less than 1.2 m/s). Slower speeds of less than 0.4 m/s occur elsewhere in the harbour in shallower water, and currents are slowest (0.2 m/s) towards the eastern and north-eastern portions of Langstone Harbour (Halcrow, 2009).

On spring tides the volume of water in the harbour increases from 8.76 million m^3 at low tide to 66.57 million m^3 at high tide and on neap tides it increases from 15.53 million m^3 to 45.81 million m^3 (Southern Water Services, 1997). Therefore, most of the water in the harbour is exchanged during the course of a tide so contaminants will generally be flushed rapidly from the harbour, particularly from sources nearer its mouth. Although the vast majority of water exchange occurs via the mouth, some exchange of water through the secondary connections to Portsmouth and Chichester Harbour has been documented. These exchanges are in an overall westerly direction, and have been estimated respectively at 1.5% and 7% of tidal prism for Langstone Harbour on spring tides (Portsmouth Polytechnic, 1976). Therefore, contamination from sources within Portsmouth Harbour is unlikely to be of significance to Langstone Harbour, whereas contamination from the Emsworth Channel in Chichester Harbour is of potential significance, particularly to any fisheries in the north east corner of Langstone Harbour.

In addition to tidally driven currents are the effects of freshwater inputs and wind. The flow ratio (freshwater input: tidal exchange) is very low and the system is well mixed (Futurecoast, 2002), so density driven circulation is unlikely to modify tidal circulation. Salinity measurements taken between 2002 and 2012 at a number of points within the harbour indicate average salinities approaching that of full strength seawater throughout (Table IX.3).

Table IX.3. Summary statistics for salinity readings taken in Langstone Harbour 2002-2012.

Site	No.	Mean	Minimum	Maximum
A2030 Bridge	95	34.2	32.2	35.5
Alpha Buoy	95	34.2	32.2	35.4
Broom Channel (Gt. Salterns)	95	34.4	32.9	35.3
Broom Channel	95	34.1	17.0	35.3
Chaldock Lake Entrance	95	33.4	20.5	35.2
Ferry Pontoon	42	33.7	12.0	35.1
Langstone Bridge	95	33.6	30.6	35.4
Langstone Channel (Southmoor Pt.)	95	33.9	31.2	35.7
Langston Channel (Deeps)	67	34.2	32.0	35.4
Shellfish Water monitoring point	105	33.9	30.4	35.5
Harbour Mouth	105	34.3	32.9	35.3
NW Sinah Buoy	95	34.3	32.9	35.3
Russells Lake	95	34.3	32.8	35.4
The Rafts	119	34.3	31.5	36.1

Data from the Environment Agency

Only three of the 1293 measurements showed salinities of less than 30 ppt, and these arose at different sites and on different days. It is therefore concluded that freshwater influence is low, and varies little throughout the harbour. One density effect of potential relevance is the tendency for sewage effluents to be buoyant and rise to the surface, which will tend to keep the sewage separate from benthic shellfish stocks in the deeper areas.

Strong winds will modify surface currents. 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) would drive a surface water current of about 1 knot or 0.5 m/s. These currents in turn drive return currents which may travel lower in the water column or along sheltered margins. The prevailing south westerly winds will tend to push surface water in a north easterly direction. Exact effects are dependent on the wind speed and direction as well as state of the tide and other environmental variables so a great range of scenarios may arise. Where strong winds blow across a sufficient distance of water they may create wave action, and where these waves break contamination held in intertidal sediments may be resuspended, although given the enclosed nature of the harbour strong wave action is not anticipated.

APPENDIX X
MICROBIOLOGICAL DATA: SEAWATER

There are no bathing water sites designated under the Directive 76/160/EEC (Council of the European Communities, 1975) within Langstone Harbour. However, *E. coli* levels within the harbour were monitored at five points from 2002 to 2005 by Portsmouth Port Health Authority.

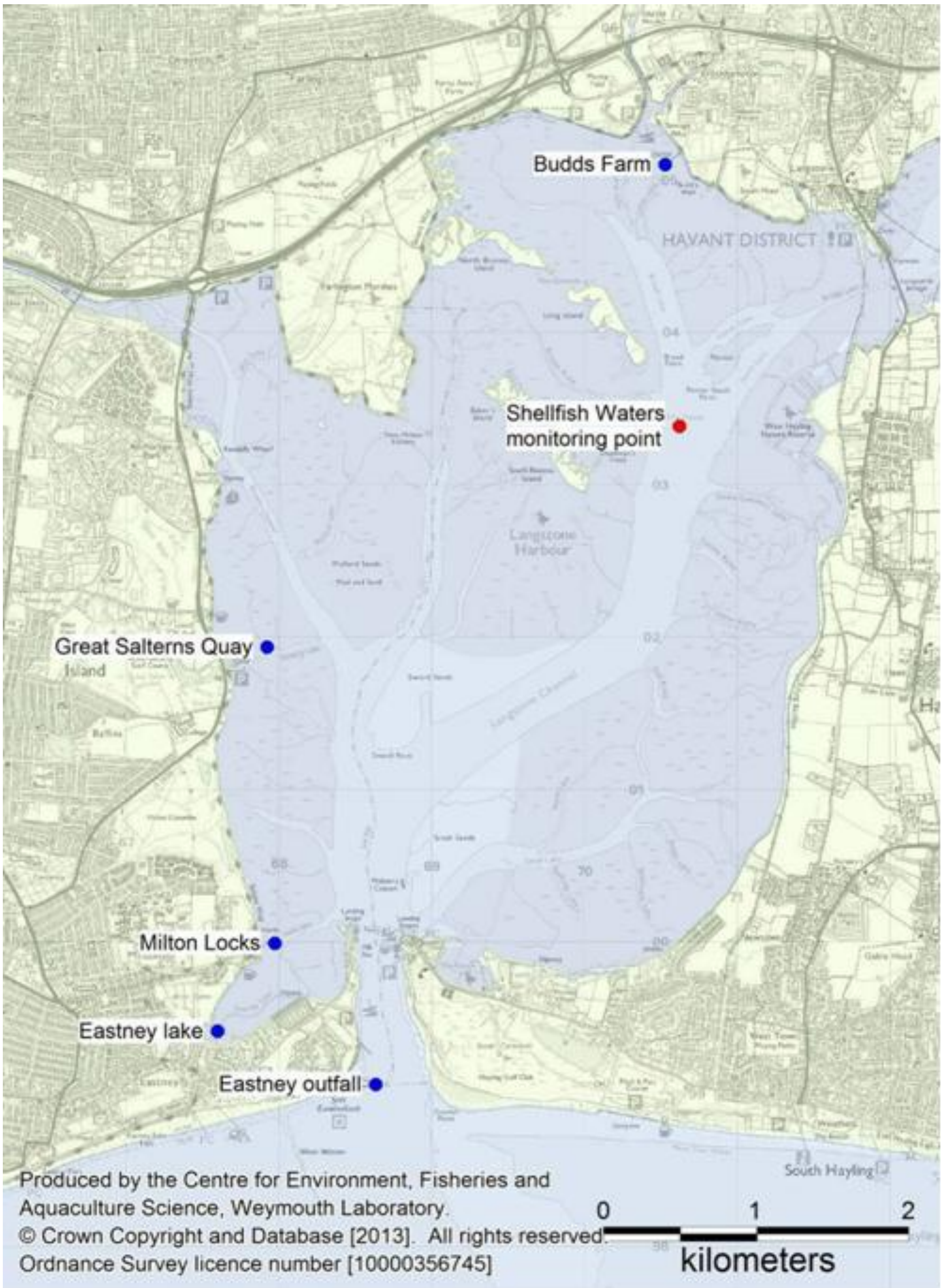

Figure X.1 Location of Portsmouth Port Health and shellfish water sampling points.

Around twelve samples were taken each year from each Port Health sampling point between 2002 and 2004 and around five samples were taken from each site in 2005.

Table X.1 and Figure X.2 and X.3 summarises the levels of *E. coli* found at these sites.

Table X.1 Summary statistics for Langstone Harbour* E. coli *results, 2002-2005 (cfu/100 ml).

Site	n	Geo-mean	Min.	Max.	% exceeding 100 cfu/100 ml	% exceeding 1000 cfu/100 ml
Eastney Outfall	42	19.0	10	790	9.5	0.0
Eastney Lake	40	51.1	10	2,400	32.5	5.0
Milton Locks	42	25.2	10	430	16.7	0.0
Great Salterns Quay	41	22.0	10	360	14.6	0.0
Budds Farm	42	86.9	10	23,000	38.1	14.3

Data from Portsmouth Port Health Authority

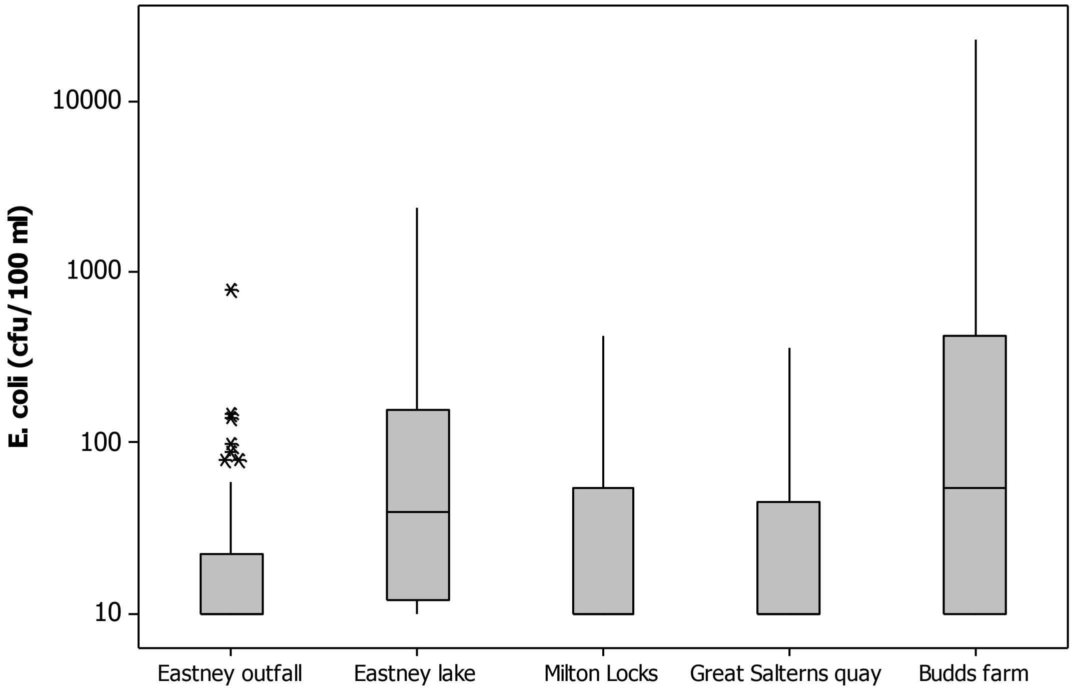

Figure X.2 Box-and-whisker plots of all* E. coli *results by site
Data from Portsmouth Port Health Authority

Comparisons of the results found significant differences in levels of *E. coli* between the sites (two-way ANOVA, p<0.001). Post ANOVA tests (Tukey's comparison) showed that Budds Farm and had Eastney Lake significantly higher levels of *E. coli* than the other three sites. Highest peak results were recorded at Budds Farm.

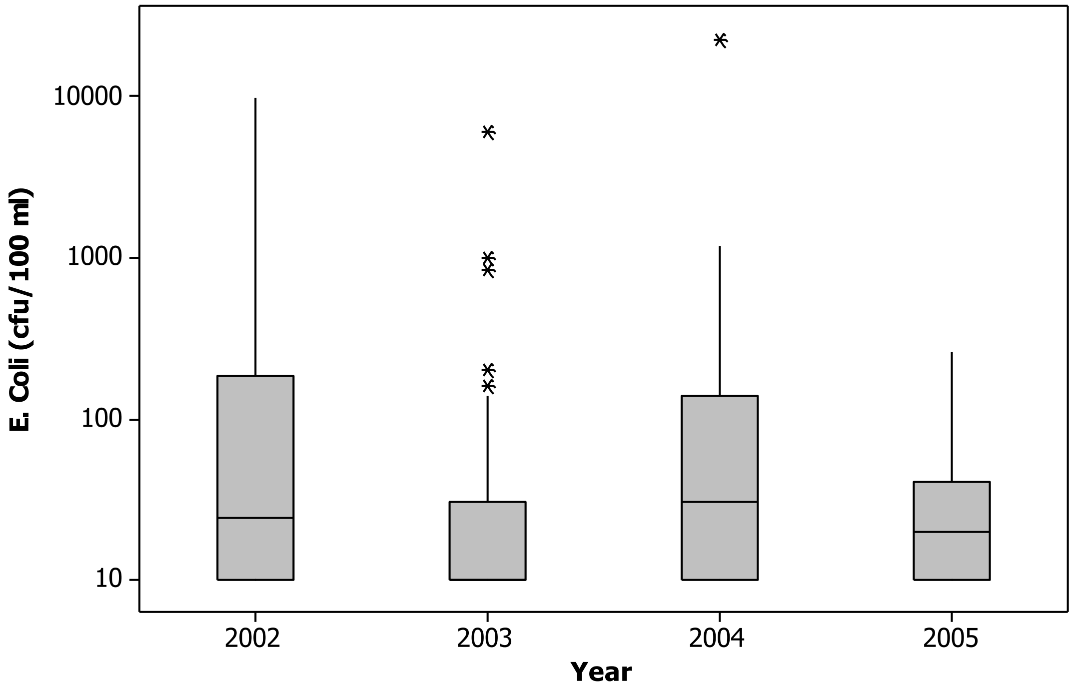

Figure X.3 Box-and-whisker plots of all* E. coli *results by year
Data from Portsmouth Port Health Authority

Comparisons of the results found significant differences in levels of *E. coli* between sampling years (two-way ANOVA, p=0.006 respectively). Post ANOVA tests (Tukey's comparison) showed that there were significantly higher levels of *E. coli* in 2002 than 2003.

To investigate the effects of tidal state on *E. coli* results, circular-linear correlations were carried out against the spring/neap tidal cycle for the Langstone Harbour sampling points. Correlation coefficients are presented in Table X.2, significant results (p<0.05) are highlighted in yellow. All of the significant results were at sites located along the western shore of the harbour. It was not possible to investigate the pattern of results against the high/low tidal cycle as exact times of sample collection were not recorded.

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

Site	n	r	p
Eastney outfall	42	0.160	0.370
Eastney lake	40	0.481	<0.001
Milton locks	42	0.430	0.001
Great Salterns quay	41	0.481	<0.001
Budds farm	42	0.277	0.050

Data from Portsmouth Port Health Authority

Figure X.4 presents polar plots of *E. coli* results against the lunar spring/neap cycle, where a statistically significant correlation was found. 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. Results of 100 faecal coliforms/100 ml or less are plotted in green, those from 101 to 1000 are plotted in yellow, and those exceeding 1000 are plotted in red.

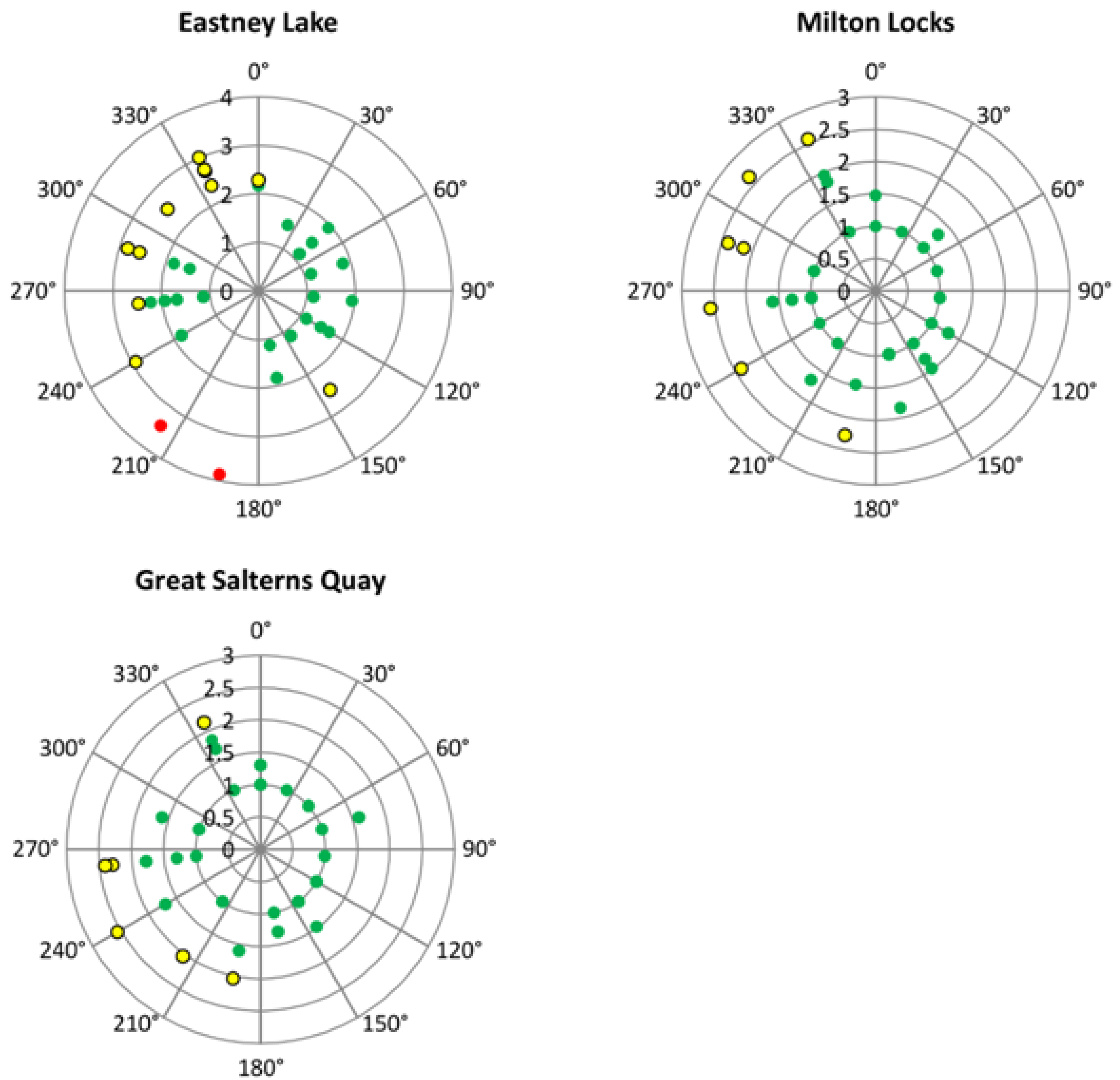

Figure X.4 Polar plots of log_{10}* E. coli *against tidal state on the spring/neap tidal cycle for monitoring points with significant correlations

The polar plots in Figure X.4 show a clear tendency for higher results during neap tides and tides of increasing size.

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

Table X.4 Spearman's Rank correlation coefficients for* E. coli *results against recent rainfall

	Site	Eastney Outfall	Eastney Lake	Milton Locks	Great Salterns Quay	Budds Farm
	n	42	40	42	41	42
24 hour periods prior to sampling	1 day	0.369	0.198	0.363	0.187	-0.049
	2 days	0.384	0.191	0.369	0.200	-0.047
	3 days	0.378	0.152	0.379	0.131	0.014
	4 days	0.280	0.130	0.246	0.072	-0.072
	5 days	0.284	0.110	0.230	0.051	-0.067
	6 days	0.336	0.228	0.256	0.084	-0.055
	7 days	0.314	0.227	0.154	-0.025	-0.059
Total prior to sampling over	2 days	0.375	0.199	0.369	0.194	-0.051
	3 days	0.372	0.191	0.375	0.185	-0.050
	4 days	0.371	0.193	0.376	0.183	-0.053
	5 days	0.372	0.189	0.372	0.180	-0.054
	6 days	0.336	0.122	0.323	0.191	-0.079
	7 days	0.373	0.139	0.263	0.133	-0.085

Data from Portsmouth Port Health Authority & Environment Agency

Table X.4 shows that rainfall influences *E. coli* levels most heavily at Eastney outfall, in the mouth of the harbour. Significant effects of rainfall only occurred at Eastney Lake 6-7 days after rainfall. The reason for this delay is unclear. High levels of *E. coli* detected at Milton Locks immediately following rainfall is likely due to storm water drains which are located in close proximity to this sampling point and have high *E. coli* loading (Appendix XIII).

Figure X.1 also shows the location of the Langstone Harbour shellfish water monitoring point, designated under Directive 2006/113/EC (European Communities, 2006). Table X.5 presents summary statistics for bacteriological monitoring results from the Langstone Harbour shellfish water monitoring point from 2o03 to 2012 , which was sampled four times a year on a quarterly basis. Only water sampling results are presented as flesh results from the shellfish hygiene monitoring programme (Appendix XII) are used to assess compliance with bacteriological standards in shellfish flesh.

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

Site	n	Geometric mean	Minimum	Maximum	% exceeding 100 cfu/100ml	% exceeding 1000 cfu/100ml
Langstone Harbour	40	6.0	<2	1080	17.5	2.5

Data from the Environment Agency

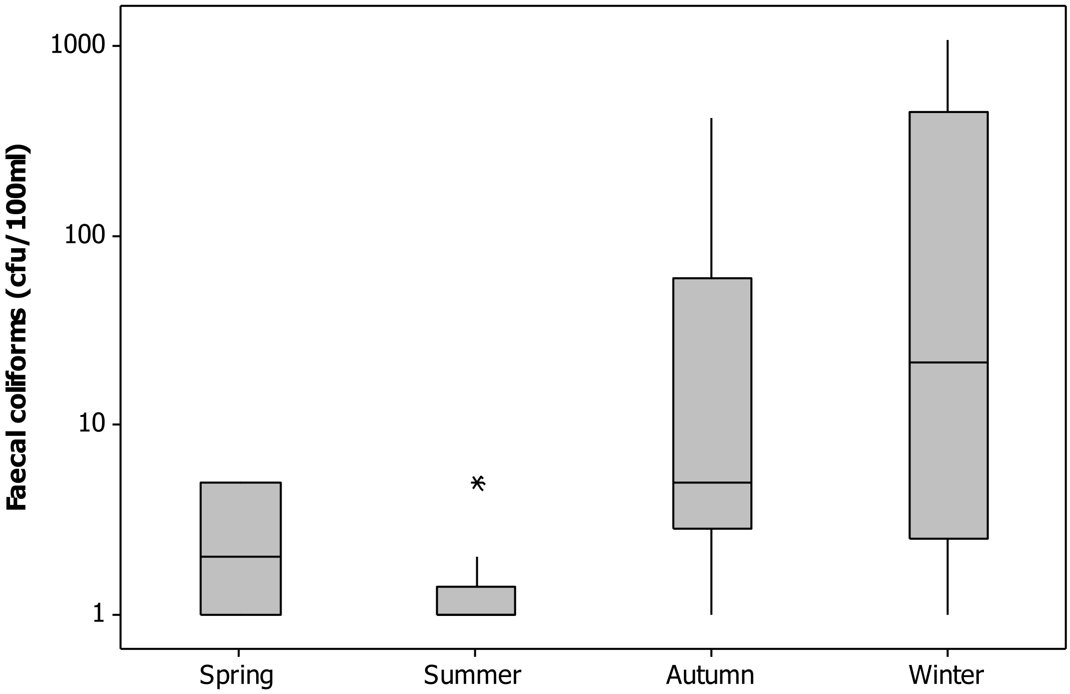

Figure X.5 Boxplot of shellfish growing waters faecal coliforms results by season
Data from the Environment Agency

Figure X.5 indicates that there is strong seasonality in levels of contamination at this monitoring point, with highest results in the winter. A statistically significant difference was found between seasons (One way ANOVA, p=0.001), with results for the winter significantly higher than spring and summer, and results for the autumn significantly higher than for the summer (Tukeys comparison).

A strong correlation was found between faecal coliforms results and the high/low tidal cycle (r=0.357, p=0.009) but not the spring/neap tidal cycle (circular-linear correlation, r=0.185, p=0.282). Figure X.6 presents a polar plot of $\log_{10}$ faecal coliforms results against tidal state on the high/low cycle. High water at Northney is at 0° and low water is at 180°. Results of 100 faecal coliforms/100 ml or less are plotted in green, and those from 101 to 1000 are plotted in yellow.

Although most samples were taken outside of the period around low water, Figure X.6 shows that the high results tended to arise whilst the tide was ebbing or at the lower states of tide.

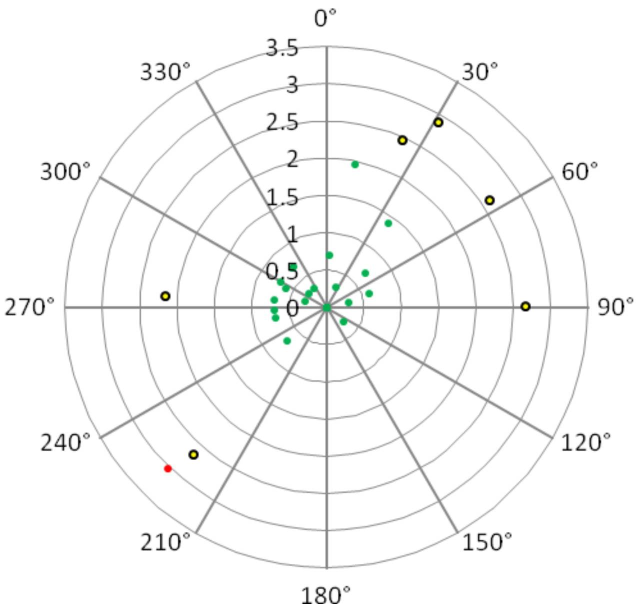

Figure X.6 Polar plots of log_{10} faecal coliforms against tidal state on the high/low tidal cycle for Langstone Harbour shellfish water
Data from the Environment Agency

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

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

		Langstone Harbour
	No.	40
24 hour periods prior to sampling	1 day	0.419
	2 days	0.394
	3 days	0.434
	4 days	0.431
	5 days	0.299
	6 days	0.37
	7 days	-0.002
Total prior to sampling over	2 days	0.436
	3 days	0.509
	4 days	0.486
	5 days	0.461
	6 days	0.454
	7 days	0.298

Data from the Environment Agency

Level of faecal coliforms at the Langstone Harbour shellfish waters site are strongly affected by rainfall for up to 6 days after a rainfall event.

APPENDIX XI
MICROBIOLOGICAL DATA: SHELLFISH FLESH

SUMMARY STATISTICS AND GEOGRAPHICAL VARIATION

The geometric mean results of shellfish flesh monitoring from all RMPs sampled from 2003 onwards are presented in Figure XI.1. Both Salterns South Quay and Milton Lake were only sampled from December 2006 until July 2007. Summary statistics are presented in Table XI.1 and boxplots for sites sampled on 10 or more occasions Figure XI.2.

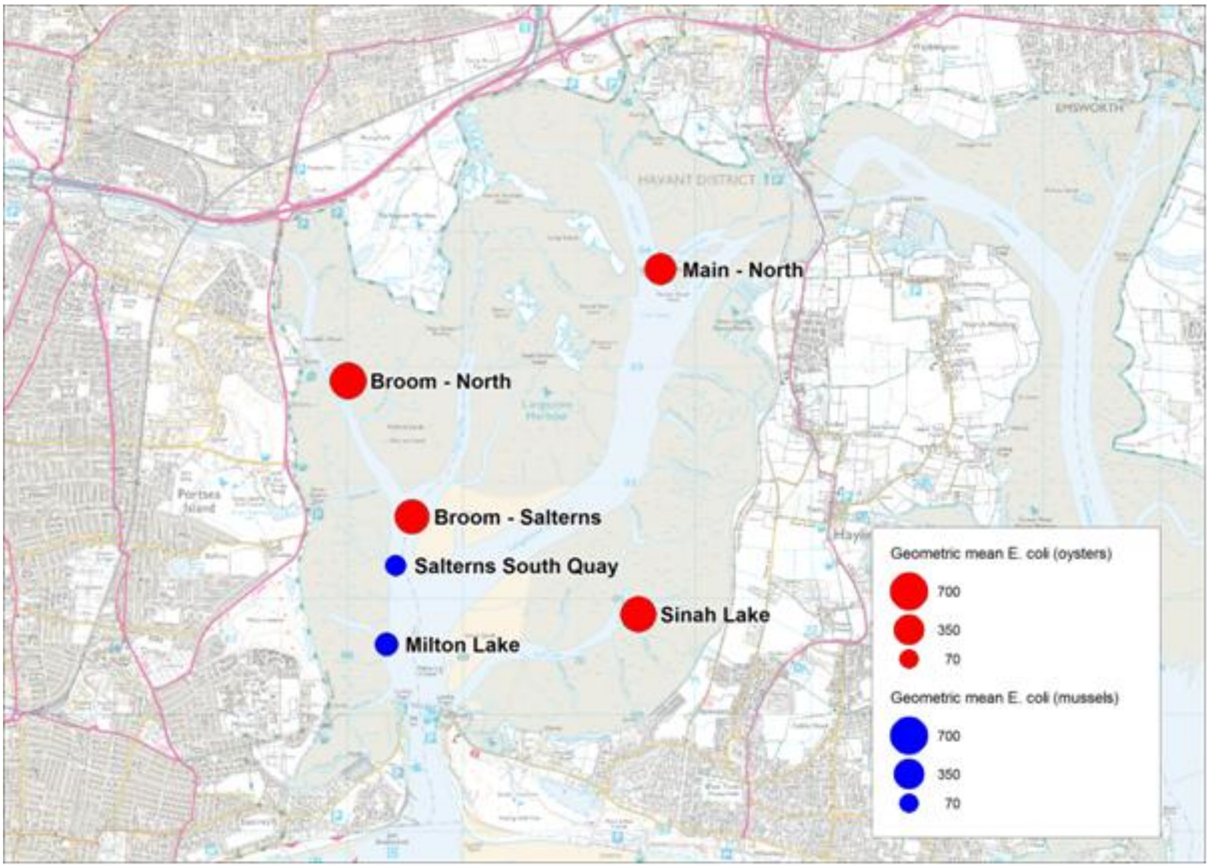

Figure XI.1 RMPs in Langstone Harbour

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

RMP	Species	No.	Date of first sample	Date of last sample	Geom -etric mean	Min.	Max.	% over 230	% over 4600
Main - North	Oysters	115	07/01/2003	06/08/2012	380.8	20	92,000	62.6	13.0
Broom - North	Oysters	115	07/01/2003	06/08/2012	662.6	<20	35,000	74.8	10.4
Broom - Salterns	Oysters	116	07/01/2003	06/08/2012	513.6	20	24,000	75.9	7.8
Sinah Lake	Oysters	114	07/01/2003	06/08/2012	577.0	20	92,000	63.2	11.4
Salterns South Quay	Mussels	9	12/12/2006	09/07/2007	102.5	20	500	33.3	0.0
Milton Lake	Mussels	9	12/12/2006	09/07/2007	128.4	<20	1,300	33.3	0.0

Of these RMPs, two were sampled on less than 10 occasions so will not be considered in detail in the following analyses (Salterns South Quay and Milton Lake)

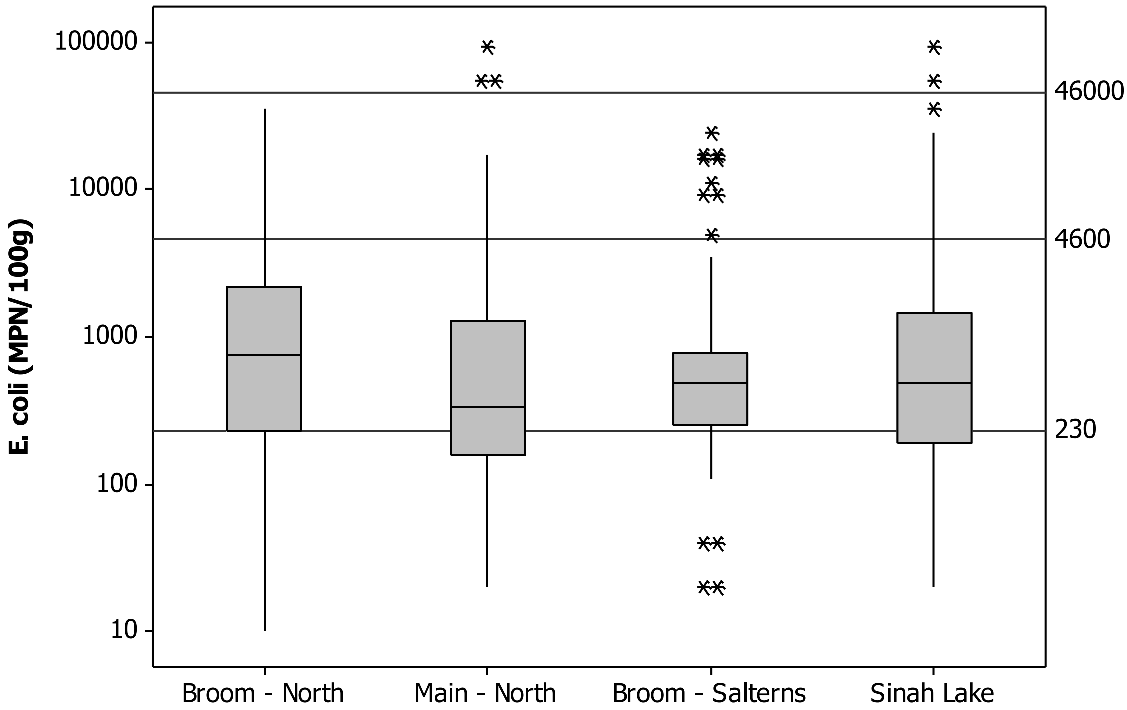

Figure XI.2 Boxplots of* E. coli *results from RMPs sampled on 10 or more occasions from 2003 onwards

Across the four main native oyster RMPs, average results were similar and a comparison of the 109 occasions when all were sampled on the same day showed no significant difference in mean result (Two-way ANOVA, p=0.265). Across the site pairings, there were significant correlations (Pearson's correlation, r=0.447 or greater, p=0.000 for all) between results on a sample by sample basis between all sites pairings, suggesting these four sites are under the influence of similar sources of contamination.

The two RMPs that are located in the eastern part of the channel (Main – North and Sinah Lake) had samples containing more than 46,000 *E. coli*/100 g indicating possible sources of contamination in the main channel and Sinah Lake. They also had slightly higher proportions of results exceeding 4600. Although the differences in the proportion of samples with greater than 4600 *E. coli*/100 g between sites were not significant (Chi^2, p=0.608), the higher proportion exceeding 4600 *E. coli*/100 g, and the presence of occasional prohibited results is likely to have classification implications.

OVERALL TEMPORAL PATTERN IN RESULTS

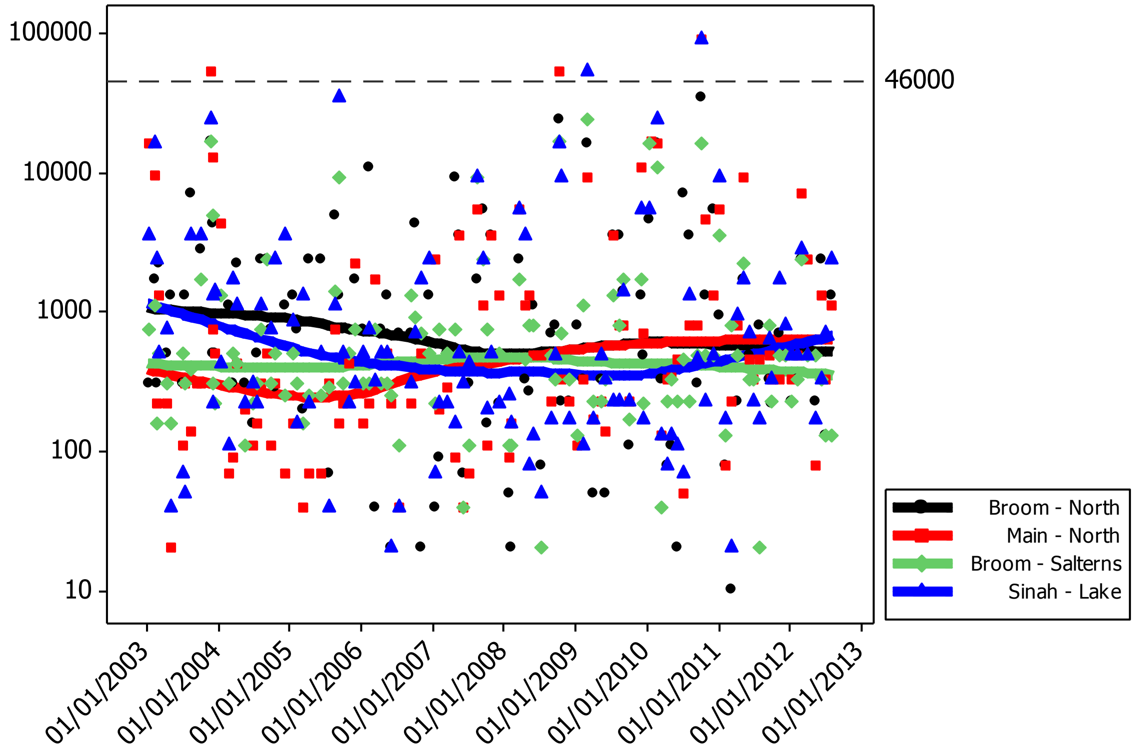

Figure XI.3 Scatterplot of* E. coli *results by RMP and date, overlaid with loess lines for each RMP

Figure XI.3 shows some fluctuations over the years, but there is no consistent pattern apparent across the harbour as a whole. However, Prohibited level results (>46,000 cfu/100 g) were found at Main – North in 2004, 2009 and 2010 and at Sinah Lake in 2009 and 2010. No prohibited levels have been recorded since 2010 at any site.

SEASONAL PATTERNS OF RESULTS

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

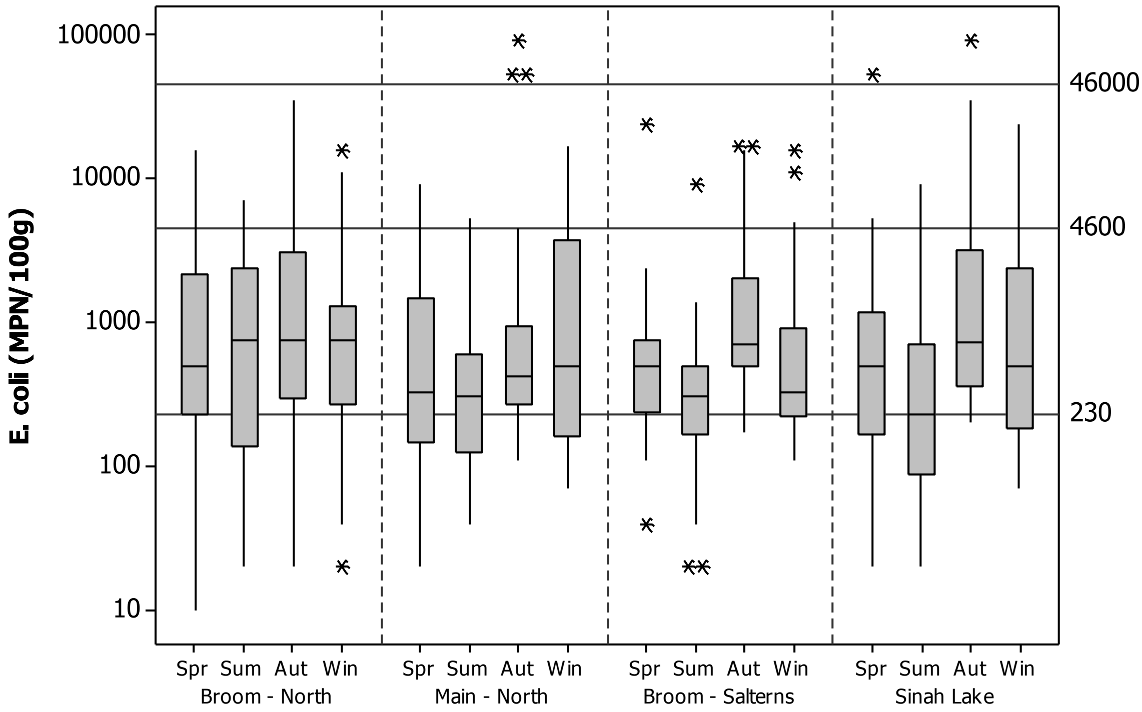

Figure XI.4 Boxplot of oyster* E. coli *results by RMP and season

There was no significant seasonal variation at the two sites on the northern end of the harbour (One way ANOVA, p=0.518 for Broom - North and 0.113 for Main - North). At the southern end significant seasonal variation was found at both RMPs (One way ANOVA, p=0.003 for Broom - Salterns and 0.003 for Sinah Lake). A post ANOVA test (Tukey comparison) indicated that results were significantly higher in the autumn compared to the summer at both these sites, but there were no significant differences between any of the other seasons. This suggests that the north and south sides of the estuary may be subject to differing contaminating influences.

INFLUENCE OF TIDE

To investigate the effects of tidal state on *E. coli* results, circular-linear correlations were carried out against the high/low and spring/neap tidal cycles for each RMP where at least 30 samples had been taken since 2003. The results of these correlations are summarised in Table XI.2, with significant correlations highlighted in yellow.

Table XI.2 Circular linear correlation coefficients (r) and associated p values for* E. coli *results against the high/low and spring/neap tidal cycles

		high/low		spring/neap	
Site	n	r	p	r	p
Broom – North	115	0.128	0.161	0.107	0.277
Main – North	115	0.108	0.272	0.029	0.912
Broom – Salterns	116	0.277	<0.001	0.178	0.028
Sinah Lake	114	0.374	<0.001	0.287	<0.001

Figure XI.5 presents polar plots of $\log_{10}$ faecal coliform results against tidal states on the high/low cycle for the correlations indicating a statistically significant effect. High water at Langstone Harbour is at 0° and low water is at 180°. Results of 230 *E. coli* MPN/100 g less are plotted in green, those from 231 to 4600 are plotted in yellow, and those exceeding 4600 are plotted in red.

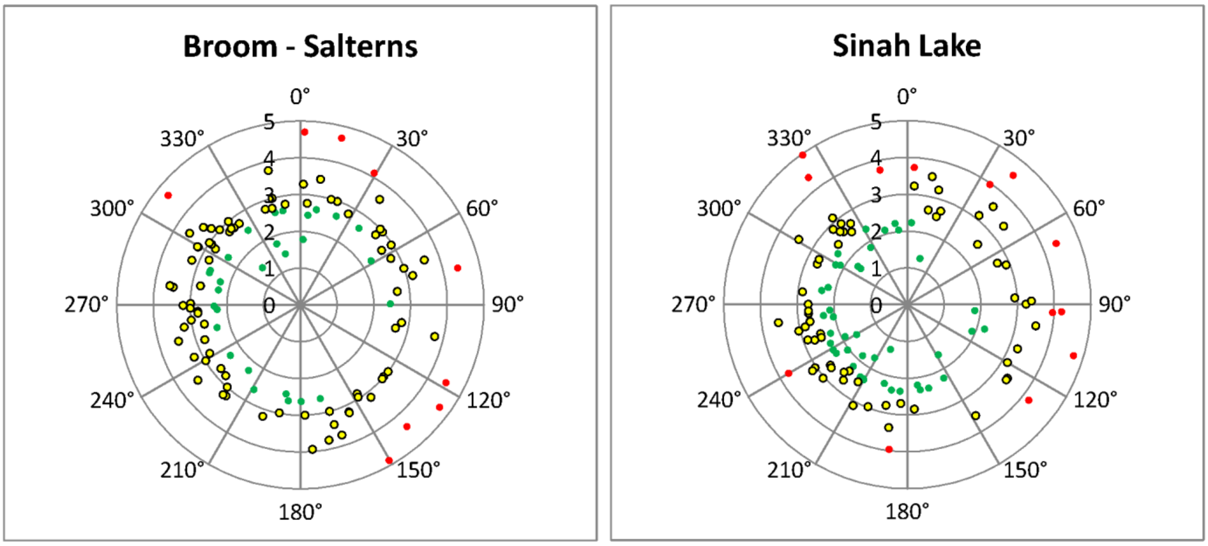

Figure XI.5. Polar plots of log_{10}* E. coli *results (MPN/100 g) against tidal state on the high/low tidal cycle for sampling points with significant correlations

At both these sites there is a clear pattern of higher results throughout the ebb tide. This suggests sources of contamination suggesting sources of contamination further up the tidal channels are a major contaminating influence. No similar effect was found for the sites further to the north, which may possibly be explained by their greater distance from the harbour entrance limiting the influence of cleaner water carried in on the flood tide.

Figure XI.6 presents polar plots of log_{10} *E. coli* results against the spring/neap tidal cycle for those RMPs that showed a significant correlation. Full/new moons occur at 0º, and half moons occur at 180º, and the largest (spring) tides occur about 2 days after the full/new moon, or at about 45º, then decrease to the smallest (neap tides) at about 225º, then increase back to spring tides. Results of 230 *E. coli* MPN/100 g less are plotted in green, those from 231 to 4600 are plotted in yellow, and those exceeding 4600 are plotted in red.

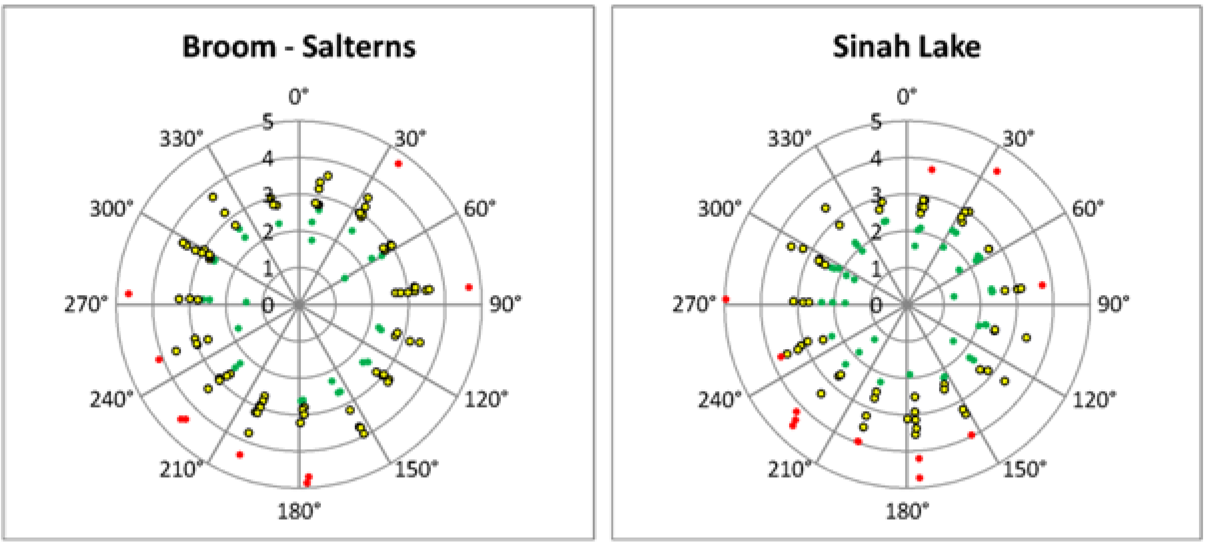

Figure XI.6. Polar plots of log_{10}* E. coli *results (MPN/100 g) against tidal state on the spring/neap tidal cycle for sampling points with significant correlations

At both Broom – Salterns and Sinah Lake, there appeared to be slightly higher levels of contamination on average during neap tides. This may be related to either the smaller amount of flushing or the slower current speeds which occur during such tides. Again, the same effect was not observed at the two RMPs further to the north.

INFLUENCE OF RAINFALL

To investigate the effects of rainfall on levels of contamination within shellfish samples Spearman's rank correlations were carried out between *E. coli* results and rainfall recorded at the Havant weather station (Appendix VI for details) over various periods running up to sample collection. These are presented in Table XI.3, and statistically significant correlations ($p<0.05$) are highlighted in yellow.

Table XI.3 Spearman's Rank correlations between rainfall recorded at Havant and shellfish hygiene results

	Site	North end Main channel	North end Broom channel	Salterns Broom channel	Sinah Lake	Salterns South Quay	Milton Lake
	Species	Native oyster	Native oyster	Native oyster	Native oyster	Mussel	Mussel
	No.	115	115	116	114	9	9
24 hour periods prior to sampling	1 day	0.109	0.008	0.033	0.113	0.458	0.797
	2 days	0.056	0.057	-0.002	0.085	0.381	0.826
	3 days	0.032	-0.015	0.03	-0.001	0.237	0.877
	4 days	0.099	-0.041	0.012	-0.036	0.224	0.882
	5 days	0.051	-0.046	0.016	0.004	0.237	0.877
	6 days	0.094	-0.022	0.042	0.03	0.365	0.906
	7 days	0.083	-0.043	0.043	0.002	0.348	0.901
Total prior to sampling over	2 days	0.056	0.022	-0.009	0.078	0.443	0.781
	3 days	0.04	-0.026	-0.001	0.017	0.316	0.907
	4 days	0.101	-0.021	0.023	-0.007	0.257	0.882
	5 days	0.073	-0.017	0.043	0.021	0.257	0.882
	6 days	0.104	-0.005	0.07	0.043	0.257	0.882
	7 days	0.1	-0.01	0.065	0.034	0.283	0.865

Rainfall data from the Environment Agency

Of all of the RMPs in Langstone harbour, only Milton Lake (mussel RMP) showed a statistically significant influence from rainfall. While only 9 samples have been taken from both of the mussel RMPs, samples were taken on the same days at both sites. The difference between the sites in terms of the influence of rainfall may possibly be explained by the location of Milton lake at the end of a channel which may receive freshwater from Milton Common. However, further sampling would be needed in order for a confident conclusion to be drawn.

USE OF NATIVE OYSTER RESULTS FOR CLASSIFICATION OF MUSSELS

After a brief period of parallel monitoring, the use of native oyster sampling results was agreed to be representative of mussels. The results of the seven paired (same-day) samplings are shown in Table XI.3.

Table XI.3 Individual results of parallel monitoring from the two mussel and nearby native oyster RMPs (E. coli MPN/100g)

	Milton Lake	Salterns Quay	Broom Channel (Salterns)
	Mussels	Mussels	Native oysters
12/12/2006	1300	160	500
15/01/2007	1300	320	220
05/02/2007	40	40	750
12/03/2007	50	500	500
23/04/2007	<20	70	750
11/06/2007	220	20	40
09/07/2007	110	40	110
Geomean	135	92	280
% exceeding 4600	0	0	0
% exceeding 230	29%	29%	57%

Results were highest on average at the native oyster RMP, and no results exceeding the class B threshold (4600 MPN/100 g). However, the peak *E. coli* result was recorded at Milton Lake. When these results were plotted (Figure XI.7) the results from Salterns Quay mussels appear to increase as they increase in native oysters in the Broom Channel, whereas results from Milton Lake mussels do not. Milton Lake is heavily influenced by recent rainfall whereas the other two RMPs were not. However, the dataset is perhaps too small to undertake statistical tests or draw firm conclusions about the suitability of using native oysters to represent mussels in this case.

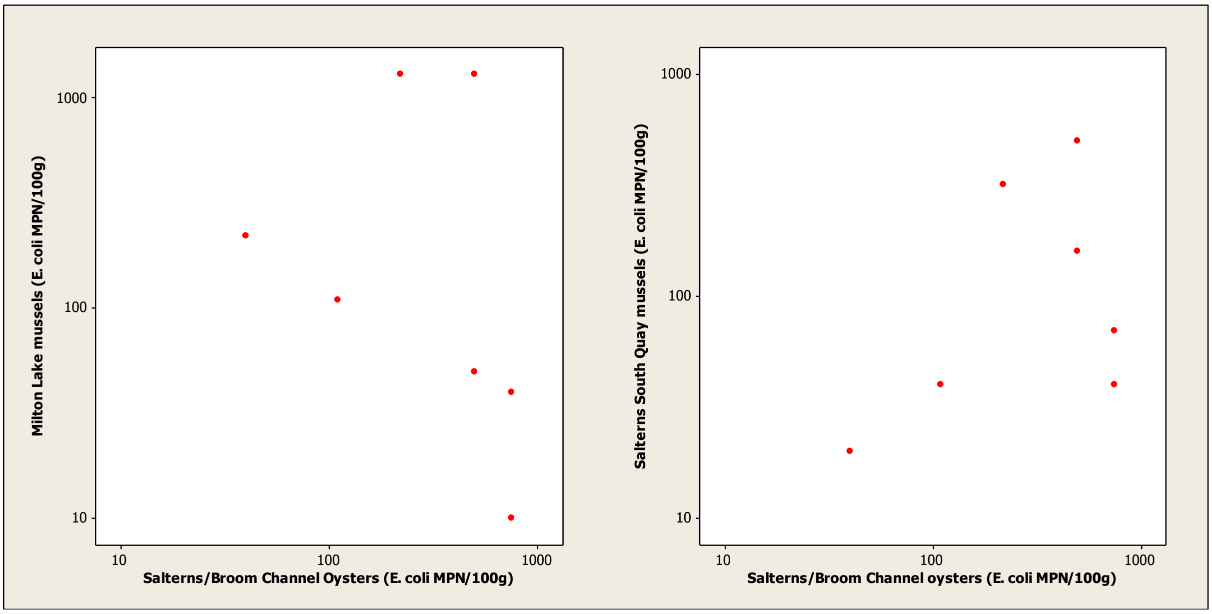

Figure XI.7. Scatterplot comparison of paired* E. coli *results from oysters at Salterns/Broom channel and the two nearby mussel RMPs

APPENDIX XII
SHORELINE SURVEY

Date (time): 23 October 2012 (0800-16:30)
24 October 2012 (0800-16:30)
25 October 2012 (0800-16:30)

Cefas Officers: David Walker, Rachel Parks

Local Enforcement Authority Officers:
David Jones (Portsmouth City Council, Port Health Authority, 23 October only)
Steve Lucking (Portsmouth City Council, Port Health Authority, 24 October only)

Area surveyed: Langstone Harbour (Figure XII.1)

Weather (12:00BST):
23 October 2012 – Wind 0° 0.0 km/h, 14.3°C, Overcast
24 October 2012 – Wind 73° 6.4 km/h, 15.8°C, Overcast
25 October 2012 – Wind 65° 11.2 km/h, 14.3°C, Overcast

Tidal predictions for Portsmouth (Proudman Oceanographic Laboratory):

Portsmouth SU62730067 England. GMT+0100. Predicted heights are in metres above chart datum.

23/10/2012			24/10/212			25/10/2012		
05:54	4.21 m	High	07:06	4.22 m	High	00:39	1.72 m	Low
10:45	1.91 m	Low	12:09	1.90 m	Low	08:11	4.34 m	High
18:18	4.01 m	High	19:32	4.05 m	High	13:17	1.73 m	Low
23:23	1.78 m	Low				20:30	4.19 m	High

Objectives:

This sanitary survey was initiated by the Food Standards Agency following a risk ranking exercise. Classifications currently exist in Langstone Harbour for mussels, native oysters and American hard clams. The shoreline survey aims to confirm the locations of identified sources of contamination, identify any additional sources and take samples and measurements of freshwater inputs to the harbour.

A full list of recorded observations is presented in Table XII.1 and the locations of these observations are mapped in Figure XII.1. Photographs referenced in Table XII.1 are presented in Figure XII.4 to Figure XII.47.

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. Small, wild stocks of cockles and dead shell from various clam species are visible from the shore particularly in the south west and north east of the harbour.

Much of the western and northern shores of Langstone harbour are covered with thick mud which is uncovered at low tide. This made surveying the intertidal area dangerous and so the survey was confined mainly to the high intertidal and supratidal zones. This meant that direct observations of mussels and oysters were not possible.

The Port Health Authority indicated that the native oyster stocks have declined in recent years and the number of boats used for harvesting has dropped from 86 to 22 as a result. The oyster harvesting season opens on the 1st November and closes at the end of February. Boats can catch between 1 to 1.5 tonnes of oysters during the early part of the season, but catches decline rapidly after the 1st week of the season.

The mussel beds derive from deposits of seed stock from elsewhere and are harvested by a private company called Viviers (UK) Ltd. The Portsmouth Port Health Authority was not aware of the classified hard clam fisheries in the north east of the harbour.

Cockles were observed in Eastney Lake and in the North of the harbour, but did not appear to be at densities high enough for commercial exploitation. Small mussels were observed on the Eastney sewerage outlet pipe, which was the only point along the survey where it was possible to access the lower inter tidal zone.

Sources of contamination

Sewage discharges

The location of intermittent discharges at Budds Farm (x2), Fort Cumberland and Burrfields Road CSOs were confirmed. None was active at the time. The Budds Farm sewerage treatment works is located at the northern end of the harbour, but its main discharge is in the south, where a pipeline runs 5 km seaward from the Eastney pumping station. A pipeline was observed running from Hayling Island to the mainland which is presumed to carry sewerage from Hayling Island to be treated at Budds farm.

There were many other pipes throughout the survey, which due to them having no entry in the permit database, are presumed to carry surface water and were sampled where possible. However, many of the outlets for these discharges are situated within the muddy intertidal area which made access for sampling dangerous. Some other discharges were also impossible to sample due to the state of the tide (i.e. tide was too high to gain access to directly sample discharged water). Some outlets had limited access which allowed a water sample to be taken, but no flow data to be recorded. There were several pipes that while not on the permit database, carry water with concentrations exceeding 10,000 cfu/100 ml, suggesting some sanitary content.

Sanitary related debris was present in varying amounts within the high water strand line around the harbour. In some areas it was in the form of old cotton buds which may have been of distant origin. 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 within the harbour.

Freshwater inputs

There are no major rivers that flow into Langstone harbour, but there are some smaller streams which appear to drain largely from the South Downs and residential settlements to the north. The most significant of the freshwater inputs that flows directly into the harbour is from Hermitage stream which is located in the north of the harbour. It was not possible to sample this waterway because of limited access to the water's edge.

Boats and Shipping

There were several small recreation boats moored throughout the harbour, as well as at the marina at in Eastney Lake. A seawater sample taken adjacent to the marina did not indicate any significant input of contamination from the marina.

Livestock

There was no livestock observed on the Portsea Island (western shore) stretch of the survey. However around 80 cattle were observed on Farlington Marshes in the north of the harbour, and about 20 cattle were seen in a field just south of Langstone. Measurement of drainage from this field did not indicate high levels of *E. coli* loading.

Wildlife

There were several flocks of birds observed around the harbour, but the highest densities were seen along the eastern shore (Hayling Island). At the northern end of Hayling Island there is a nature reserve where upwards of 100 birds could be seen in a single location.

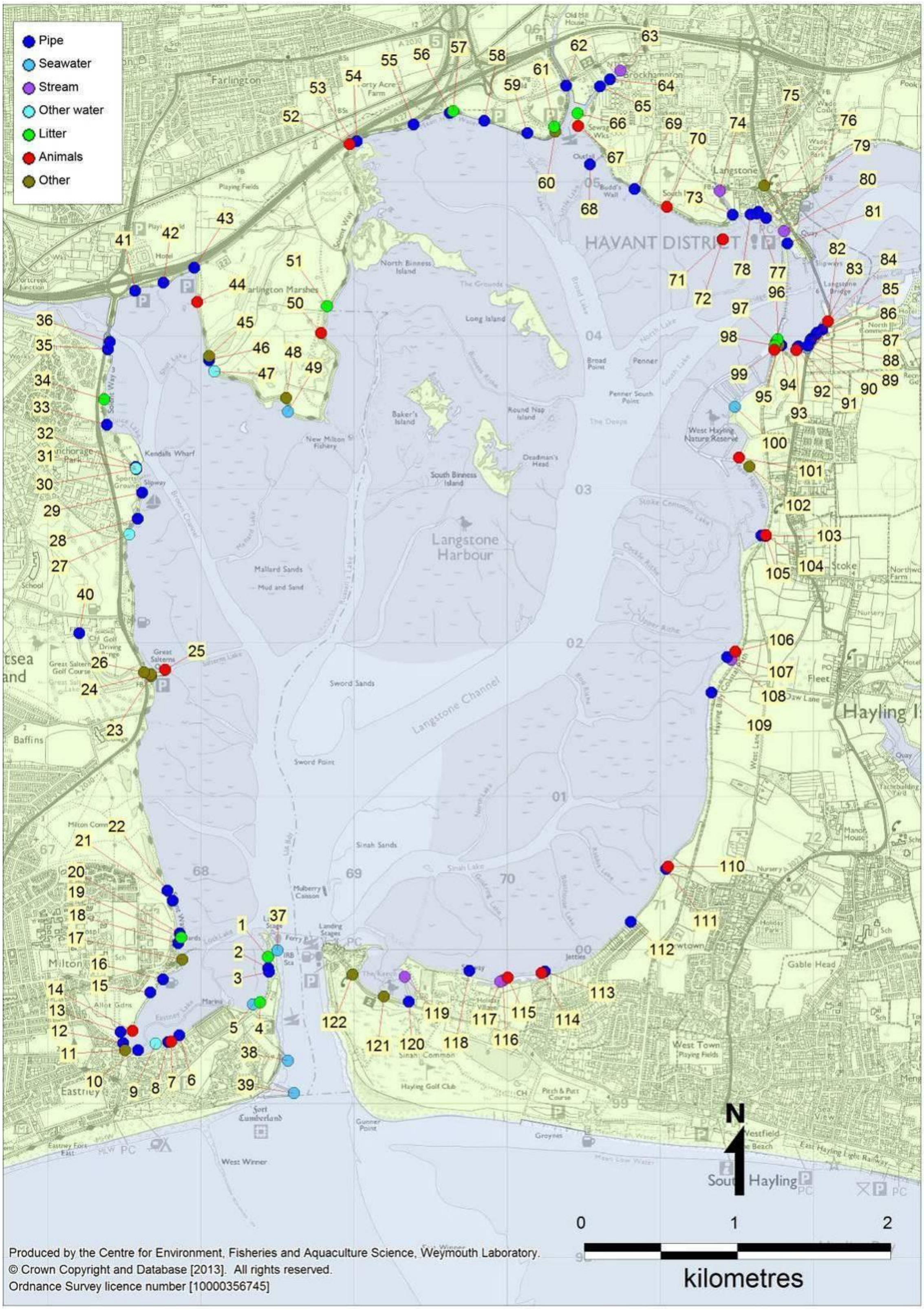

Figure XII.2 Locations of shoreline observations for Langstone Harbour (see Table 1 for details)

Table XII.1. Details of shoreline observations

Number	Date & Time	NGR	Image	Type	Description
1	23/10/2012 09:00	SZ 68438 99955		Litter	Cotton buds
2	23/10/2012 09:02	SZ 68441 99882	Figure XII.4	Pipe	Iron pipe (FW1)
3	23/10/2012 09:06	SZ 68445 99858	Figure XII.5	Pipe	Plastic pipe (FW2)
4	23/10/2012 09:13	SZ 68388 99659		Litter	Cotton buds
5	23/10/2012 09:16	SZ 68341 99646	Figure XII.6	Seawater	Seawater adjacent to marina (SW3)
6	23/10/2012 09:28	SZ 67860 99446		Pipe	Pipe outlet - No flow
7	23/10/2012 09:32	SZ 67807 99404		Animal	Seagulls x20
8	23/10/2012 09:36	SZ 67787 99401	Figure XII.7	Pipe	Iron pipe (FW4)
9	23/10/2012 09:41	SZ 67705 99392	Figure XII.8	Other water	Standing water (SW14)
10	23/10/2012 09:46	SZ 67591 99348	Figure XII.9	Pipe	Iron pipe (FW5)
11	23/10/2012 09:48	SZ 67504 99349		Other	Residential caravan park
12	23/10/2012 09:49	SZ 67492 99394	Figure XII.10	Pipe	Pipe outlet - oily water (FW15)
13	23/10/2012 09:56	SZ 67476 99467	Figure XII.11	Pipe	Pipe outlet (FW6)
14	23/10/2012 09:58	SZ 67553 99475		Animal	Seagulls x20
15	23/10/2012 10:06	SZ 67671 99724	Figure XII.12	Pipe	Water runoff from allotments (FW7)
16	23/10/2012 10:12	SZ 67752 99811	Figure XII.13	Pipe	Large outlet with grating (FW8)
17	23/10/2012 10:15	SZ 67878 99938		Other	Old canal - input too shallow to measure
18	23/10/2012 10:18	SU 67852 00045	Figure XII.14	Pipe	Inaccessible pipe
19	23/10/2012 10:21	SU 67871 00082		Litter	Cotton buds & sanitary products
20	23/10/2012 10:22	SU 67862 00109		Pipe	Drainage in wall
21	23/10/2012 10:32	SU 67816 00322	Figure XII.15	Pipe	Culverted stream (FW9)
22	23/10/2012 10:33	SU 67782 00389		Pipe	Drain
23	23/10/2012 11:08	SU 67676 01785		Other	Drain cover close to where there is supposed to be a stream
24	23/10/2012 11:10	SU 67673 01798		Other	Lots of dead shell - mainly slipper limpets
25	23/10/2012 11:14	SU 67768 01825		Animal	Wading birds & several discharges along pier - inaccessible
26	23/10/2012 11:18	SU 67628 01810	Figure XII.16	Other	EA pump for Salterns Lake
27	23/10/2012 12:17	SU 67531 02707	Figure XII.17	Other water	Standing water (FW10)
28	23/10/2012 12:20	SU 67587 02811		Pipe	Pipe outlet - No flow
29	23/10/2012 12:23	SU 67618 02980		Pipe	Pipe outlet - No flow
30	23/10/2012 12:26	SU 67578 03134		Pipe	Pipe outlet - No flow
31	23/10/2012 12:27	SU 67576 03137		Other water	Standing water adjacent to shoreline (does not appear to flow on to beach)
32	23/10/2012 12:29	SU 67575 03147		Pipe	Pipe outlet - Water flowing from Kendall's Wharf - inaccessible
33	23/10/2012 12:39	SU 67387 03422	Figure XII.18	Pipe	Freshwater input - Sluice lake - inaccessible
34	23/10/2012 12:44	SU 67368 03588		Litter	Cotton buds
35	23/10/2012 12:50	SU 67394 03912		Pipe	Pipe outlet - No flow
36	23/10/2012 12:52	SU 67406 03962		Pipe	Pipe outlet - No flow

Number	Date & Time	NGR	Image	Type	Description
37	23/10/2012 13:25	SZ 68500 99999	Figure XII.19	Seawater	Sea water in harbour inlet (SW11)
38	23/10/2012 13:48	SZ 68570 99280	Figure XII.20	Seawater	Sea water near Fort Cumberland Intermittant discharge (SW12)
39	23/10/2012 13:50	SZ 68608 99068	XII.Figure 21	Seawater	Sea water at end of abandoned outfall (SW13)
40	23/10/2012 15:01	SU 67206 02064	Figure XII.22	Pipe	Burrfields road CSO drain into pond on golf course (heading towards points 25 & 26) (FW16)
41	24/10/2012 08:02	SU 67570 04294		Pipe	Overflow discharge
42	24/10/2012 08:08	SU 67755 04348		Pipe	Outflow (SW17)
43	24/10/2012 08:15	SU 67957 04444		Pipe	Overflow discharge
44	24/10/2012 08:27	SU 67977 04222		Animal	Seagulls
45	24/10/2012 08:33	SU 68053 03869		Other	Sluice gates
46	24/10/2012 08:34	SU 68053 03842		Pipe	Small pipes draining from marsh (inaccessible)
47	24/10/2012 08:38	SU 68088 03769	Figure XII.23	Other water	Marsh creek (FW18)
48	24/10/2012 08:49	SU 68556 03598		Other	End of restricted route
49	24/10/2012 09:00	SU 68570 03507	Figure XII.24	Seawater	Sea water adjacent to marsh (SW19)
50	24/10/2012 09:20	SU 68785 04021		Animal	Cattle (300° 200m) x50
51	24/10/2012 09:24	SU 68823 04194		Litter	Cotton buds
52	24/10/2012 09:44	SU 68973 05248		Animal	Cattle (310° 150m) x30
53	24/10/2012 09:50	SU 69018 05269	Figure XII.25	Pipe	Pipe (4" PVC) going to ground - from direction of main road, surrounding area with lots of algae. Inaccessible
54	24/10/2012 09:50	SU 69018 05269	Figure XII.26	Pipe	Outlet (SW20)
55	24/10/2012 10:02	SU 69391 05378	Figure XII.27	Pipe	Outlet (SW21)
56	24/10/2012 10:16	SU 69627 05453	Figure XII.28	Pipe	Outlet, gas bubbles rising from algae beds (FW22)
57	24/10/2012 10:26	SU 69647 05465		Litter	Plastic sanitary products
58	24/10/2012 10:30	SU 69852 05403	Figure XII.29	Pipe	Outflow (FW23)
59	24/10/2012 10:43	SU 70134 05321		Pipe	Outlet 5m wide (inaccessible)
60	24/10/2012 10:48	SU 70315 05331		Other	Contaminated shellfish sign
61	24/10/2012 10:50	SU 70309 05364		Litter	Cotton buds
62	24/10/2012 10:55	SU 70387 05631		Pipe	Overflow pipe
63	24/10/2012 11:20	SU 70740 05727	Figure XII.30	Stream	Budds farms outfall 1 to stream (FW24)
64	24/10/2012 11:23	SU 70674 05672		Pipe	Intermittent pipe - no flow
65	24/10/2012 11:38	SU 70607 05625	Figure XII.31	Pipe	Pipe outfall (FW25)
66	24/10/2012 11:50	SU 70461 05451		Litter	Cotton buds
67	24/10/2012 11:55	SU 70465 05367		Animal	Seagulls
68	24/10/2012 12:16	SU 70542 05118	Figure XII.32	Pipe	Budds farm outfall 2 (SW26)
69	24/10/2012 12:28	SU 70833 04957	Figure XII.33	Pipe	Outflow (FW27)
70	24/10/2012 12:44	SU 71045 04842		Animal	Cattle (80° 50m) x20
71	24/10/2012 12:56	SU 71410 04630		Other	Cockles observed

Number	Date & Time	NGR	Image	Type	Description
72	24/10/2012 12:57	SU 71411 04630		Animal	Sea birds
73	24/10/2012 13:11	SU 71475 04790	Figure XII.34	Pipe	Run off from adjacent field (FW28)
74	24/10/2012 13:36	SU 71389 04945	Figure XII.35	Stream	Stream (FW29)
75	24/10/2012 13:45	SU 71680 04980		Other	Southern Water green box #102305
76	24/10/2012 14:00	SU 71642 04809		Pipe	Groundwater drainage pipe - no flow
77	24/10/2012 14:01	SU 71633 04798		Pipe	Groundwater drainage pipe - no flow
78	24/10/2012 14:01	SU 71592 04792		Pipe	Groundwater drainage pipe - low flow
79	24/10/2012 14:05	SU 71693 04767	Figure XII.36	Pipe	Outflow (FW30)
80	25/10/2012 08:21	SU 71810 04684	Figure XII.37	Stream	High tide, freshwater input mixed (SW31)
81	25/10/2012 08:34	SU 71831 04602		Pipe	Pipe - not flowing, inaccessible
82	25/10/2012 08:47	SU 72097 04095		Animal	Horses (150° 75m) x2
83	25/10/2012 08:50	SU 72059 04042		Pipe	Pipe - not flowing
84	25/10/2012 08:51	SU 72025 04022		Pipe	Pipe - not flowing
85	25/10/2012 08:51	SU 72021 04016		Pipe	Pipe - not flowing
86	25/10/2012 08:52	SU 71988 03981		Pipe	Pipe - not flowing
87	25/10/2012 08:53	SU 71985 03976		Pipe	Pipe - not flowing
88	25/10/2012 08:53	SU 71983 03969		Pipe	Pipe - not flowing
89	25/10/2012 08:54	SU 71965 03938		Pipe	Pipe - not flowing
90	25/10/2012 08:56	SU 71960 03926	Figure XII.38	Seawater	Sea water in artificial cove (SW32)
91	25/10/2012 08:59	SU 71904 03933		Pipe	Pipe - not flowing
92	25/10/2012 09:00	SU 71900 03931		Pipe	Pipe
93	25/10/2012 09:02	SU 71889 03907		Animal	Cattle x6
94	25/10/2012 09:07	SU 71792 03939		Pipe	Pipe - below water
95	25/10/2012 09:09	SU 71775 03942		Other	Manhole cover
96	25/10/2012 09:16	SU 71769 03979		Litter	Cotton buds
97	25/10/2012 09:18	SU 71756 03959	Figure XII.39	Other	Underwater pipe running to mainland (suspected sewerage pipe to Budds Farm)
98	25/10/2012 09:19	SU 71750 03937		Litter	Cotton buds
99	25/10/2012 09:20	SU 71746 03910		Animal	Birds x200 on rocky outcrop
100	25/10/2012 09:35	SU 71488 03538	Figure XII.40	Seawater	Seawater adjacent to bird reserve (SW33)
101	25/10/2012 09:46	SU 71517 03208		Animal	Birds x100
102	25/10/2012 09:49	SU 71585 03149		Other	Manhole cover on beach, no sign of pipe
103	25/10/2012 10:01	SU 71661 02701		Pipe	Pipe under water
104	25/10/2012 10:04	SU 71690 02702		Animal	Horses x6
105	25/10/2012 10:09	SU 71691 02699	Figure XII.41	Pipe	Drainage stream leading into pipe at point 103 (FW34)
106	25/10/2012 10:26	SU 71492 01944		Animal	Horse manure
107	25/10/2012 10:31	SU 71439 01909		Pipe	Pipe under water

Number	Date & Time	NGR	Image	Type	Description
108	25/10/2012 10:33	SU 71464 01891	Figure XII.42	Stream	Stream leading into pipe at point 107 (FW35)
109	25/10/2012 10:42	SU 71337 01678	Figure XII.43	Pipe	Pipe (FW36)
110	25/10/2012 11:13	SU 71052 00544		Animal	Birds x25
111	25/10/2012 11:13	SU 71039 00529	Figure XII.44	Pipe	Pipe (FW37)
112	25/10/2012 11:32	SU 70809 00183		Pipe	Groundwater drainage pipes from gardens
113	25/10/2012 11:46	SZ 70247 99861		Pipe	End of gardens with groundwater drainage pipes
114	25/10/2012 11:51	SZ 70227 99852		Animal	Birds
115	25/10/2012 12:03	SZ 70004 99823		Animal	Birds
116	25/10/2012 12:10	SZ 69974 99802	Figure XII.45	Stream	Stream (SW38)
117	25/10/2012 12:11	SZ 69957 99796		Stream	Stream (SW39)
118	25/10/2012 12:19	SZ 69754 99866	Figure XII.46	Pipe	Pipe (FW40)
119	25/10/2012 12:32	SZ 69332 99827	Figure XII.47	Stream	Stream (SW41)
120	25/10/2012 12:39	SZ 69358 99665		Pipe	Pipe (SW42)
121	25/10/2012 12:47	SZ 69196 99699		Other	Houseboats x8
122	25/10/2012 12:52	SZ 68993 99842		Other	Southern Water enclosure #100497. No outfall visible.

Sample results

A total of 42 water samples were taken during the survey (Table XII.2 and Figure XII.2). These included fresh and brackish water from pipes and streams as well as sea water. Where possible, flow rates of streams and pipes were taken to allow estimates of *E. coli* loading to be calculated.

Table XII.2. Water sample* E. coli *results

No.	Date & time	Easting	Northing	Type	*E. coli* (cfu/100 ml)	Salinity (ppt)	Flow (m^3/day)	*E. coli* (cfu/day)
1	23/10/2012 09:02	468441	99882	Pipe	<10		232	<2.32 x10^7
2	23/10/2012 09:06	468445	99858	Pipe	<10		801	<8.01 x10^7
3	23/10/2012 09:16	468341	99646	Seawater	90			
4	23/10/2012 09:36	467787	99401	Pipe	500		163	8.16 x10^8
5	23/10/2012 09:41	467591	99348	Pipe	600000			
6	23/10/2012 09:46	467476	99467	Pipe	7000		35.3	2.47 x10^9
7	23/10/2012 09:49	467671	99724	Pipe	660		20.2	1.33 x10^8
8	23/10/2012 09:56	467752	99811	Pipe	14000			
9	23/10/2012 10:06	467816	100322	Pipe	450000		117	5.26 x10^{11}
10	23/10/2012 10:12	467531	102707	Other water	410	30.1		
11	23/10/2012 10:32	468500	99999	Seawater	40	33.2		
12	23/10/2012 12:17	468570	99280	Seawater	30	33.5		
13	23/10/2012 13:25	468608	99068	Seawater	20	33.7		
14	23/10/2012 13:48	467705	99392	Other water	20	31.9		
15	23/10/2012 13:50	467492	99394	Pipe	2100	13		
16	23/10/2012 15:01	467206	102064	Pipe	6200			
17	24/10/2012 08:08	467755	104348	Pipe	20			
18	24/10/2012 08:38	468088	103769	Other water	40			
19	24/10/2012 09:00	468570	103507	Seawater	30			
20	24/10/2012 09:50	469018	105269	Pipe	220	18.3		
21	24/10/2012 10:02	469391	105378	Pipe	70	31.2		
22	24/10/2012 10:16	469627	105453	Pipe	70		1599	1.12 x10^9
23	24/10/2012 10:30	469852	105403	Pipe	40		517	2.07 x10^8
24	24/10/2012 11:20	470740	105727	Stream	3200		5723	1.83 x10^{11}
25	24/10/2012 11:38	470607	105625	Pipe	480		1296	6.22 x10^9
26	24/10/2012 12:16	470542	105118	Pipe	10			
27	24/10/2012 12:28	470833	104957	Pipe	5800		499	2.90 x10^{10}
28	24/10/2012 13:11	471475	104790	Pipe	70		1125	7.87 x10^8
29	24/10/2012 13:36	471389	104945	Stream	190		11569	2.20 x10^{10}
30	24/10/2012 14:05	471693	104767	Pipe	170		12.1	2.06 x10^7
31	25/10/2012 08:21	471810	104684	Stream	130	32.3		
32	25/10/2012 08:56	471960	103926	Seawater	110	33		
33	25/10/2012 09:35	471488	103538	Seawater	40	32		
34	25/10/2012 10:09	471691	102699	Pipe	12000		253	3.03 x10^{10}
35	25/10/2012 10:33	471464	101891	Stream	550		1116	6.14 x10^9
36	25/10/2012 10:42	471337	101678	Pipe	6600		42.9	2.83 x10^9
37	25/10/2012 11:13	471039	100529	Pipe	2800		6076	1.70 x10^{11}
38	25/10/2012 12:10	469974	99802	Stream	1300	28.2	403	5.24 x10^9
39	25/10/2012 12:11	469957	99796	Stream	190	31.5	1285	2.44 x10^9
40	25/10/2012 12:19	469754	99866	Pipe	<10			
41	25/10/2012 12:32	469332	99827	Stream	120		1050	1.26 x10^9
42	25/10/2012 12:39	469358	99665	Pipe	<10	27	1.97	<1.97 x10^5

*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.

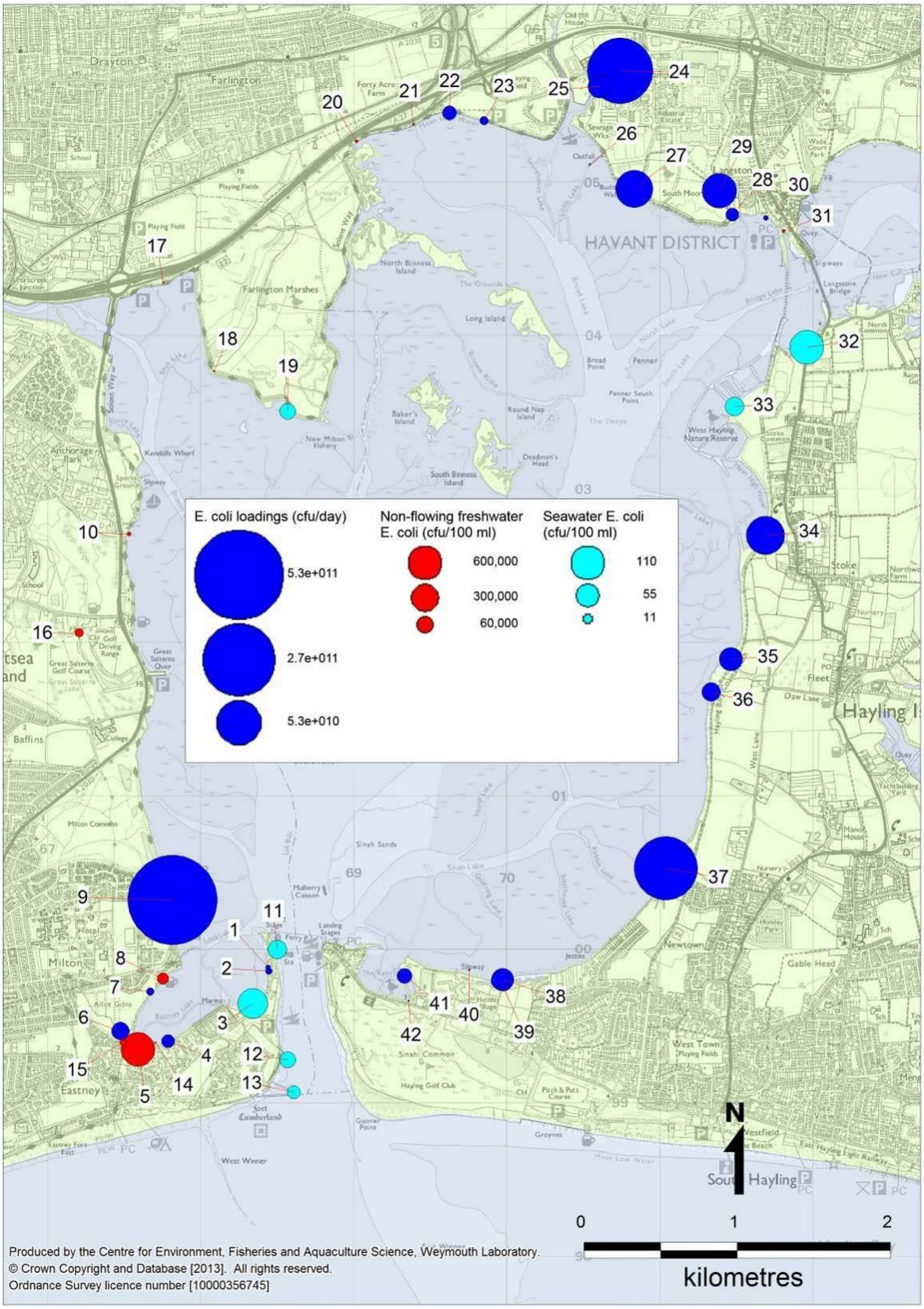

Figure XII.3 Seawater sample results and calculated loadings of freshwater inputs

Seawater samples indicated low levels of contamination throughout the harbour. The higher levels of *E. coli* in seawater were found within two of the more sheltered areas: Eastney marina and between the road bridge and the old railway bridge.

The highest *E. coli* loadings from freshwater inputs were recorded at a storm water drain near Milton Locks (sample 9), which is within the long term class B mussel beds. No flow reading was taken for sample 5, but this point had the highest *E. coli* concentration measurement (600,000 cfu/100 ml) and so it is likely that it is a significant source of contamination. There were also high *E. coli* loadings at an outlet from the Budds Farm sewage treatment works (FW24) and a drainage stream north of Newtown on Hayling Island (FW37).

Conclusions

With no major continuous sewage discharges or river inputs to Langstone Harbour, the most important potential sources of contamination would appear to be intermittent discharges. The most contaminated areas in the harbour are the south east corner, where the largest concentration of small surface water outfalls was found; and the north where other significant discharges were found. Both of these areas are in close proximity to shellfish beds (mussels and hard clams respectively).

Figure XII.4

Figure XII.5

Figure XII.6

Figure XII.7

Figure XII.8

Figure XII.9

Figure XII.10

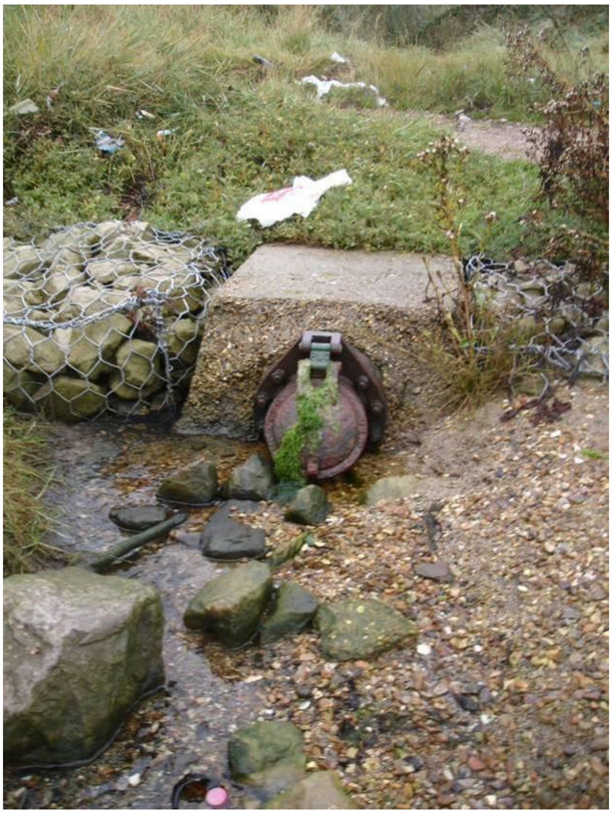

Figure XII.11

Figure XII.12

Figure XII.13

Figure XII.14

Figure XII.15

Figure XII.16

Figure XII.17

Figure XII.18

Figure XII.19

Figure XII.20

XII.Figure 21

Figure XII.22

Figure XII.23

Figure XII.24

Figure XII.25

Figure XII.26

Figure XII.27

Figure XII.28

Figure XII.29

Figure XII.30

Figure XII.31

Figure XII.32

Figure XII.33

Figure XII.34

Figure XII.35

Figure XII.36

Figure XII.37

Figure XII.38

Figure XII.39

Figure XII.40

Figure XII.41

Figure XII.42

Figure XII.43

Figure XII.44

Figure XII.45

Figure XII.46

Figure XII.47

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List of Abbreviations

AONB	Area of Outstanding Natural Beauty
BMPA	Bivalve Mollusc Production Area
CD	Chart Datum
Cefas	Centre for Environment Fisheries & Aquaculture Science
CFU	Colony Forming Units
CSO	Combined Sewer Overflow
CZ	Classification Zone
Defra	Department for Environment, Food and Rural Affairs
DWF	Dry Weather Flow
EA	Environment Agency
E. coli	*Escherichia coli*
EC	European Community
EEC	European Economic Community
EO	Emergency Overflow
FIL	Fluid and Intravalvular Liquid
FSA	Food Standards Agency
GM	Geometric Mean
IFCA	Inshore Fisheries and Conservatrion Authority
ISO	International Organization for Standardization
km	Kilometre
LEA (LFA)	Local Enforcement Authority formerly Local Food Authority
M	Million
m	Metres
ml	Millilitres
mm	Millimetres
MHWN	Mean High Water Neaps
MHWS	Mean High Water Springs
MLWN	Mean Low Water Neaps
MLWS	Mean Low Water Springs
MPN	Most Probable Number
NM	Nautical Miles
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
STW	Sewage Treatment Works
UV	Ultraviolet
WGS84	World Geodetic System 1984

Glossary

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

Flow ratio	Ratio of the volume of freshwater entering into an estuary during the tidal cycle to the volume of water flowing up the estuary through a given cross section during the flood tide.
Geometric mean	The geometric mean of a series of N numbers is the N^{th} root of the product of those numbers. It is more usually calculated by obtaining the mean of the logarithms of the numbers and then taking the anti-log of that mean. It is often used to describe the typical values of skewed data such as those following a log-normal distribution.
Hydrodynamics	Scientific discipline concerned with the mechanical properties of liquids.
Hydrography	The study, surveying, and mapping of the oceans, seas, and rivers.
Lowess	LOcally WEighted Scatterplot Smoothing, more descriptively known as locally weighted polynomial regression. At each point of a given dataset, a low-degree polynomial is fitted to a subset of the data, with explanatory variable values near the point whose response is being estimated. The polynomial is fitted using weighted least squares, giving more weight to points near the point whose response is being estimated and less weight to points further away. The value of the regression function for the point is then obtained by evaluating the local polynomial using the explanatory variable values for that data point. The LOWESS fit is complete after regression function values have been computed for each of the *n* data points. LOWESS fit enhances the visual information on a 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”.

Summary of consultations on draft report

Consultee	Comment	CEFAS response
Environment Agency		
Southern Water		
Portsmouth Port Health		
Havan Council		
Southern IFCA		

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